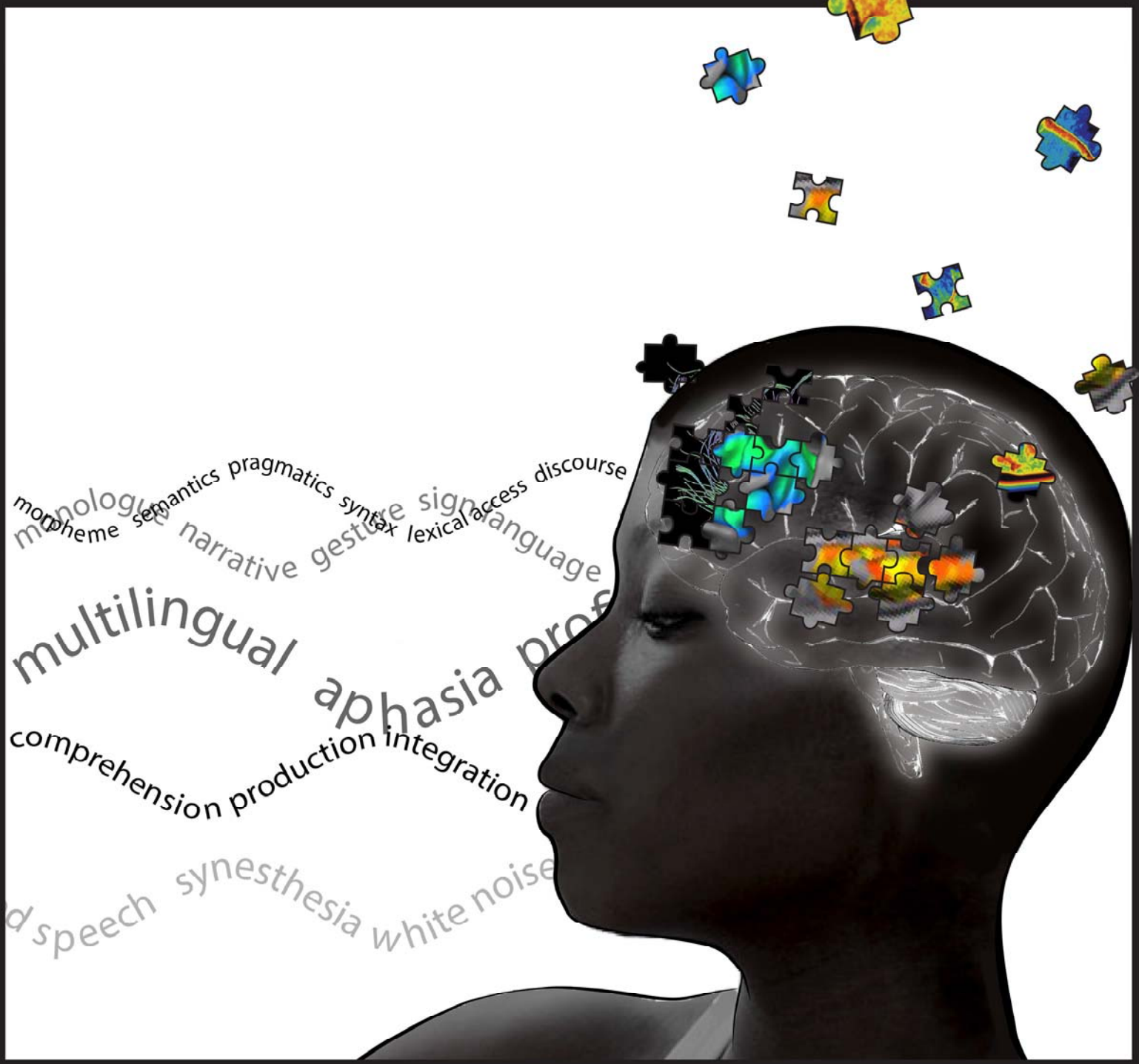
Prosody provides cues to morphosyntactic structure : an EEG-fMRI study of neural networks subserving Swedish word tone processing

Söderström, Pelle; Horne, Merle; Mannfolk, Peter; Shtyrov, Yury; Johansson, Mikael; Roll, Mikael

Published in:
[Publication information missing]

2014

SOCIETY FOR THE NEUROBIOLOGY OF LANGUAGE



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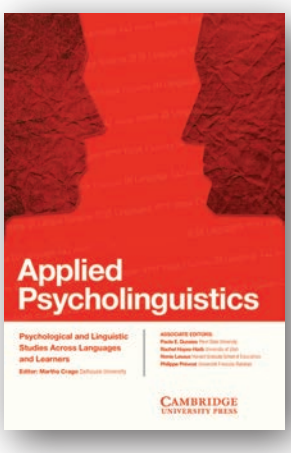

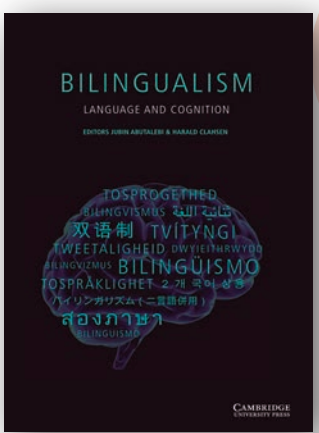

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Welcome to SNL 2014, Amsterdam, the Netherlands

Welcome to the Sixth Annual Meeting of the Society for the Neurobiology of Language. A meeting like this finds its raison d'être in the conviction that science is not only about having ideas, but also about communicating them. Our Society is an important vehicle for the communication of ideas, insights, and findings related to the neurobiological infrastructure for human language. One of the great challenges for science in the 21st century is to understand how the microcosm of the human brain enables the key cognitive capacities that we command. Understanding how the brain gives rise to language is central in this endeavour. Our annual meeting brings together researchers that share this common goal, and it is encouraging that every year more researchers are joining this important endeavour. Our Society continues to grow. This year there were more submissions than ever before.

The increasing number of members of our Society and the ever larger numbers of participants at our annual meeting has influenced the organization of our Society and our annual meeting. The website (www.neurolang.org) and the monthly newsletter have proven to be a major asset for making our Society more professional. I would like to express special thanks to our meeting planner, Shauney Wilson and her colleague Shawna Lampkin, and to Carolin Lorenz for organizing this year's meeting in Amsterdam. I would like to thank the PhD students and postdocs in my own research group, who were tremendously helpful in organizing this year's meeting, including designing the cover of the program booklet, the T-shirt, etcetera. Without their contributions this meeting simply would not have taken place. In addition, I would like to express my sincere thanks to our sponsors, whose substantial financial contributions have made it possible to hold this meeting while keeping registration fees affordable.

The program of this year's meeting has a line-up of excellent keynote speakers, a debate on the foundations of the neurobiology of language, and for the first time, a symposium. At the core of our meeting, however, are your contributions: posters, oral slide sessions, and active participation at the different sessions. You are the sole reason for the existence of this Society, and its continued success depends on you. Therefore we will continue to need your active contributions and feedback.

On behalf of the SNL Board and the local organizers, welcome to Amsterdam, historically a central hub in worldwide communication and the exchange of goods, science and arts. In line with this history, I hope that this year's meeting will encourage you to build your own connections with colleagues and students from around the world.

Peter Hagoort
Chair, Society for the Neurobiology of Language

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Schedule of Events

All events are held at the Beurs van Berlage.

Wednesday, August 27

11:00 am – 5:30 pm	Pre-Registration Check-in and Onsite Registration *Beursfoyer*
1:00 – 1:30 pm	Opening Remarks - Peter Hagoort, SNL Chair *Effectenbeurszaal*
1:30 – 2:30 pm	**Keynote Lecture - Willem J.M. Levelt** Localism versus holism. The historical origins of studying language in the brain. *Effectenbeurszaal*
2:30 – 3:00 pm	Coffee Break *Grote Zaal*
2:30 – 4:30 pm	Poster Session A *Grote Zaal*
4:30 - 5:50 pm	Slide Session A – Speech Processing *Effectenbeurszaal*
7:00 - 8:00 pm & 8:15 - 9:15 pm	Canal Boat Tour (Sign up for your preferred time at the Registration Desk)

Thursday, August 28th

7:30 am – 7:00 pm	Pre-Registration Check-In and Onsite Registration *Beursfoyer*
8:00 - 8:30 am	Coffee Break *Grote Zaal*
8:30 - 9:50 am	Slide Session B – Language Evolution and Brain Structure *Effectenbeurszaal*
10:00 - 10:30 am	Coffee Break *Grote Zaal*
10:00 am – 12:00 pm	Poster Session B *Grote Zaal*
12:00 – 1:00 pm	Lunch Served *Grote Zaal*
1:00 – 2:00 pm	**Keynote Lecture - Constance Scharff** Singing in the (b)rain *Effectenbeurszaal*
2:15 – 3:45 pm	Symposium – A neurobiology of naturalistic language use? *Effectenbeurszaal*
3:45 - 4:15 pm	Coffee Break *Grote Zaal*
3:45 - 5:45 pm	Poster Session C *Grote Zaal*
5:45 – 6:15 pm	Business Meeting *Effectenbeurszaal*
6:15 – 7:15 pm	**Keynote - Pascal Fries** Brain rhythms for bottom-up and top-down signaling *Effectenbeurszaal*
7:15 – 8:15 pm	Social Hour *Beurs van Berlage Café*

Friday, August 29th

7:30 am – 7:00 pm	Pre-Registration Check-In and Onsite Registration *Beursfoyer*
8:00 - 8:30 am	Coffee Break *Grote Zaal*
8:30 - 9:50 am	Slide Session C – Combinatorial Processing: Syntax, Semantics, Pragmatics *Effectenbeurszaal*
10:00 - 10:30 am	Coffee Break *Grote Zaal*
10:00 am – 12:00 pm	Poster Session D *Grote Zaal*
12:00 – 1:00 pm	Lunch Served *Grote Zaal*
1:00 – 2:20 pm	Slide Session D - Lexical Processing and Cognitive Control *Effectenbeurszaal*
2:30 – 4:00 pm	**Panel Discussion** What counts as neurobiology of language – a debate *Effectenbeurszaal*
4:00 – 4:30 pm	Coffee Break *Grote Zaal*
4:00 - 6:00 pm	Poster Session E *Grote Zaal*
6:00 – 7:00 pm	**Keynote Lecture – Mike Tomasello** Communication without Conventions *Effectenbeurszaal*
7:00 – 7:15 pm	Closing Remarks - Nina Dronkers, SNL Chair-Elect *Effectenbeurszaal*
7:15 – 8:15 pm	Social Hour *Beurs van Berlage Café*

Abstract Merit Awards

The Society for the Neurobiology of Language Abstract Merit Awards are given to the students and postdocs who submitted the highest ranked abstracts.

Graduate Student Merit Award Winners

Mirjam de Jonge, University of Amsterdam, Netherlands

Sara Pillay, Medical College of Wisconsin, USA

Post Doctoral Merit Award Winners

Tristan Davenport, University of California, San Diego, USA

Benjamin Wilson, Newcastle University, UK

Travel Awards

This year, the Society for the Neurobiology of Language granted twelve Travel Awards. The awards, funded by the National Institutes of Health (NIH), help to cover travel and registration costs for the 2014 Society for the Neurobiology of Language Meeting in Amsterdam.

Through the travel awards, SNL aims to encourage and foster the participation of junior scientists who are members of underrepresented groups.

The 2014 Travel Awards were given to:

Mariana Aparicio Betancourt, University of Illinois at Urbana-Champaign, USA

Alexandra Basilakos, University of South Carolina, USA

Gangyi Feng, South China Normal University, China

Andrea Gajardo Vidal, University College London, UK

Amanda Garcia, University of Florida, USA

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Paul Metzner, Universität Potsdam, Germany

Anna Simmonds, Imperial College London, UK

Susann Ullrich, Humboldt University, Germany

Brianna L. Yamasaki, University of Washington, USA

Canal Boat Tour

All attendees are invited to enjoy a FREE one hour tour through Amsterdam's historic and enchanting canals on Wednesday, August 27, at the close of the first day of SNL 2014. A tour of Amsterdam's stunning canals is one of the best ways to experience Amsterdam and see some of its famous sites.

The 165 canals were created over the centuries to stimulate trade and transport and reclaim land to expand the city. They continue define the city's landscape and in 2010 Amsterdam's canal ring was recognized as a UNESCO world heritage site.

Two embarkation times are available: 7:00 pm and 8:15 pm. Sign up at the Registration desk for your preferred time. You MUST arrive at the mooring location no less than 10 minutes prior to departure.

Mooring location: Krasnapolsky hotel, Oudezijds Voorburgwal – located in front of the back entrance of the Krasnapolsky hotel on the Oudezijds Voorburgwal 228.

Keynote Lectures

LOCALISM VERSUS HOLISM. THE HISTORICAL ORIGINS OF STUDYING LANGUAGE IN THE BRAIN.

Wednesday, August 27, 1:30 – 2:30 pm, Effectenbeurszaal

Chair: Peter Hagoort, Max Planck Institute for Psycholinguistics, Nijmegen, Netherlands

Willem Levelt

Director Emeritus of the Max Planck Institute for Psycholinguistics in Nijmegen

"Show me the forces of the soul, and I will find the organ and the seat thereof", Franz Joseph Gall wrote in 1818. Ever since, the issue of localism versus holism would remain a major controversy in the study of brain and language. I will discuss how this controversy developed from Gall's beginnings through the first half of the 20th century. For the sake of exposition I will distinguish three phases in this theoretical history. During the first phase, from Gall to Broca, localizing the faculty of articulate speech became the litmus test for Gall's general localistic theory. During the second phase of "diagram making", since Wernicke and Lichtheim, networks of language functions were related to neural networks in the brain. During the third phase, since Marie's "revolt against localism" of 1906/7, various attempts were made to "de-modularize" language and to relate this "intellectual function" to holistic brain action. However, their proponents (such as Head and Goldstein) did not manage to resolve the controversies.

SINGING IN THE (B)RAIN

Thursday, August 28, 1:00 – 2:00 pm, Effectenbeurszaal

Chair: Simon Fisher, Max Planck Institute for Psycholinguistics, Nijmegen, Netherlands

Constance Scharff

Professor of Animal Behavior at the Freie Universität Berlin

Spoken language and birdsong share a number of striking parallels. Comparing the biologically tractable cognitive abilities necessary for language and for birdsong is a fruitful endeavor to identify, which properties are shared and which are unique to each. I will review evidence for the relevance of the FoxP2 gene and its associated molecular network for speech and its role in modulating variability in the songbird basal ganglia circuit relevant for the acquisition and production of birdsong. However, I will argue that the similarities between human language and songbirds are not limited to sensorimotor processes – but may extend to other structural and functional properties. Many questions regarding the similarities between spoken language and birdsong remain unanswered, but increasing evidence suggests that human and non-human communication systems may rely on conserved molecular toolkits that act as genetic modules. These may specify the neural circuits subserving these particular behaviors, and organize their function. Elucidating these genetic modules in different animal models may inform the evolution of language and other complex traits.

BRAIN RHYTHMS FOR BOTTOM-UP AND TOP-DOWN SIGNALING

Thursday, August 28, 6:15 – 7:15 pm, Effectenbeurszaal

Chair: Kate Watkins, Department of Experimental Psychology & FMRIB Centre, University of Oxford, UK

Pascal Fries

Director of the Ernst Strüngmann Institute (ESI) for Neuroscience in Cooperation with Max Planck Society

Our brain generates rhythms continuously, and I will show in this lecture how some of these rhythms serve the communication between brain areas. One of the most intriguing rhythms is the gamma-band rhythm, which is strongly enhanced when a brain region is activated. When the gamma in one brain region entrains a gamma rhythm in another brain region, then signals can be sent over. If this entrainment or synchronization does not happen, then also no signal will flow, as I will demonstrate for the case of selective attention studied with high-resolution electrocorticography in monkeys. Thus, the selective gamma-band synchronization serves as a selective communication protocol. In these experiments, we found that gamma, together with theta, generally serves the bottom-up signaling of sensory information. By contrast, top-down signaling was served by beta-band synchronization. The pattern of inter-areal influences in the theta, beta and gamma bands was closely related to the hierarchical relationship between areas, as determined by laminar anatomical connection patterns. In fact, a hierarchy of visual areas derived purely from directed inter-areal influences was almost identical to the anatomical hierarchy. I will demonstrate that this holds for visual areas in human subjects studied with magnetoencephalography. It might hold also for other human brain areas, including language areas. Finally, I will show that bottom-up signaling in the gamma band is structured by a theta rhythm. The theta cycle implements one cycle of visual attentional sampling, as can be seen from human psychophysics and magnetoencephalography.

COMMUNICATION WITHOUT CONVENTIONS

Friday, August 29, 6:00 – 7:00 pm, Effectenbeurszaal

Chair: Nina Dronkers, VA Northern California Health Care System and University of California, Davis

Mike Tomasello

Co-Director of the Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany

For obvious and very good reasons the study of human communication is dominated by the study of language. But from a psychological point of view, the basic structure of human communication – how it works pragmatically in terms of the intentions and inferences involved – is totally independent of language. The most important data here are acts of human communication that do not employ conventions. In situations in which language is for some reason not an option, people often produce spontaneous, non-conventionalized gestures, including most prominently pointing (deictic gestures) and pantomiming (iconic gestures). These gestures are universal among humans and unique to the species, and in human evolution they almost certainly preceded conventional communication, either signed or vocal. For prelinguistic infants to communicate effectively via pointing and pantomiming, they must already possess species-unique and very powerful skills and motivations for shared intentionality as pragmatic infrastructure. Conventional communication is then built on top of this infrastructure – or so I will argue.

Panel Discussion

WHAT COUNTS AS NEUROBIOLOGY OF LANGUAGE – A DEBATE

Friday, August 29, 2:30 – 4:00 pm, Effectenbeurszaal

Chair: Nina Dronkers, VA Northern California Health Care System and University of California, Davis

Panelists:

Steve Small

University of California, Irvine, USA

Angela Friederici

Director, Department of Neuropsychology, Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany

Obviously the study of the neurobiology of language is about the brain and about language. What is less clear, however, is how these two areas intersect. What do we mean when we say that our goal is to understand the neurobiological mechanisms that underlie speaking and understanding language? Does it suffice to know where the processes of comprehension and production happen in the brain (fMRI) or when they happen (ERPs)? How exactly do we envision that the crucial aspects of language, such as sound, meaning, and syntax, will map onto the neural architecture of the human brain? Will the ultimate answer to these questions come from analyzing the firing patterns of individual neurons, measuring the joint contributions of neuronal populations, or perhaps from understanding the organization of large scale brain-wide networks? Do we need cognitive models of language in order to ask the relevant questions about the underlying neurobiology, or will our understanding of the cognitive organization emerge from our understanding of the brain? These and related issues form the core of the debate on what counts as the 'true' neurobiology of language.

Symposium

A NEUROBIOLOGY OF NATURALISTIC LANGUAGE USE?

Thursday, August 28, 2:15 – 3:45 pm, Effectenbeurzaal

Chair: Roel Willems, Donders Institute Nijmegen

Speakers: Roel Willems, Jeremy Skipper, Giovanna Egidi, Uri Hasson

When we think of everyday language use, the first things that come to mind include colloquial conversations, reading and writing emails, sending text messages or reading a book. But can we study the brain basis of language as we use it in our daily lives? As a topic of study, the neurobiology of language is far removed from these language-in-use examples, and most research is at the level of isolated words or sentences. However, recent developments in methodology have made studying the neural underpinnings of naturally occurring language much more feasible. For instance, it is now possible to meaningfully interpret fMRI data that was collected while people listen to complete narratives, or when they are in face-to-face communication with each other. Some view these methodological advances mainly as technical niceties: it is nice that the techniques are available, but this will not change our thinking about the neurobiology of language much. Others argue that 'going more naturalistic' will change the way we think about the neurobiological basis of language, and will lead to a revision of current ideas. In this symposium we propose to explore what the new developments in studying the neural basis of naturalistic language are, and how they inform the neurobiology of language. Four speakers who are at the forefront of this development will share their current views and findings. Roel Willems (Nijmegen) will illustrate recent approaches to naturalistic language comprehension, and show how application of new methods allows for the use of neuroimaging in studying how people comprehend literature. Jeremy Skipper (UCL London) will show how investigation of the neural basis of language comprehension using rich, multimodal stimuli (e.g. recordings of TV shows) leads to a reframing of the role of a basic area involved in language comprehension, namely the auditory cortex. Giovanna Egidi (Trento) will show current insights in an important subprocess of language for which one has use stimuli beyond the sentence level, namely discourse comprehension. Finally, Uri Hasson (Trento) will tie the previous talks together, and will present a new framework for studying the neurobiology of high-level, more naturalistic language use. Experiments employing more naturalistic language stimuli have been dominated by methodological developments, and the outcomes of such studies have not as yet left their impact of the field. In this symposium there will be apt coverage of methods and techniques, but the main focus will explicitly be on a critical discussion of the implications for understanding the neural basis of language. Whether and how our field should make a move towards studying the neural basis of more naturalistic language, is a topic of considerable debate, with fierce proponents as well as opponents among members of the SNL. This symposium tries to kick start discussion about this issue, with four lively speakers presenting their fresh and discussion-provoking ideas to the SNL crowd. The symposium is informative, timely, and importantly aims at sketching the potentially wide-ranging implications of studying the neurobiology of naturalistic language use for our understanding of language and the brain.

What literature comprehension reveals about the neural basis of language

Roel Willems, Donders Institute for Brain, Cognition and Behavior, Radboud University Nijmegen and Max Planck Institute for Psycholinguistics, Nijmegen, The Netherlands

Narratives are important during development, as well as in adult life. An increasingly popular question is how neuroimaging can be used to get better insight into the neurocognitive mechanisms underlying literature comprehension. In this talk I will take the opposite perspective and ask instead how the study of literature comprehension can inform the neurobiology of language. One pressing issue in understanding the neural basis of language comprehension is whether we simulate the content of language in order to understand it. Activation of the motor cortex to action verbs for instance has been taken as evidence in favor of mental simulation to play an important role during language comprehension. Others have instead argued that activation of sensori-motor areas should not be taken as evidence for a simulationist account. Sensori-motor simulation during language comprehension has however almost exclusively been studied at the single word or sentence level, and one striking feature of current research is that sensori-motor (or 'embodiment') effects seem versatile and sensitive to task specifics of the experiment. Recent studies have therefore studied simulation in a more natural habitat, namely that of literary narratives. In this talk I will evaluate how moving from single words / sentences to narratives has increased our understanding of when and what we simulate during language comprehension, with a special focus on individual differences. On a related note I will show that recent neuroimaging work on literature comprehension makes clear that several areas which are not part of the classical language network, are very important during natural language comprehension. Specifically the cuneus and precuneus will be shown to act as hubs in the language network when participants engage in narrative comprehension. The main message of my talk will be that studying narrative comprehension with neuroimaging is a) possible and b) can provide insights into the neurobiology of language comprehension that are often missed in experiments at the level of single words and sentences. I will conclude by arguing that evidence from the more traditional, and

the more naturalistic approaches should be combined in future research.

Echoes of the Spoken Past: Why real-world speech perception is not all that auditory to the brain

Jeremy Skipper, University College London, UK

What do we hear when someone speaks? What does auditory cortex (AC) do with that information? I present neuroimaging data suggesting that the impression that we simply hear "sounds" and that AC is the bottom of feedforward processing hierarchy are the wrong answers to these questions. Rather, when engaged by naturalistic language stimuli, AC is the afferent recipient of multimodal information extracted from preceding discourse content, observable mouth movements, speech-associated gestures, emotional facial displays, written text, and more. Such contextual information seems to be the starting point for the formation of hypotheses that are used to derive predictions about the nature of the information that might arrive in AC. Strong predictions result in a large conservation of metabolic resources in AC, presumably because no further evidence from the auditory world is required to confirm hypotheses. Thus, results suggest that a great deal of what we hear is not sound but, rather, an echo of internal knowledge that shapes and constrains interpretation of the impoverished information reaching AC. That is, hearing speech and AC functioning is a constructive process that relies on multimodal information available during real-world communication.

Making the case for discourse comprehension: Why studying broad contexts matters for a neurobiological theory of language

Giovanna Egidi, Center for Mind/Brain Sciences, University of Trento, Italy

Discourse comprehension requires the integration of incoming information with prior context. A dominant view is that integration at the sentence and discourse levels is essentially the same process, and is mediated by the same neurobiological substrates. We argue here that this view of discourse comprehension should be revised: Discourse context can change the process by which incoming information is integrated and the brain networks recruited. With respect to linguistic context, our fMRI data show that different networks are involved depending on whether incoming information is integrated with recent or distal context, and whether incoming information is coherent with more or less recently introduced content. These results demonstrate that integration is not a unitary process, but its neurobiological instantiation changes with the features of the discourse context. We also show that non-overlapping networks subserve the encoding of language content to memory and that the configuration of these networks depends on the processes performed. Specifically, when the meaning of incoming information is determined only by the most recent context, there is a relatively weak relation between brain activity during comprehension and subsequent memory. In contrast, when the meaning of incoming information depends on integration with a broad context, activity in a bilateral fronto-temporal semantic network is related to subsequent memory. Thus, there is no single system that encodes meaning to memory: The networks that encode content to memory vary depending on the amount of information considered during integration and the ease with which incoming information is integrated with recent or more distal context. We suggest that discourse features such as the length or the complexity of a text may in and of themselves induce activity in different systems: For minimal texts that can be understood by relying on local textual relations, comprehension may rely on a certain system, whereas for texts that require integration over a larger amount of information, comprehension may rely on another. As a consequence, it cannot be assumed that comprehension of different types of texts fundamentally involves the same brain networks. Just as word and sentence processing are usually considered as regulated by different mechanisms, we propose that there are different levels of processing within discourse comprehension itself, as the integration process is highly sensitive to both the amount of prior context that is potentially related to incoming information and even the affective state of the comprehender.

Why we should reconsider the current interpretive framework for the neurobiological basis of language comprehension

Uri Hasson, Center for Mind/Brain Sciences, University of Trento, Italy

The study of the neurobiological organization of language relies on an implicit division of labor: Cognitive theories are tasked with functionally defining or describing what are the language-related computations, whereas neurobiological theories hypothesize how the brain achieves these functions. This research paradigm has been useful when using tightly controlled experimental paradigms that target the neurobiological basis of experimentally isolable processes. However, I suggest that this mode of conceptualization requires a revision, as it fails to achieve a qualitative advance in understanding how the brain performs language comprehension in natural contexts where discourse comprehension (1) relies on continuous updating and revision of prior content, (2) depends on memory and attention operations, and (3) is subservient to various types of internal and external contexts. I argue that we need to revise the taxonomy describing what computations are the building blocks for neurobiological accounts of language. I will draw on recent neurobiological work performed within and outside the domain of language per se, which make the following points and suggests a revision to our thinking about the computations carried out during (naturalistic) language comprehension. 1. Avoiding myopia: We

should consider a more restricted role for 'language content/context' when understanding how language comprehension occurs in the brain. Linguistic context is just another sort of context, and the information being integrated during discourse comprehension is not solely linguistic. Instead, related information from long-term memory, and importantly, non-semantic constraints jointly interact to affect comprehension. Particularly pertinent are EEG studies showing immediate effects of mood and social information on language comprehension, pointing to contextual computations but without priority for linguistic input. In addition, fMRI shows that endogenous filtering for content impacts activity in areas implicated in semantic processing. Postulating a separation between semantic/syntactic operations and such co-occurring contextual filters is not tenable, and results in weaker explanatory power. 2. Avoiding language-essential interpretations: Computations considered as core to linguistic processing (e.g., evaluation of semantic consistency) are more parsimoniously explained by postulating basic computations (a basis set) that are not limited to language comprehension, but that have been documented in so-called language networks. As such: a. Information integration and prediction processes are mediated by systems that operate in the same way for stimuli lacking semantics or syntax. b. Consistency evaluation is mediated by systems active for both linguistic and non-linguistic inputs. c. The tracking of narrative event structure is potentially mediated by lower-level systems that track changes in non-semantic domains. 3. Relaxing the comprehension/memory divide: There is no strict separation between interpretation, memory encoding, and memory retrieval during comprehension, but a tight link between areas mediating memory encoding/retrieval and areas sensitive to semantic manipulations. 4. Letting go of a language network: There is evidence that during discourse comprehension, brain networks are brought online and offline dynamically, depending on the content comprehended or preferences of comprehenders. To summarize: My talk would argue that we should seriously look at current neurobiological findings which together call for a re-evaluation of what are the functional tasks the brain performs during naturalistic language comprehension.

General Information

ATM

Several ATM machines are located within 100 meters of the Beurs van Berlage.

Abstracts

The full text of poster, slide, and sympoisum abstracts can be found in the PDF version of the SNL 2014 Program, which is downloadable from the www.neurolang.org website.

Audio-Visual

A Windows PC and LCD projector will be provided in Effectenbeurszaal for your presentation. You may present from your own computer if you prefer. If you are presenting from your own computer, you must have a VGA port or adaptor to connect to the projector.

You must bring your presentation (PowerPoint and supporting files) on a flash drive if presenting on the provided PC and as a backup if bringing your own computer.

We recommend that you arrive 30 minutes before the start of your session to set up and test your presentation.

Canal Boat Tour

All attendees are invited to enjoy a FREE one hour tour through Amsterdam's historic and enchanting canals on Wednesday, August 27, at the close of the first day of SNL 2014. See page 5 for more information.

Certificate of Attendance

To receive a Certificate of Attendance, please visit the registration desk. If you require any amendments, we will be happy to email/mail a copy after the meeting (info@neurolang.org).

Contact Us

To contact us onsite, visit the Registration Desk, or send an email to info@neurolang.org. We will respond to your email at our earliest opportunity.

Copying, Printing and Office Supplies

The closest print shop is "Printerette" located at Spuistraat 128. They offer self-service copying in color and black & white, as well as large format and poster printing. Printerette also offers a selection of office supplies.

Dining

The Beurs van Berlage Café is open every day from 10:00 am – 6:00 pm, serving sandwiches, soups, salads and an assortment of finger foods.

Disclaimer

The SNL Program Committee reserves the right to make changes to the meeting program at any time without notice. This program was correct at the time of printing.

Duplication / Recording / Photography

Photography, audiotaping, video recording, digital taping or any other form of duplication is strictly prohibited in the sessions and poster areas.

Food Service

Complimentary food and beverage service is available to all registered attendees at the times shown below. All food and beverages are served in Grote Zaal.

Wednesday

Afternoon Coffee, 2:30 – 3:00 pm

Thursday

Coffee Break, 8:00 - 8:30 am
Coffee Break, 10:00 - 10:30 am
Lunch, 12:00 - 1:00 pm
Afternoon Coffee, 3:45 - 4:15 pm

Friday

Coffee Break, 8:00 - 8:30 am
Coffee Break, 10:00 - 10:30 am
Lunch, 12:00 - 1:00 pm
Afternoon Coffee, 4:00 – 4:30 pm

Future Meetings

SNL 2015 will be held October 14-16, 2015 in Chicago, IL, USA.

Internet

Free wireless Internet is available in all Beurs van Berlage meeting rooms.

Lost & Found

Please check with the SNL Registration Desk for lost and found items.

Meeting Rooms

All general sessions (Keynotes, Symposium, Panel Discussion and Slides) are held in Effectenbeurszaal.

All poster sessions are in Grote Zaal.

Messages

A bulletin board will be available for messages and job postings near the SNL Registration Desk.

Mobile Phones

Attendees are asked to silence their mobile phones when in sessions.

Name Badges

For security purposes, all attendees must wear their name badges to all sessions and social functions. Entrance into sessions is restricted to registered attendees only. If you misplace your name badge, please go to the Registration Desk for a replacement.

Onsite Meeting Registration

The SNL Registration Desk is located in the Beursfoyer. The Registration Desk hours are:

Wednesday, August 27, 11:00 am – 5:30 pm
Thursday, August 28, 7:30 am – 7:00 pm
Friday, August 29, 7:30 am – 7:00 pm

Poster Sessions

Posters are located in Grote Zaal. See page 14 for the poster schedule.

Smoking

Smoking is not permitted in the Beurs van Berlage. A smoking area is provided outside the main entrance.

SNL Social Hour

The Beurs van Berlage Café will be open to SNL attendees only for an SNL Social Hour, 7:15 pm – 8:15 pm immediately following the last session on both Thursday and Friday. A no-host bar will be available so that attendees can relax and interact with colleagues and friends.

Speakers

Please ensure that you are available at least thirty minutes before the start of the session. See Audio-Visual for technical information.

Transportation

Arrival by Plane

Amsterdam Airport Schiphol (AMS), the primary international airport in the Netherlands, is located about 20 kilometres from Amsterdam. You can reach the city from Schiphol in less than half an hour by train, taxi or hotel shuttle.

Taking the train is the fastest and most convenient way to get to the city center. The train station is located directly underneath the airport and trains to Amsterdam Central Station run about every 10 minutes. The platforms can be entered at Schiphol Plaza. You can buy train tickets at the yellow ticket machines near the platforms or at the ticket offices, situated close to the red/white-checked cube at Schiphol Plaza. More information on how to travel by train in the Netherlands can be found here link: https://www.ns.nl/en/travellers/home.

Arrival by Train

If you arrive by train, the nearest station to our conference venue and hotels is Amsterdam Central Station. There are frequent train connections from Germany, Belgium, France, UK and Austria.

Local Transportation Tickets

GVB (en.gvb.nl) is the public transport company of Amsterdam providing integrated metro, tram and bus service throughout Amsterdam and its surrounding areas. There are 1 up to 7 days GVB day cards available, which allow for unlimited travel on all trams, buses, metros and night buses of GVB for the duration of the card and provide economical way for visitors to explore the city. Another alternative is the I amsterdam city card for 1 to 3 days unlimited travel with GVB transport and free entry or substantial discount for museums, canal trips etc. The GVB day card and I amsterdam city card can be bought at the GVB ticket machines in the Amsterdam train stations and the Visitors Information Centre at Schiphol Plaza, Arrivals 2 (open daily 7am-10pm) or the GWK Travelex offices at Schiphol airport or in Amsterdam. Note that these cards are not valid for trains.

If you have been in Amsterdam before and used the strippenkaart, we should inform you, that these tickets are no longer valid in the Netherlands.

How to Get Around Amsterdam

Walking: Amsterdam is a wonderfully walkable city with most major sites located in or near the city center.

Biking: Of course biking is the preferred Dutch way to travel. Bicycle rentals are readily available throughout the city. Central Station, Leidseplein and Dam Square are all major rental hubs. Day rates average 8€ with some multi-day rates as low as €4.

Trams: Trams provide the best way to get around in Amsterdam and run regularly until 12:15am.

City Buses: Buses are primarily used to reach outlying suburbs and are also used after the trams have stopped running. Night buses run from midnight until 7am with routes connecting to Central Station, Rembrandtplein and Leidseplein.

Metro: The four metro lines will quickly carry you to the distant suburban areas of the city. Three of the Amsterdam metro lines start their run from the Central Station.

Rental Cars: Although driving in Amsterdam is not recommended, car rental services are readily available at Schiphol Airport. All major agencies are represented including Avis, Budget, Europcar, Hertz, National and Alamo.

Slide Sessions

Slide Session A

Wednesday, August 27, 4:30 - 5:50 pm, Effectenbeurszaal

Speech Processing

Speakers: Kristen Berry, Mirjam J.I. de Jonge, Julius Fridriksson, Joao Correia

4:30 pm

A1 The When and Where of Multisensory Speech Processing *Kristen Berry[1], Valerie Nunez[1], Werner Doyle[1], Callah Boomhaur[1], Lucia Melloni[1,3], Daniel Friedman[1], Patricia Dugan[1], Orrin Devinsky[1], Eric Halgren[4], Thomas Thesen[1,2]; [1]NYU Comprehensive Epilepsy Center, Department of Neurology, School of Medicine, New York University, [2]Department of Radiology, School of Medicine, New York University, [3]Department of Neurophysiology, Max Planck Institute for Brain Research, Frankfurt am Main, Hessen, Germany, [4]Multimodal Imaging Lab, University of California, San Diego*

Converging evidence suggests that audio-visual speech integration occurs "early" in superior temporal regions. However, additional and spatially widespread cortical areas have been identified in audio-visual speech integration, including the inferior frontal gyrus, premotor cortex, and anterior cingulate gyrus. Little is known about the spatio-temporal dynamics of auditory-visual processing and integration across these other areas of cortex. Further, it is unclear if audiovisual speech integration occurs exclusively in speech specific areas or extends to non-speech specific audio and visual regions as well. In this study, we use electrocorticography (ECoG) recordings, which offer improved spatial and temporal resolution over non-invasive human neuroimaging techniques to study auditory-visual speech integration. We recorded intracranial EEG in 13 patients implanted with subdural electrodes for invasive monitoring prior to epilepsy surgery. Patients were presented with words in the form of video images of the lower face and corresponding auditory speech signals. Conditions included auditory (A), visual (V), and audio-visual (AV) speech, as well as sensory control stimuli (Ac, Vc). A non-parametric randomization test with temporal clustering to correct for multiple comparisons was used to compare average high gamma (70-190Hz) power (HGP) band responses for speech specificity (A > Ac; V >Vc) and integration (AV vs. A+V). We recorded from a total of 1627 surface and depth electrodes across the whole brain. Significant responses to experimental stimulation were found in 312 (19%) of the electrodes. Of these, 148 (47%) showed auditory speech-specificity, whereas 34 (11%) showed visual speech-specificity, and 31 (10%) showed integration responses. Of the electrodes showing integration responses, 10 (32%) also showed auditory speech specificity and 16 (52%) showed visual speech specificity. Electrodes were localized to structural MRI scans and grouped based on anatomical parcellations and responsiveness. Both auditory speech-specificity and multisensory integration was highest in posterior superior temporal gyrus (pSTG) where 35% of all electrodes in this region exhibited speech-specificity and 11% showed integration responses. Of the electrodes showing integration in pSTG, a majority (83%) also showed auditory speech-specificity and 50% showed visual speech-specificity. The earliest evidence for auditory speech-specificity occurred in pSTG and supramarginal gyrus (SMG) around 100ms relative to auditory onset. Similarly, the earliest evidence of integration was observed in SMG (104ms) and pSTG (144ms). Late integration responses were found in precentral (244ms) and caudal middle frontal (319ms) regions of the frontal lobe. Integration responses in the caudal middle frontal area occurred exclusively in electrodes selective for visual speech (V>Vc). This study shows that auditory-visual speech integration is a multistage process occurring across widespread cortical areas. Early integration occurs in both speech-specific and non-specific auditory areas of the superior temporal gyrus. This is followed by later integration in frontal areas exclusively involved with visual speech processing and precentral areas involved with both speech-specific and non-specific processing.

4:50 pm

A2 Featural underspecification, not acoustic peripherality, predicts neural mismatch response: evidence from French *Mirjam J.I. de Jonge[1], Paul Boersma[1]; [1]University of Amsterdam, Netherlands*

Different theories predict different levels of perceived contrast between speech sounds based on acoustic or abstract phonological properties. The peripherality hypothesis (PH, Polka & Bohn, 2003) states that listeners are most sensitive to changes towards the periphery of the vowel space. The Featurally Underspecified Lexicon model (FUL, Lahiri & Reetz, 2002) predicts that listeners are most sensitive to changes towards sounds with sparse phonological representations. In this study we investigated which theory best explains listeners' neural mismatch responses (MMN, Näätänen, 2001) to vowels contrasting in place of articulation (PoA) and height. We recorded the EEG of 24 righthanded native monolingual French participants in a passive oddball task while they were watching a silent movie. Stimuli were 150 ms long synthesised tokens of the vowels [y, u, o, ø] with formants 1 to 3 based on the average male formant values reported in Calliope (1989). A session consisted of 4 blocks, in each block one of the vowels served as standard (85%) and the other 3 vowels served as deviants (5% each). Mastoid-referenced ERPs were computed at Fz from 100 ms before to 400 ms after stimulus onset and the MMN was computed as the deviant minus standard ERP in the 100-250 ms interval after stimulus onset. MMNs of all stimulus vowels were compared in three vowel contrast conditions: PoA Only, Height Only, or Both. Overall MMN magnitude was larger in the PoA Only and Both conditions compared to Height Only,

presumably reflecting the larger acoustic differences in these conditions. Additionally, front vowels [y, ø] elicited larger MMNs overall than back vowels [u, o]. There is no evident acoustic origin for this effect but it is predicted by FUL as a consequence of underspecification for [CORONAL] place, while PH predicts the opposite. In PoA Only contrasts, high deviants [y, u] evoke larger MMNs than high-mid deviants [ø, o] as predicted by PH, but in contrasts where vowel height changes (Height Only and Both contrasts) the larger response is elicited by high-mid deviants, as predicted by FUL. A similar trend is observed for PoA: the larger MMN elicited by front vowels is particularly pronounced in PoA and Both contrasts. The occurrence of phonology-based asymmetries precisely in those conditions where the phonological feature in question plays a role shows that the MMN does not just reflect acoustic stimulus properties but also the linguistic analysis that is made in the listener's brain. The lack of interactions between stimulus PoA and Height is further confirmation that the effects are not driven by individual vowels but indeed by their abstract phonological properties. Altogether, our results indicate that early auditory processing is affected by top-down influence of phonological context, and that formulating phonological representations in terms of underspecified features predicts MMN patterns better than the Peripherality Hypothesis.

5:10 pm

A3 Speech entrainment reveals a crucial role of efference copy for fluent speech production *Julius Fridriksson[1], Alexandra Basilakos[1], Leonardo Bonilha[2], Chris Rorden[1]; [1]University of South Carolina, Columbia, SC, [2]Medical University of South Carolina, Charleston, SC*

Speech production is guided by an internal motor plan and on-line auditory and proprioceptive feedback (efference copy) that enables error detection and fine-tuning of speech output. Patients with Broca's aphasia present with impaired speech fluency, characterized as halting speech. Recently, Fridriksson and colleagues (2012) demonstrated that patients with Broca's aphasia can produce fluent speech by mimicking an audio-visual speech model. They referred to this phenomenon as speech entrainment – the patient's speech is pulled along by the external model. Successful speech entrainment suggests that the external audio-visual speech model provides patients an alternative efference copy that guides speech production. This study examined localized brain damage that predicts patients' ability to speak with the aid of speech entrainment. Forty-eight patients with left hemisphere stroke underwent behavioral testing and high-resolution MRI. Behavioral testing: 1. Speech entrainment– Patients attempted to mimic audio-visual speech models that included a speaker producing a one-minute script about a generic topic. Each patient attempted to mimic three separate scripts; 2. Picture description– Patients described pictures including rich visual material. For both the speech entrainment task and the picture description task, the dependent factor was qualified as the number of words produced per minute. Additionally, to determine improvement in speech output with the aid of speech entrainment in comparison to free speech (picture description), standard scores were calculated for the dependent factors in both behavioral tasks. Then, Z-scores for speech entrainment were subtracted from Z-scores for picture description to make a third dependent factor that represented the difference in words per minute produced in each of the two tasks. Each patient underwent MRI (3T) with high-resolution T1 and T2. Lesions were demarcated on T2 images, using the T1 for guidance, in native space. The T1 and T2 images were coregistered and the T1 images were normalized using cost-function masking for the lesion. The T2 images and lesions were yoked into standard space using the T1 transformation matrix. Voxel-wise lesion symptom mapping was accomplished using Non-Parametric Mapping (Rorden et al., 2007) with which independent regression analyses were run for the three dependent measures (permutation thresholding to control for multiple comparisons). Statistically significant results were revealed for the speech entrainment and picture description conditions. Damage to the left middle and posterior portions of the superior temporal sulcus (STS) and the posterior portion of the insula was associated with poor speech entrainment ability. In contrast, impaired speech output in the picture description condition was predicted by damage to the anterior segment of the arcuate fasciculus and the anterior and middle portions of the insula. Damage to the portions of the pars opercularis and pars triangularis was associated with improved speech production with the aid of speech entrainment (uncorrected). Findings suggest that patients who are able to speak more fluently with the aid of speech entrainment have damage to Broca's area. However, patients whose damage involves the STS and surrounding regions cannot mimic audio-visual speech. These results have crucial implications for understanding the role of internal feedback mechanisms (efference copy) in speech production.

5:30 pm

A4 Decoding articulatory features from fMRI responses to speech *Joao Correia[1], Bernadette Jansma[1], Milene Bonte[1]; [1]Department of Cognitive Neuroscience, Faculty of Psychology and Neuroscience, Maastricht University, The Netherlands*

Sensorimotor integration, linking the neural systems involved in perceiving and producing speech, is crucial for verbal communication. Sensorimotor integration has been proposed to not only play an important role in acquiring and monitoring speech production but also in speech perception, via the transformation of acoustic/auditory to articulatory/phonetic features. The cortical locus of this transformation remains unclear however. In particular, methodological constraints related to experimental design and analysis methods have so far prevented the disentanglement of neural responses to acoustic versus articulatory features of speech. In this fMRI study, we use multivariate pattern analysis (MVPA) combined with a classification procedure that

allows discriminating spoken syllables based on their articulatory features independently of the acoustic properties of the individual syllables. Stimuli consisted of 24 consonant-vowel syllables constructed from eight consonants (/b/, /d/, /f/, /p/, /s/, /t/, /v/, /z/) and three vowels (/a/, /i/, /u/) forming two features per articulatory dimension (place of articulation: labial and alveolar; manner of articulation: stop and fricative; voicing: voiceless and voiced). The three different vowels introduced acoustic variability. Ten Dutch subjects were instructed to attend to the syllables presented in a slow event-related fashion (jittered inter-trial-interval, ITI=12-16 s) during a silent scanning gap (time of repetition, TR=2.0 s; time of acquisition, TA=1.3 s). Functional image acquisition was performed on a Siemens TRIO 3 tesla scanner using a multiband-2 sequence (2mm isotropic voxels). After pre-processing and univariate evaluation of the fMRI data we performed multivariate decoding of the articulatory features of the syllables. Decoding of articulatory features relied on the generalization capability across the different articulatory dimensions. For example, we trained a classifier to discriminate between two places of articulation (labial vs. alveolar) for stop consonants and tested whether this training generalizes to fricatives, i.e. decoding place of articulation independent of manner of articulation. The decoding analysis combined a moving surface-based searchlight procedure that selected cortical points based on their spatial proximity and multivariate classification (support vector machines, SVM). Individual results were group aligned based on cortical curvature information (cortex based alignment, CBA), statistically assessed in random-effects (exact permutation testing, $p<0.05$) and corrected for multiple comparisons using cluster-size thresholds (alpha=5%). Decoding place of articulation and manner of articulation independent of acoustic variation was successful in the left auditory (superior temporal gyrus) and somatosensory (inferior post central gyrus) regions. Place of articulation was also significantly decoded in the left supramarginal gyrus, whereas voicing was not possible to decode. These results suggest that the representation of spoken syllables during speech perception includes the transformation of acoustic input to articulatory codes at several levels of the speech processing network, including areas within the left temporo-parietal-junction proposed to subserve sensorimotor integration during speech perception.

Slide Session B

Thursday, August 28, 8:30 - 9:50 am, Effectenbeurszaal

Language Evolution and Brain Structure

Speakers: Benjamin Wilson, Frederic Dick, Uri Hasson, Tristan Davenport

8:30 am

B1 Artificial-grammar learning engages evolutionarily conserved regions of frontal cortex in humans and macaques *Benjamin Wilson[1,2], Yukiko Kikuchi[1,2], Kenny Smith[3], William Marslen-Wilson[4], Christopher Petkov[1,2]; [1]Institute of Neuroscience, Henry Wellcome Building, Newcastle University, Framlington Place, Newcastle upon Tyne, NE2 4HH, United Kingdom., [2]Centre for Behaviour and Evolution, Henry Wellcome Building, Newcastle University, Framlington Place, Newcastle upon Tyne, NE2 4HH, United Kingdom., [3]School of Philosophy, Psychology and Language Sciences, University of Edinburgh, Edinburgh, United Kingdom., [4]Department of Psychology, University of Cambridge, Cambridge, United Kingdom.*

Understanding the evolutionary origins of the neurobiological systems that underpin human language requires us to distinguish between human-unique neurocognitive processes that support language function and domain-general, evolutionarily-conserved processes that are traceable back to our primate ancestors. The human ability to evaluate syntax—the grammatical relations between words in an utterance—is a uniquely human adaptation. However, a key component of this capacity is the ability to learn how sensory elements are appropriately sequenced. Recent behavioural experiments have shown that a range of nonhuman animals, including nonhuman primates, are able to learn the structure of sequences of stimuli generated by artificial grammars and recognise violations of these structures (e.g., Wilson, et al. 2013; Gentner, et al. 2006; Murphy, et al. 2008). However, to determine whether the cognitive processes involved in these tasks are supported by homologous, functionally-conserved brain areas or by different neurobiological substrates, cross-species neuroimaging studies are required. Here, we combined functional Magnetic Resonance Imaging (fMRI) with an artificial grammar learning task to explore the neural distribution of the processes that support the learning of sequences of auditory syllables in Rhesus macaques and human participants. We used an artificial grammar with a forward-branching structure, designed to model certain aspects of the non-deterministic nature of word transitions in natural language (Saffran, et al., 2008), which we have previously demonstrated that monkeys can learn (Wilson, et al. 2013). Both humans and macaques were initially exposed to exemplary sequences of syllables, consistent with the artificial grammar structure. In two fMRI experiments, adult humans (n = 12) and Rhesus macaques (n = 3) were then presented with sequences that were either consistent with the artificial grammar or which violated the structure. In both humans and macaques, region-of-interest analyses revealed that key regions of ventral frontal and opercular cortex were sensitive to violations of the artificial grammar structure (fMRI activity contrast, 'violation' > 'consistent'), but with no significant lateralisation in either humans or monkeys. These areas lie directly ventral to presumed homologues of Broca's territory (Brodmann Areas (BA) 44/45) and have been reported to be associated with sequence interpretation in human language processing. BA44/45 itself was statistically involved in the macaques but not in humans, suggesting that these structurally homologous regions in humans

and in Rhesus macaques are not fully functionally equivalent. Overall, the results suggest that regions in human ventral frontal and opercular cortex have functional counterparts in the monkey brain, providing a critical step in the development of an animal model in which these processes could be studied at the neuronal level. The study further raises the possibility that certain ventral frontal neural systems, which play a significant role in language function in modern humans, originally evolved to support domain-general cognitive processes related to sequence learning and evaluation.

8:50 am

B2 The relationship of auditory language regionalization to myeloarchitectonically and tonotopically-defined auditory areas: axes of stability and variability within and between subjects. *Frederic Dick[1], Marty Sereno[1,2], Rachel Kelly[1], Mark Kenny-Jones[1], Martina Callaghan[2]; [1]Birkbeck College, University of London, [2]University College London*

There are hundreds of fMRI studies on the regionalization of different auditory language tasks. However, it is often unclear how to mesh these findings with what we know about 'primate-general' auditory functional organization, due to lack of clarity about where and what the human homologues of other primates' auditory areas are. How have different aspects of language function colonized the auditory system? Do the observed functional regionalizations have any clear relationship to known indices of auditory cortex organization? How much of 'higher-level' language function preferentially recruits cortex outside of definable auditory areas? Are these extra-auditory 'language' regions associated with any architectonic characteristics? Finally, how variable is the functional regionalization of language (both within participants and across subjects), relative to the variability in basic auditory cortical organization? To begin to address these questions, we scanned healthy adults in multiple structural and functional sessions. We first mapped auditory cortical areas using combined myeloarchitectonic and tonotopic methods (Dick et al., 2012). Cortical myelination was estimated using high-resolution (512um^3) quantitative multiparameter mapping (MPM) at 3T followed by optimized cortical surface reconstruction techniques with adjustment of myelin maps for effects of local cortical curvature and thickness (Lutti et al., 2014). Repeat MPM data were acquired on a subset of participants to evaluate myelin mapping replicability. High-resolution (343um^3) semi-quantitative T1 data were also acquired at 7T on a subset of participants for the same purpose. Finally, a combination of MPM measures were used to create estimates of cortical vasculature that were used in both myelination and functional analyses. Tonotopic maps were derived from multiple phase-encoded runs of band-pass-swept natural sounds or amplitude-modulated white noise. For all participants, tonotopic data were acquired at 3mm^3 resolution at 1.5T with 32-channel head coil. To assess stability of maps, on a subset of participants, tonotopy runs were acquired at 1.5T using 4x acceleration multi-band EPI at 2.3mm isotropic resolution, and at 7T at 1.2mm isotropic resolution. All functional data were also compared with estimates of cortical vasculature derived from MPMs. All participants underwent an additional functional scanning session with standard auditory language tasks, carried out with high-resolution whole-head multi-band-accelerated EPI at 1.5T with 32-channel head coil. All experiments used block design paradigms in multiple runs. To establish the sentence comprehension network and to map general effects of comprehensibility and intelligibility, we compared passive activation to forward, backward, and foreign language sentences. To map regions involved in sentential/syntactic interpretation, we compared active interpretation of sentences varying in syntactic complexity, presented with and without acoustical degradation. Finally, we mapped regions which were modulated by more phonological versus semantic task demands during sentence listening. We found complex patterns of constancy and variability within and across subjects, with remarkable consistency of anatomical and tonotopic fields, more variability in higher-level functional organization, and overlap of tonotopic maps with sentence-level processing. The findings have implications for theories about language evolution and development.

9:10 am

B3 Caudal-rostral and lateral-medial organization of subregions of the supratemporal plane revealed by cortical-thickness covariation patterns *Uri Hasson[1], Pascale Tremblay[2], Isabelle Deschamps[2]; [1]University of Trento, [2]Université Laval*

**Introduction: Cortical thickness (CT) covaries across brain areas in a way that suggests grouping according to common functions (Chen et al., 2008; doi: 10.1093/cercor/bhn003). Applying this concept to the study of supratemporal plane (STP) cortex morphometry, we examined whether distinct factors determine covariation of CT within small-scale sub areas in the STP. Finding a markedly clustered organization, we further showed that whole-brain CT covariation patterns differed for adjacent STP regions. **Methods: Structural images from 33 participants (age range = 18 – 40, median = 24) were collected from two MR centers. Images were processed using FreeSurfer and corrected for topological defects. FreeSurfer's initial 6-region segmentation of STP was manually edited to derive 13 subregions per hemisphere, by further dividing the planum temporale into 3 anterior-posterior sections, transverse temporal sulcus and gyrus into medial/lateral sections, superior temporal gyrus into 3 anterior-posterior sections, and the posterior Sylvian fissure into anterior and posterior portions. For each participant, the meant CT was extracted for each subregion resulting in a 33 [participants] by 26 [regions] matrix. This matrix was analyzed via a hierarchical clustering procedure that utilizes bootstrapping to identify statistically significant clusters. **Results: STP subregions organized into 3 main clusters based on CT

covariation patterns (Figure https://db.tt/ourJ2aL0): 1) a 4-region "anterior association" cluster including anterior STG and PP bilaterally, 2) a "posterior association" cluster including, bilaterally, all PT subregions and lateral TTG, and right lateral TTS, and 3) a bilateral "root/core" cluster including medial TTG, TTS, and the SF, with SFp bilaterally and SFa bilaterally forming 2 internal significant sub-clusters. The bilateral arrangement found for all 3 clusters shows that the correlations cannot be attributed to method-artifact such as inaccurate image registration across participants, which would artificially induce CT-covariation between adjacent subregions within but not across hemispheres. Repeating this analysis after partialling out Age from each region's CT values revealed no significant clusters, suggesting that age plays a central role in this organization. Given this clustering, we examined whether adjacent STP regions also show different structural correlations with areas outside STP, which was indeed the case (Figure https://db.tt/svNAuOuN). Whereas medial TTG was strongly correlated with motor regions, lateral TTS showed correlation with left-hemisphere areas strongly implicated in language comprehension: IFG, SMG, STG, and MTG **Summary and Implications: Our findings indicate that CT covariation patterns partition between STP subregions. Notably, the resulting clusters bear out: 1) The bilateral organization of primary and secondary association cortices of STP; 2) The marked differentiation between regions considered core/root auditory regions (medial TTS and TTG as well as SF) and secondary association regions (PP, PT); and 3) The differentiation between PP and PT, both considered auditory association cortices, but repeatedly implicated in different levels of processing. The whole-brain structural connectivity maps support the notion of sharp boundaries between adjacent STP regions in showing markedly different correlation maps for such regions. In summary, the work shows that CT-correlations can be used to study the organization of STP regions and offers a potential tool for quantifying morphometric organization in different populations.

9:30 am

B4 Effects of childhood language deprivation on picture processing: Insights from adolescent first-language learners *Tristan Davenport[1], Naja Ferjan Ramirez[2], Matthew Leonard[3], Rachel Mayberry[1], Eric Halgren[1]; [1]University of California, San Diego, [2]University of Washington, [3]University of California, San Francisco*

When language is acquired in early life, words are processed primarily in the left hemisphere (LH) perisylvian network, while picture processing shows a right hemisphere (RH) bias. This study examines whether the same neural organization patterns for picture vs. words holds when language is not acquired in early life, but instead in adolescence. This study addresses the extent to which the neural basis of a nonlinguistic semantic process, picture processing, is affected by language experience. We investigated picture vs. word processing in two deaf adolescents who, due to their profound deafness from birth and lack of access to special services and other deaf individuals throughout early childhood, began to learn American Sign Language, ASL, at age 14 via immersion. Prior to learning ASL, they had acquired no spoken, written, or signed language and communicated only in limited pantomime (Ferjan Ramirez et al, 2013a). Using anatomically constrained magnetoencephalography (aMEG) (Dale et al, 2000) with a picture-sign priming paradigm, we studied the adolescents' neural responses to ASL signs after 2.5 years of ASL experience (Time 1; Ferjan Ramirez et al, 2013), and again after 4 years of experience (Time 2; Ferjan Ramirez et al, 2013b). At Time 1, the adolescents exhibited lexico-semantic priming effects in the RH superior parietal, anterior occipital, and dorsolateral prefrontal areas. At Time 2, their brain responses to words they knew well became more concentrated in LH perisylvian cortex. Given that their early deprivation was linguistic in nature, the question is whether their brain responses to pictures would be preserved. MEG recordings taken at Time 1 and Time 2 were analyzed for brain activity related to presentation of the picture primes. During each experimental session, each picture was presented twice (in a novel condition and a repeat condition), allowing us to measure an N400 repetition effect. Event-related fields were calculated by averaging within condition (novel vs. repeated) the changes in magnetic field strength time-locked to picture presentation. Examination of waveforms and source localization maps revealed that in both adolescents, the N400 response to pictures was bilateral. However, in Time 2 relative to Time 1, the N400 repetition effect and the size of the N400 response decreased in LH temporal lobe, but not in RH. This suggests that in the absence of language, pictures serve a symbolic function and thus engage LH perisylvian cortex. At the same time, words may initially be processed in a less symbolic fashion by RH perceptual cortex. Then, as language is learned for the first time in adolescence, language gradually occupies the LH perisylvian network and picture processing is concurrently displaced. References: Ferjan Ramirez, N., Leonard, M., Torres, C., Hatrak, M., Halgren, E., & Mayberry, R. (2013). Neural language processing in adolescent first-language learners. Cerebral Cortex. Doi: 10.1.1093/cercor/bht137. Ferjan Ramirez, N., Leonard, M., Torres, C., Halgren, E., & Mayberry, R. (2013b). Neural language processing in adolescent first-language learners: Longitudinal case studies in American Sign Language. Poster presented at the Neurobiology of Language Conference, San Diego

Slide Session C

Friday, August 29, 8:30 - 9:50 am, Effectenbeurszaal

Combinatorial Processing: Syntax, Semantics, Pragmatics

Speakers: Connor Lane, Monika Mellem, Annika Hultén, Evelina Fedorenko

8:30 am

C1 Sensitivity to syntactic complexity in visual cortex of blind adults. *Connor Lane[1], Shipra Kanjlia[1], Akira Omaki[1], Marina Bedny[1]; [1]Johns Hopkins University*

Introduction: It is widely held that left fronto-temporal cortical regions are uniquely adapted for processing language. Recent research suggests that early blind individuals activate "visual" areas of the occipital lobe during verbal tasks. Do these atypical neural responses reflect language processing? We tested two predictions 1) Occipital responses to language are domain specific, relative to symbolic math and memory for sequences. 2) Occipital responses to language are sensitive to syntactic complexity of sentences. Methods: We acquired fMRI data from early blind and sighted adults while they performed two sentence comprehension tasks. In the first task, participants listened to high and low complexity sentences and answered yes/no questions about them. The high complexity sentences involved a long-distance "movement" dependency in the form of an object-extracted relative clause. In a sequence memory control condition, participants heard lists of non-words followed by short probe lists made up of some of the original non-words. Participants had to decide whether the non-words in the probe lists were in the same order as they had been in the target lists. In the second task, participants listened to pairs of sentences and decided whether they had the same meaning. Sentences within a pair always contained identical words. In each pair, one sentence was in active voice, the other in passive voice. In half of the pairs, the agent-patient relations were the same across the two sentences. In the other half, there was an agent-patient role switch. In a control condition, participants heard pairs of spoken equations (e.g. X-5=7) and were asked to decide if the value of "X" was the same in the two equations. Equations were either easy (single digit) or hard (double digit). fMRI data were preprocessed in FSL and Freesurfer using standard analysis procedures. After fitting a first level general linear model, we defined functional ROIs in each subject's language dominant hemisphere using the sentences > equations contrast from the second task at P<.01. ROIs were defined in inferior frontal cortex (sighted and blind participants) and occipital cortex (blind participants). Parameter estimates for orthogonal contrasts were extracted from each ROI (sentences > non-words; high complexity > low complexity sentences; hard > easy equations). Results: In early blind individuals, regions of occipital cortex 1) responded more to spoken sentences than lists of non-words or math equations, 2) responded more to high complexity than low complexity sentences and 3) were insensitive to math difficulty. We observed a similar response profile in the inferior frontal cortex of sighted (and blind) adults (see also Fedorenko et al., 2011; Ben-Shachar et al., 2003). Conclusion: In early blind individuals, regions of "visual" cortex respond selectively to language and are sensitive to syntactic complexity. We hypothesize that in the absence of vision, language invades cortical territory that is typically devoted to vision. These results illustrate a striking functional flexibility in the human brain during development.

8:50 am

C2 Activity in left anterior temporal cortex is modulated by constituent structure of sentences, but only with social/emotional content *Monika Mellem[1], Kyle Jasmin[1], Cynthia Peng[1], Alex Martin[1]; [1]Lab of Brain and Cognition, NIMH/NIH, Bethesda, MD*

Both social/emotional processing (e.g., Simmons et al., 2010; Olsen et al., 2007) and building of words into phrases and sentences (i.e., constituent structure; Pallier et al., 2011) have been found to activate anterior areas of the temporal lobe. Often these studies have examined phrase-building processing using sentences of a social and/or emotional nature. This raises the question of whether these phrase-building effects in anterior temporal lobe reflect domain-general effects (for all types of content) or are preferably for social and/or emotional sentences and phrases. To investigate this question we modulated syntactic complexity and content type in a 3x4 design. Subjects were presented with trials consisting of scrambled words, 3-word constituent phrases, or 6-word sentences of 4 content types: Social-Emotional, Social, Object, and Jabberwocky (designed similarly to Pallier et al., 2011). A trial consisted of six words, each presented for 300 ms (total trial time was 1800 ms): six single words (1-word condition), two 3-word phrases (3-word condition), or one 6-word sentence (6-word condition). Areas sensitive to increasing complexity should show increasing activity across the 1-, 3- and 6-word trials. Stimuli were matched for total word length, frequency, and concreteness across content types and complexity levels. Additionally, trials were created from separate sentences, so phrases and sentences were never repeated. Jabberwocky trials were created from the real word trials with all open class words replaced by pseudowords of the same length and similar morphology. Forty trials of each condition were presented in a fast event-related design optimally randomized and jittered with the program Optseq2. Subjects were told to silently read the words and respond to the occasional trial instructing them to press a button. Data was acquired on a 7 Tesla Siemens scanner with 1.6 mm isotropic voxels and a TR of 2 seconds. After standard preprocessing and general linear modeling in AFNI, a 2-way ANOVA revealed main effects of Content and Complexity as well as their interaction. Preliminary analyses (n = 9) revealed that the left anterior superior temporal sulcus and gyrus showed a main effect of Complexity ($p<0.01$), and this activity was limited to the Social-Emotional and Social conditions (Content X Complexity interaction; $p<0.01$). Both main effects also overlapped in the left fusiform gyrus (Content: $p<0.05$; Complexity: $p<0.05$). But this area preferred objects (Object > Social-Emotional; $p<0.05$) and showed a Complexity effect for the Object conditions (Object 6-word > Object 1-word; $p<0.09$). In contrast, the triangularis portion of left inferior frontal gyrus (LIFG) was not modulated by content and showed only a main

effect of Complexity ($p<0.01$). Thus, whereas LIFG is involved in domain-general syntactic processing, this process is preferentially linked to social and social-emotional stimuli in left anterior temporal cortex. These dissociations challenge the prevailing claims in the field that the anterior temporal lobe is a general phrase-building area. Instead, phrase-building seems to happen within areas that process domain-specific knowledge.

9:10 am

C3 Effects of sentence progression in event-related and rhythmic neural activity measured with MEG *Annika Hultén[1,2], Jan-Mathijs Schoffelen[1,2], Julia Uddén[1,2], Nietzsche Lam[1,2], Peter Hagoort[1,2]; [1]Max Planck Institute for Psycholinguistics, Nijmegen, The Netherlands, [2]Radboud University Nijmegen, Donders Institute for Brain. Cognition and Behaviour. Donders Centre for Cognitive Neuroimaging, Nijmegen, The Netherlands*

Natural language operates mostly at the level of sentences and beyond (i.e. discourse) and it is therefore imperative that language is also studied at this level and that the cognitive mechanisms underlying it are understood. One cognitive mechanism that is paramount for sentence processing is the ability to unify incoming words with the sentence context. In order to explore the unification process at the neural level, we used magnetoencephalography (MEG) to track the neural dynamics of sentences as they unfold. We quantified both the event-related and oscillatory responses to visually presented words that were either part of a sentence or a word list (scrambled sentence). Data was acquired from 102 participants and analysed from -0.2 to 1.0 s from the onset of each word. We performed source reconstruction with minimum norm estimation (MNE) for the event-related fields and a frequency domain beamformer for the oscillatory responses. In order to track the effect of sentence progression we modelled the event-related and oscillatory responses as a linear function of the ordinal word position and then contrasted the sentence with the word list condition. In the event-related responses we observed a parametric decrease of amplitude (0.4-0.6 s) as the sentence progressed in the inferior frontal area, the middle and superior temporal cortex as well as in the ventral sensorimotor cortex. In the oscillatory responses, a relative bilateral power decrease was observed both in the theta (5 Hz) and beta (16 Hz) bands in occipital, parietal and posterior temporal regions. In other words, in the event-related and the oscillatory domain, classic language areas react to increasing unification constraints towards the end of the sentence by decreased activation for each incoming word. This is also in line with the prediction of the Memory, Unification and Control model for sentence processing (Hagoort, 2005). In the oscillatory domain, the additional effects in non-classical language regions such as the parietal and superior frontal cortex, suggest involvement of executive and/or attentional functions and/or working memory. These are cognitive functions that are part, but not specific to sentence processing and that by being on-going in nature are also less likely to be strictly time-locked. An incremental power increase was observed in the left anterior temporal cortex in both the beta and theta band as well as in the superior frontal cortex (midline) in the beta band. This effect may be a reflection of the information build-up that occurs towards the end of the sentence. Alternatively processing of the word list condition evokes a type processing which is not present to the same degree in sentences. Overall, the results suggest that event-related and oscillatory activity provide complementary measures of brain activation as they did not capture identical spatial or functional properties of the on-going sentence processing. Importantly, the neural dynamics of sentence unification can with both measures be seen to unfold over the course of a sentence.

9:30 am

C4 The cognitive and neural basis of pragmatic processing: A case study of jokes *Evelina Fedorenko[1], Jeanne Gallée[2], Zuzanna Balewski[3]; [1]MGH, [2]Wellesley College, [3]MIT*

Neuropsychological investigations of brain-damaged individuals have long suggested that the right hemisphere (RH) plays an important role in processing non-literal aspects of language (e.g., Critchley, 1962; Eisenson, 1962; Zaidel, 1985; Myers, 1999; Lehman Blake, 2005). For example, patients with RH damage experience difficulties with processing conversational inferences (e.g., Kaplan et al., 1990) – including indirect requests (e.g., Weylman et al., 1989; Stemmer, 1994) and commands (e.g., Foldi, 1987) – humor and sarcasm (e.g., Gardner, 1975), and information conveyed by prosody (e.g., Heilman et al., 1975). However, the RH contains several distinct systems that could be contributing to these deficits, including i) the RH homologues of the high-level language processing regions (e.g., Binder et al., 1997); ii) the RH subset of the system that supports social cognition / Theory of Mind (e.g., .Saxe & Kanwisher, 2003); and iii) the RH subset of the domain-general fronto-parietal cognitive control system implicated broadly in goal-directed behavior (e.g., Duncan, 2010). It is therefore difficult to determine which of these RH systems is the key contributor to our pragmatic abilities. This is especially true given that many pragmatic phenomena are complex and thus possibly require some combination of linguistic, social, and generic problem-solving abilities. We here address this question using the functional localization approach in fMRI. In each participant (n=12), we functionally identified three sets of brain regions using independent "localizer" tasks: i) the language regions, ii) the regions that support Theory of Mind (ToM), and iii) the cognitive control regions. We then examined the responses of these sets of regions in the RH to jokes and their literal controls matched for various lexical-level factors known to affect comprehension, as in (1), using the materials from Coulson & Williams (2005). This approach provides a powerful way to probe the relative contributions of these three systems to pragmatic processing, while avoiding the common problem of reverse inference in fMRI

(Poldrack, 2006, 2011), and yielding high sensitivity and functional resolution (Nieto-Castañon & Fedorenko, 2012). (1) She went on a fourteen-day diet, but she only lost two weeks/ounces. The ToM regions, including the most functionally selective RH ToM region (rTPJ; Saxe & Powell, 2006), responded more strongly during jokes than during the literal control conditions (ps<0.05). In contrast, although the language and the cognitive control regions responded robustly to both jokes and literal controls relative to a low-level baseline, they did not strongly differentiate between these two conditions: a few language and cognitive control regions showed weak preferences for jokes, but if anything, these preferences were stronger in the LH regions. We therefore conclude that the RH deficits in pragmatic processing as well as the left-visual-hemifield or right-ear processing advantages for non-literal aspects of language (Coulson & Lovett, 2004; Coulson & Williams, 2005; Coulson & Wu, 2005) plausibly arise from damage to the ToM circuits rather than the RH homologues of the language regions or the RH subset of the cognitive control system.

Slide Session D

Friday, August 29, 1:00 – 2:20 pm, Effectenbeurszaal

Lexical Processing and Cognitive Control

Speakers: Sara Pillay, Olaf Dimigen, Alexis Hervais-Adelman, Megan Zirnstein

1:00 pm

D1 Category-related semantic impairment: A "chronometric" voxel-based lesion-symptom mapping study

Sara Pillay[1,2], Colin Humphries[1], Diane Book[1], William Gross[1], Jeffrey Binder[1]; [1]Medical College of Wisconsin, [2]RFUMS

Category-related semantic impairments are sometimes observed in patients with focal brain damage, but the underlying mechanisms are not yet understood. Deficits involving knowledge about living things have typically been associated with anterior temporal lobe lesions, and deficits involving tools and other artifacts have been associated with posterior temporal and parietal lesions, but the reliability of these lesion correlations is unknown. Functional imaging studies have yielded inconsistent results except for an association between processing of manipulable object concepts and activation of the left posterior middle temporal gyrus (MTG). We sought to clarify the neural basis of a set of category-related processing impairments using a novel chronometric voxel-based lesion symptom mapping (VLSM) approach in 39 patients with left hemisphere stroke. All patients were right-handed, native English speakers and at least 6 months from stroke onset. Patients performed a word-picture matching task in which they matched a spoken or written word to one of four semantically related pictures taken from the same category. Trials were presented using a computer touch-screen system that recorded reaction time (RT) on each trial. There were 160 trials (80 spoken, 80 written), including 28 Animal, 32 Plant, 24 Body Part, 16 Musical Instrument, 28 Tool (non-musical manipulable objects), and 32 miscellaneous artifact trials. Mean accuracy was 92.7%. Mean RT was computed, for correct trials only, for each category in each patient. VLSMs were conducted for each category using RT for that category as the dependent variable, and mean RT across all other trials as a covariate to control for nonspecific task demands and other sources of between-subject variance. Slowing of RT specific to Plant trials was correlated with damage in the anterior STG and MTG. Slowing specific to Body Part trials was correlated with damage in the angular gyrus. Slowing specific to Musical Instrument trials was correlated with damage to primary sensory-motor cortex in the central sulcus. Slowing specific to Tool trials was correlated with damage to the posterior STG and MTG. No lesion correlates of slowing specific to Animal trials were identified. We hypothesize that the results may reflect differential contributions of embodied sensory and motor knowledge across categories. For example, body part recognition may depend largely on posterior parietal representations of the "body schema," whereas plant recognition depends on visual, olfactory, and gustatory knowledge that converges in the ATL. A surprising result was the correlation between musical instrument recognition and primary sensory-motor cortex integrity, suggesting that recognition of musical instruments may involve low-level motor simulations. RT-based VLSM is a novel and sensitive method for detecting specific processing impairments in the context of relatively high task accuracy.

1:20 pm

D2 The impact of parafoveal preprocessing on natural word recognition: Evidence from fixation-related potentials and RSVP with flankers

Olaf Dimigen[1], Benthe Kornrumpf[1], Florian Niefind[1], Michael Dambacher[2], Reinhold Kliegl[3], Werner Sommer[1]; [1]Humboldt University at Berlin, Germany, [2]University of Potsdam, Germany, [3]University of Konstanz, Germany

Brain-electric correlates of visual word recognition are traditionally recorded during word-by-word presentation (RSVP), a procedure that eliminates important aspects of the normal reading process. Natural reading not only involves self-paced saccadic eye movements, but allows for the parafoveal preprocessing of not-yet-fixated words. At the behavioral level, these benefits of preview are evident in the form of shorter fixation durations on words that were parafoveally visible (rather than masked) during preceding fixations. Goal of this presentation is to summarize several key results from a 6-year research program in which we have combined EEG recordings with simultaneous high-resolution eye tracking in order to study word recognition under natural conditions with and without parafoveal preview. In all experiments, fixation-related brain potentials (FRPs) were recorded during active, left-to-right reading, while the availability of parafoveal information was manipulated using the gaze-contingent Boundary Technique. All experiments also included

a control condition in which the same materials were shown with RSVP (at a reading-like SOA of 280 ms), either with or without the concurrent presentation of parafoveal flanker words. In a first set of experiments, we investigated the timing of N400 word predictability effects in contextually constraining sentences. In a second set of experiments, a simplified list reading paradigm was employed to systematically manipulate the amount and type of parafoveal information, for example by masking a varying number of letters of the upcoming word. We report four basic findings: (1) If parafoveal processing is artificially precluded, topography, size, and time course of N400 effects are strikingly similar in RSVP and natural reading. This similarity also holds for other psycholinguistic EEG effects, such as the effect of a word's lexical frequency. (2) However, under realistic conditions that include a parafoveal preview, the time course of effects can be dramatically shifted. In particular, centroparietal N400 effects arise no later than 120-160 ms after the first direct fixation of an unpredictable word, indicating a comparatively early access to word meaning. (3) The availability of parafoveal information not only changes the timing of effects, but modulates the brain-electric response to words in absolute terms. In particular, the amplitude of the occipitotemporal N1 component is inversely related to the amount of useful information (number of visible word-initial letters) obtained during the preceding fixation – and therefore markedly attenuated during natural reading with a full preview. (4) Qualitatively similar effects of preview are also obtained when flanker words are presented during RSVP. However, our results suggest that this procedure strongly underestimates the size of preview effects, presumably because RSVP does not require the pre-saccadic attention shift that is part of normal oculomotor preparation. Taken together, our results are compatible with the notion that the parafoveal extraction of sub-lexical features (e.g., partial orthographic priming) facilitates the subsequent recognition of words, allowing for a rapid access to a word's meaning once it is directly fixated. The fact that most words are already partially processed by the time they enter foveal vision should be considered if findings from EEG studies are generalized to natural reading.

1:40 pm

D3 A longitudinal fMRI investigation of simultaneous interpretation training

Alexis Hervais-Adelman[1,2], Barbara Moser-Mercer[2], Narly Golestani[1]; [1]Brain and Language Lab, Department of Clinical Neurosciences, University of Geneva, [2]Department of Interpretation, Faculty of Translation and Interpretation, University of Geneva

Learning to become a simultaneous interpreter depends upon acquiring a high degree of control over language management skills, attention and working memory, in order to enable the interpreter to rapidly produce accurate translation in a variety of contexts. Using fMRI we carried out a longitudinal investigation of functional plasticity arising from simultaneous interpretation training. 22 simultaneous interpretation trainees (10 female, 3 left-handed, mean age: 25 years) and 20 multilingual controls (11 female, mean age: 24 years, 5 left-handed) were scanned at two time-points, 14 months apart. Between scans, trainee interpreters received training in simultaneous interpretation, while controls studied unrelated disciplines. All participants reported a high level of proficiency in a minimum of three languages, including English or French. A sparse fMRI paradigm was employed (TA=2s, TR=9s, 3mm*3mm voxels, 3.6mm interslice gap). Participants were presented with sentences, over headphones, during the quiet 7s intervals between scans. On-screen instructions cued participants to listen passively ("PL"), to shadow ("SH", simultaneously repeat the sentence) or to interpret ("SI" simultaneously translate the sentence). Condition order was randomized. Stimuli were quartets of thematically-linked sentences in English or French (participants chose their preferred language). Sentences from every quartet were presented sequentially and within the same condition. Each quartet was followed by a null event. In order to reveal training-related changes in brain responses to SI, the univariate contrasts SH – PL and SI – PL were compared pre- and post-training, between the groups. A significant ($p_{uncorrected}<0.005$) time-by-group-by-condition interaction was observed notably in the right caudate nucleus, as well as in the left inferior frontal gyrus (LIFG), left precentral gyrus (LPCG) and left superior cerebellum. Post hoc pairwise tests revealed that effect in the caudate nucleus and in the cerebellum was driven by a decrease in BOLD response during interpretation in the trained but not the control group, suggesting training-related change. However, in LIFG and LPCG, change in BOLD response during SI in trained participants was not significant. We also carried out a multivariate pattern classification analysis. A linear SVM classifier was trained to classify the group (simultaneous interpretation trainees or controls) to which belonged difference maps (Scan 2 – Scan 1) of SI activation. Balanced classification accuracy was 68.9%, significantly above chance ($p=0.022$), indicating an effect of training on the brain network recruited during SI. The right caudate and left cerebellum exhibit expertise-related functional changes, and are less engaged during simultaneous interpretation after training. This is consistent with existing studies of training-induced functional plasticity, and with the notion that expertise-contingent automatisation of task-performance reduces demands on cerebral resources. Expertise requires the ability to rapidly and dynamically respond to various inputs within the trained domain, and depends on the flexible deployment of acquired action repertoires. The caudate nucleus is a plausible candidate for such a managerial role, being involved in action pattern selection and refinement, in predictive systems and in the control of goal-directed action. Our findings add further weight to the idea that the exercise of multilingual language control shapes brain networks involved in executive control.

2:00 pm

D4 The Dual Roles of Cognitive Control and Verbal Fluency in Prediction Generation and Recovery: Evidence from Monolinguals and Bilinguals

Megan Zirnstein[1], Janet G. van Hell[1,2], Judith F. Kroll[1]; [1]Pennsylvania State University, [2]Radboud University, Nijmegen

The ability to accurately predict upcoming information, in particular semantic features of words, has been shown to be highly beneficial for readers, often leading to lower amplitude N400 event-related potential (ERP) effects (Federmeier, 2007; van Berkum 2008). This suggests that successful prediction reduces subsequent processing load, and may therefore free up cognitive resources for other, more demanding tasks. This is especially relevant when considering bilinguals who are attempting to read or communicate via their second language (L2), which has been shown to induce greater cognitive demands than that in the L1 (e.g., Hasegawa et al., 2002). Research has also shown that monolingual readers tend to produce a delayed frontal positivity in response to unexpected but plausible words in contexts where prediction is likely to occur (Federmeier et al., 2007). This effect may be the result of difficulty with inhibiting a previously formed prediction and/or in mediating the conflict between two competing representations (i.e., the prediction and the unexpected word). If this is true, then cognitive control ability (in particular inhibitory control) should predict the magnitude of this effect, possibly more strongly for bilinguals reading in the L2. We therefore tested English monolinguals (Experiment 1) and Chinese-English bilinguals (Experiment 2) in an online sentence reading task while their EEG was recorded. ERPs were time-locked to expected or unexpected target words that were embedded in high or low semantically constraining contexts. Participants also completed a battery of behavioral tasks, including a measure of inhibitory control ability (the AX-CPT; Cohen et al., 1999) and a verbal production fluency task (in both the L1 and L2 for bilinguals; e.g., Luo et al., 2010). Results from Experiment 1 showed that, for monolingual readers, having lower inhibitory control ability resulted in the greatest unexpected word cost (i.e., when unexpected words occurred in highly semantically constraining contexts), resulting in a greater frontal positivity in comparison to expected targets. High control monolinguals, in contrast, showed no such effect. In Experiment 2, these findings were replicated for bilinguals reading in their L2 (English). However, control ability also interacted with L1-L2 verbal production fluency dominance. Bilingual readers who were higher in cognitive control ability showed no difficulty with unexpected target words. Bilinguals who were lower in inhibitory control only produced a frontal positivity if they were relatively high in L1 fluency, whereas those with low L1 and L2 fluency instead produced a significant N400 effect. These data suggest that the repercussions for prediction recovery are evident in both monolinguals and bilinguals, and that these ERP costs may be the result of difficulty with inhibition and/or conflict resolution. In addition, it appears that prediction generation, especially in the L2, may require a high level of production ability, without which individuals rely on more bottom-up strategies when reading for comprehension.

Poster Schedule

Poster sessions are scheduled on Wednesday, August 27 through Friday, August 29. Poster sessions are 2 hours, and presenting authors are expected to be present the entire time. Posters are located in Grote Zaal. You may post your materials on the board assigned to you starting at the scheduled "Set-up Begins" time shown below. Please note that any posters not removed by "Teardown Complete" time will be discarded. Do not leave personal items in the poster room.

Date & Time	Posters	Topics
Poster Session A Wednesday, August 27 2:30 - 4:30 pm Setup Begins: 12:30 pm Teardown Complete: 6:30 pm	A1 - A5	Methods
	A6 - A9	Gesture, Prosody, Social and Emotional Processes
	A10 - A20	Auditory Perception, Speech Perception, Audiovisual Integration
	A21 - A24	Orthographic Processing, Writing, Spelling
	A25 - A28	Phonology, Phonological Working Memory
	A29 - A40	Language Development, Plasticity, Multilingualism
	A41 - A53	Lexical Semantics
	A54 - A58	Discourse, Combinatorial Semantics
	A59 - A70	Syntax, Morphology
	A71 - A76	Control, Selection, Working Memory
	A77 - A86	Language Disorders
Poster Session B Thursday, August 28 10:00 am - 12:00 pm Setup Begins: 8:00 am Teardown Complete: 1:00 pm	B1 - B6	Gesture, Prosody, Social and Emotional Processes
	B7 - B17	Auditory Perception, Speech Perception, Audiovisual Integration
	B18 - B24	Motor Control, Speech Production, Sensorimotor Integration
	B25 - B37	Language Development, Plasticity, Multilingualism
	B38 - B48	Lexical Semantics
	B49 - B62	Discourse, Combinatorial Semantics
	B63 - B73	Syntax, Morphology
	B74 - B85	Language Disorders
Poster Session C Thursday, August 28 3:45 - 5:45 pm Setup Begins: 1:00pm Teardown Complete: 7:15 pm	C1 - C5	Methods
	C6 - C14	Auditory Perception, Speech Perception, Audiovisual Integration
	C15- C20	Motor Control, Speech Production, Sensorimotor Integration
	C21 - C27	Orthographic Processing, Writing, Spelling
	C28 - C32	Phonology, Phonological Working Memory
	C33 - C35	Signed Language
	C36- C47	Language Development, Plasticity, Multilingualism
	C48 - C56	Lexical Semantics
	C57 - C62	Discourse, Combinatorial Semantics
	C63 - C72	Syntax, Morphology
	C73 - C78	Control, Selection, Working Memory
	C79 - C86	Language Disorders
Poster Session D Friday, August 29 10:00 am - 12:00 pm Setup Begins: 8:00 am Teardown Complete: 1:00 pm	D1 - D6	Gesture, Prosody, Social and Emotional Processes
	D7 - D18	Auditory Perception, Speech Perception, Audiovisual Integration
	D19 - D26	Motor Control, Speech Production, Sensorimotor Integration
	D27 - D35	Language Development, Plasticity, Multilingualism
	D36	Orthographic Processing, Writing, Spelling
	D37 - D44	Language Development, Plasticity, Multilingualism
	D45 - D60	Lexical Semantics
	D61 - D65	Discourse, Combinatorial Semantics
	D66 - D73	Syntax, Morphology
	D74 - D86	Language Disorders
Poster Session E Friday, August 29 4:00 - 6:00 pm Setup Begins: 1:00 pm Teardown Complete: 7:00 pm	E1 - E13	Auditory Perception, Speech Perception, Audiovisual Integration
	E14 - E20	Motor Control, Speech Production, Sensorimotor Integration
	E22 - E27	Orthographic Processing, Writing, Spelling
	E28 - E31	Phonology, Phonological Working Memory
	E32 - E43	Language Development, Plasticity, Multilingualism
	E44 - E55	Lexical Semantics
	E56 - E60	Discourse, Combinatorial Semantics
	E61 - E72	Syntax, Morphology
	E73 - E77	Control, Selection, Working Memory
	E78 - E85	Language Disorders

Poster Session A

Methods

A1 Testing the validity of wireless EEG for cognitive research with auditory and visual paradigms

Ethan Weed[1], Alexandra R. Kratschmer[1], Michael N. Pedersen[1]; [1]Aarhus University

One of the challenges in collecting ERP data is the time-consuming process of fitting caps and prepping electrodes with gel. This can be particularly true when working with clinical populations, where efficiency in data collection is important. Recently gel-free wireless headsets designed for brain computer interface have advanced to the point where they offer an attractive alternative to traditional EEG methods. However, although research exists suggesting that some of these devices can register the robust P300 component (e.g. Duvinage et al, 2012), little is known about their validity for earlier and smaller cognitive components. To test the feasibility of these headsets for cognitive research, we compared performance of the Emotiv Epoc wireless headset (EM) with Brain Products ActiCAP (BP) active electrodes on two well-studied components: the auditory mismatch negativity (MMN) and the visual face-sensitive N170. We collected ERP data from 32 healthy adult participants who performed passive listening (MMN) and passive viewing tasks (N170). Because of recording error, data from only 30 participants were available from the Brain Products MMN session, and 25 from the Emotiv N170 and the Brain Products N170 sessions. Data were collected first with Emotiv, and then with the Brain Products electrodes. For the MMN, participants heard 6-8 standard tones (440 Hz) followed by a deviant (340 Hz or 640 Hz). For the N170, participants viewed images of 20 unknown faces and 20 houses in randomized order. The MMN is typically measured at frontal midline electrodes (Fz and Cz). Because the electrode layout in the Emotiv does not allow this, we measured the MMN in the Emotiv at neighboring electrodes F3 and F4, and at F3, F4, and Fz in the Brain Products electrodes. The traditional N170 sites, P7 and P8, are available in both Emotiv and Brain Products layouts, so we used these in our analysis. Both MMN and N170 were measured as difference waves (MMN: deviants - standards, N170: faces - houses). Significance was measured with one-sample t-tests at each of the chosen electrodes. The MMN was visible in data collected from both systems. T-test results were as follows: F3 (BP: $t(29) = -4.2$, $p = 0.0002$; EM: $t(31) = -2.4$, $p = 0.023$) , F4 (BP: $t(29) = -4.1$, $p = 0.0003$; EM: $t(31) = -3.6$, $p = 0.001$) and Fz (BP: $t(29) = -2.4$, $p = 0.022$). The N170 was visible in the Brain Products data, but not in the Emotiv data. T-test results were as follows: P7 (BP: $t(24) = -4.2$, $p = 0.0003$; EM: $t(24) = -0.9$; $p=0.34$) P8 (BP: $t(24) = -3.7$, $p = 0.001$; EM: $t(24) = -0.2(24)$, $p = 0.86$). We successfully measured a comparable MMN response in a wireless headset and a traditional electrode set. The N170 component, however, was only visible with traditional electrodes. Our data suggest that, depending on the paradigm used, wireless headsets like the Emotiv may be a viable alternative to traditional ERP collection methods. However, issues like low sampling rate and limited scalp coverage currently still limit their broad applicability.

A2 A data-driven parcellation of structural language networks using probabilistic tractography and automated meta-analysis

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Aims: Define language-relevant cortical areas and white matter connectivity networks using diffusion MR tractography and automated fMRI meta-analysis. Introduction: Through databases such as BrainMap (brainmap.org) and Neurosynth (neurosynth.org), instant topic-based meta-analyses are possible using the large scale of data available from already published fMRI research. These approaches allow the identification of functional networks support different language systems but the anatomical connections supporting these systems are less well understood. Recently, we have established a technique using independent component analysis (ICA) to parcellate cortical areas according to their diffusion-tractography based connectivity. The advantage of this approach is a simultaneous parcellation of both likely white matter bundles and their cortical / subcortical origin. Here we use this approach to parcellate cortical and subcortical grey matter and identify structural networks associated with different language functions. Methods: Diffusion weighted images were downloaded for 102 adult subjects (40 female, mean age 33.9 years) from the International Neuroimaging Data-sharing Initiative (Rockland Sample, Nooner et al, 2012). After standard preprocessing and image registration using the FSL toolkit, probabilistic tractography was performed from a large mask of cortical grey matter. This mask was then parcellated according to tractography-derived structural connectivity using a data-driven technique; independent component analysis (ICA, O'Muircheartaigh et al, 2011). Using a freely available meta-analysis tool, the resulting grey matter parcels and white matter bundles were categorized according to their association to language-related topics (reading, phonological fluency, semantic fluency) as well as non-language topics (faces, spatial attention) Results: The ICA decomposition of tractography patterns successfully decomposed multiple known white matter bundles (e.g. IFO, ILF, SLF, Arcuate etc), but importantly also identified cortical regions where these bundles originate. Using the neurosynth package we demonstrate that different networks of grey matter regions and their white matter connections relate to differing gross subcategories of language. These networks were clearly different from the control non-language categories. Though there is some overlap in grey matter parcels corresponding to differing language functions, their overall white matter connectivity was different. Discussion: The overlap of these structural regions and connections, derived in a data-driven fashion, correspond well to know functional classifications in language studies. In this way, we try to provide both a hodological and topographic mapping of the structural networks involved in specific language

abilities (Benedictis & Duffau, 2011) The white and grey matter regions associated with different functions were qualitatively similar to critical areas identified in lesion studies so future work will investigate the prognostic utility of these images to predict specific and general post-insult language dysfunction.

A3 Word frequency in context shows differential effects on fixation-related potentials and eye fixations

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Modality-specific changes in the topography of the N400 have been repeatedly reported despite the fact that the N400 is assumed to reflect modality-independent linguistic processing in other cases (e.g. Holcomb & Neville 1990; Kutas & Federmeier 2011). Here, we investigate whether the N400 might also show modality-specific adjustment in the treatment of non-sensory bottom-up information – particularly focused on a well-known methodological discrepancy between ERPs and eye fixations in reading: while lexical frequency enhances N400 amplitudes for infrequent words presented in lists or at the beginning of sentences (e.g. Münte et al. 2001), it has no such influence with increasing contextual information. That is, with unfolding sentence context, the N400 amplitude appears to be solely dependent on a word's predictability, as measured via cloze probability (Van Petten & Kutas 1990,1991). Eye fixations of readers, by contrast, have consistently revealed robust and independent effects of both frequency and predictability (e.g. Rayner et al. 2004). We aimed to investigate whether sensitivity of the N400 to lexical frequency in context might change in natural reading due to different task demands induced by oculomotor control. The present experiment therefore used a concurrent EEG-eye movement experimental setup to measure fixation-related potentials (FRPs) and fixation durations within the same group of participants. Thirty-eight native speakers of English read 160 single sentences for comprehension while their EEG and eye movements were recorded. Using a 2x2 design, 80 frequent and 80 infrequent target words were embedded in a unique sentence frame, which either did or did not make the target word predictable. Frequencies were based on the SUBTLEX corpus (Brysbaert & New 2009) and predictability scores were collected with a cloze task. FRPs and fixation durations were analyzed for the first fixation on the target as well as for the prior fixation. Analyses for the FRPs were restricted to posterior electrodes as these are least affected by ocular artifacts in the EEG signal (Picton et al. 2000). Our findings confirm the previously reported lack of an N400 frequency effect when a word is preceded by substantial sentence context. In fact, frequency did not seem to influence any part of the FRP signal elicited by foveal or parafoveal processing (first fixation and prior fixation). High predictability from context, by contrast, led to reduced N400 amplitudes for target words and also enhanced the preceding positivity (P200). All predictability effects were triggered by the first fixation on the target. The eye movement results replicated the independent main effects of both factors: the duration of the first fixation on the target was longer for low frequency or unpredictable words, with these effects being strictly additive. In replicating this well-known discrepancy between methods, we can rule out explanations based on the unnatural reading situation in previous studies using rapid serial visual presentation. The cross-method comparison suggests that N400 and eye movement effects may reflect only partly overlapping aspects of word recognition and that lexical frequency is more important in oculomotor planning than in modality-independent semantic processes in language comprehension.

A4 High-definition transcranial direct current stimulation of single word processing

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Introduction. High-definition transcranial direct current stimulation (HD-tDCS) is a brain stimulation method that modulates neuronal excitability by transmitting low current through multiple electrodes placed on the scalp. HD-tDCS is designed to exceed other brain stimulation methods in safety and focality, increasing its potential as a clinical tool. The present study investigated whether HD-tDCS can modulate language processing and therefore potentially serve to complement treatment for neurogenic language disorders such as aphasia. We were particularly interested in the processing of verbs with different levels of argument-structure complexity, as this may underlie sentence processing mechanisms. Methods. Twenty-one healthy participants received three types of HD-tDCS stimulation on separate days: anodal, cathodal, and sham (continuous stimulation bypassing the cortex). In standard tDCS applications, anodal current direction is generally excitatory, while cathodal is inhibitory to the activation thresholds of underlying neurons. However, in HD-tDCS, the electrode setup is modeled to provide the maximum coverage and focality to a specific cortical area, which means that the current flow is not necessarily 'anodal' or 'cathodal' and that excitatory vs. inhibitory effects are less predictable. We stimulated left Broca's area in 10 participants and left angular gyrus in 11 participants. Immediately after each stimulation session, participants performed two single-word processing tasks: picture naming and lexical decision. Stimuli included verbs of different argument structure complexity (one-, two- and three-argument verbs) and nouns. Results. Analysis of the naming task data is in progress and will be available at the time of presentation. For lexical decision, accuracy and reaction times were analyzed at the individual and group level using a general linear model approach, with stimulus condition, stimulation type and session order as independent variables. Group level analysis yielded no significant effect of stimulation. However, individual level analyses reveal that within 10 participants with Broca's area stimulation, two showed significant effects of stimulation ($\alpha < .05$; not accounted for by order/practice effects). Within the 11 participants who received stimulation of the angular gyrus, seven showed significant effects of stimulation, and six showed a significant interaction between stimulation

and stimulus condition, suggesting that stimulation differently affected the processing of different stimulus types (non-words, nouns, verbs of different argument structure). The nature of stimulation effects (whether anodal/cathodal stimulation reduced or increased reaction times and what stimuli conditions were driving the interaction) showed great individual variability. Conclusions. In a survey, participants gave low ratings of experienced pain and unpleasantness on a 1-10 scale (means 2.6 and 2.8 at the start of stimulation and 1.0 and 1.1 at the end), indicating high tolerability of HD-tDCS and suggesting a potential for routine clinical use. Eight out of 21 participants (chance level) correctly guessed which session applied placebo stimulation, indicating sufficient blinding, which is an improvement over what is generally seen with standard tDCS. We preliminarily suggest that HD-tDCS of the left angular gyrus can modify the speed of single-word processing in healthy individuals. However, the direction of effects shows great individual variability, possibly partly due to individual differences in the gyral structure, warranting further research.

A5 Neural signatures of incremental text processing correlate with word entropy in a natural story context

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Humans understand the world by incrementally integrating sensory observations into a rich model based on prior experiences (Friston, 2005). Researchers of language have identified brain signatures (e.g. the N400) of the fit of a word with its context, with more context providing a better fit (Van Petten & Kutas, 1990; George, Mannes, & Hoffinan, 1994). Due to methodological and computational constraints, previous research has focused on categorial estimators of semantic association and activation in artificial contexts. Recently, researchers have increasingly called for natural contexts (Small & Nusbaum, 2004) and the application of powerful statistical tools on rich corpora has demonstrated the possibility of continuous estimators. Here, we investigate the emergence of meaning in a non-categorical, natural, coherent design. Extending prior work on text predictability using measures like cloze probability, we used Shannon entropy as a predictor. Shannon entropy expresses the average amount of new information each item contributes, which should correlate well with an index of brain activity necessary to process this new information. Specifically, the individual contribution to the total entropy of its type served as the predictor for each token, using a data-driven semantic approach different from previous work using structural-syntactic entropy as a parsing oracle (cf. Hale 2006; Levy 2008). The entropy predictor thus models the overall expectedness of a given word in the entirety of the text. Frequencies from the Leipziger Wortschatz (Quasthoff, Richter, & Biemann, 2006) served as a baseline. EEG data was acquired from 52 subjects passively listening to a short story (Max Dauthendey 1923: Der Kuli Kimgun). EEG was cleaned of artefacts using automatic ICA processing (Winkler et al., 2011) and 52*1682 segments extracted, time locked to content words. We examined single trial mean amplitude over posterior brain regions in the time window 300-500ms, known to indicate meaning construction (Kutas & Federmeier, 2011). Linear mixed effects models provide a way to compare model predictors to single trial human EEG data (Alday, Schlesewsky, & Bornkessel-Schlesewsky, 2013). We compared our entropy predictor to logarithmically binned corpus derived word frequency and examined their interaction. Frequency class was the stronger predictor (larger t-values) but the overall model fit for the entropy predictor was better as measured by AIC. Moreover, in further models with an interaction term for token index (linear position in the text), the entropy model substantially outperformed the frequency model. Tellingly, the frequency model was significantly improved by the entropy predictor but not vice versa. In line with previous research, baseline activation, as given by frequency estimation, accounts for broad activation patterns. However, the adaptive brain aligns itself with the local context, which entropy better models. This is most clearly seen in the significant interaction between entropy and index: the further into the story a token is, the more aligned the actual context is with the global context used in the entropy calculation. During the processing of natural stories, the N400 is initially determined by nonspecific priors (e.g. frequency), but, as a sufficient context is incrementally constructed, increasingly reflects local, informed expectability.

Gesture, Prosody, Social and Emotional Processes

A6 Prosody conveys speakers' intentions: Acoustic cues for speech act perception

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Recent years have seen a major change in views on language and language use. Traditionally taken as a conventionally coded string of symbols transferring information between sender and receiver, language is more and more recognized as an intentional action (Grice, 1957). In the form of speech acts (Austin, 1962; Searle, 1969), language expresses the speaker's communicative intents designed to shape the interlocutor's conversational reactions. The present study aimed to investigate in how far prosody conveys the speaker's intents and which acoustic properties of the speech signal are responsible for the correct understanding of different speech acts. Therefore, we adopted an approach from emotional prosody research (Banse & Scherer, 1996) combining behavioural ratings and acoustic analyses on a novel set of single word utterances intoned to express different intentions. The German words "Bier" (beer) and "Bar" (bar) and the non-words "Diem" and "Dahm" were recorded from four (two female) speakers expressing six different speech acts in their prosody – criticism, wish (expressives), warning, suggestion (directives), doubt, and naming (assertives). Acoustic measures for pitch, duration, intensity, and spectral features were

extracted with PRAAT and subjected to a discriminant analysis that accurately classified the stimuli according to their intended speech act category. Furthermore, a behavioural classification task for the six speech act categories showed that listeners were able to identify the prosodic differences and to recognize the correct intention of the speaker. Multiple regression analyses on participants' ratings of the different intentions and the acoustic measures are assumed to further identify patterns of physical properties that determine the categorization of the prosodic intentions, as has been established for emotional prosody (Sauter et al., 2010). Our results demonstrate that prosodic cues convey sufficient detail to classify short (non-)word utterances as different speech acts, at acoustic as well as perceptual levels. Future investigations will be concerned with the neural substrates of this interpersonal role of prosodic comprehension.

A7 Investigating the acoustic and emotional properties of evoked and emitted laughter. *Carolyn McGettigan[1], Nadine Lavan[1], Eamonn Walsh[2], Zarinah Agnew[3], Rosemary Jessop[4], Sophie Scott[4]; [1]Royal Holloway, University of London, [2]King's College, University of London, [3]UCSF, [4]University College London*

Introduction: In a recent functional imaging study (McGettigan et al., 2013), we reported that the left and right superior temporal gyri showed greater responses during passive listening to laughter produced during a state of genuine amusement (Evoked), compared with acted laughs (Emitted). We suggested that this response profile in bilateral auditory cortex reflected acoustic differences between the two laughter types, where emotionally authentic expressions are more engaging to the auditory system. Here, we present a detailed acoustic and behavioural investigation of these stimuli, as well as a new analysis of how the neural responses to laughter are paramterically modulated by the acoustic and emotional properties of the individual tokens. Method and Results: Twenty-one evoked and 21 emitted laughter samples (described in McGettigan et al., 2013) were presented to 20 adult listeners (10 F; mean age 25.1 years, range 20-46), who rated the stimuli on 7-point Likert scales for perceived Arousal, Valence, Emotional Contagiousness, and Behavioural Contagiousness. The evoked laughs were rated as significantly more positively valenced ($p < .001$) and more contagious (both emotionally ($p < .001$) and behaviourally ($p < .005$)) than the emitted laughs. From each of the evoked and emitted laughs, we extracted acoustic measures of duration (total duration, average burst duration), fundamental frequency (F0; mean, standard deviation), spectral properties (spectral centre of gravity, harmonics-to-noise ratio), and mean intensity. The evoked laughs had significantly higher mean F0 ($p < .001$), a greater proportion of unvoiced content ($p < .05$) and shorter mean burst duration ($p < .001$) than the emitted laughs. A discriminant analysis including all of the acoustic predictors was able to classify the laughs with very high accuracy (95.2%). Multiple regression analyses, using the acoustic properties above as independent variables and each of the emotional ratings scales as dependents, revealed constellations of significant predictors explaining 58-91% of the variance in perceived arousal, valence, and emotional and behavioural contagiousness, within and across the laughter categories. Finally, parametric modulation analyses of the neural responses to laughter (in 21 independent participants; see McGettigan et al, 2013), revealed that token-by-token variation in the acoustic and emotional properties of laughter (both within and across the evoked and emitted sets) modulated the signal in sites largely restricted to the superior temporal gyrus in the right and left hemispheres of the brain. Conclusions: Laughter produced under genuine and acted emotional states differs both acoustically and perceptually, where there is evidence for a strong behavioural relationship between the acoustic properties of individual laughs and listeners' emotional evaluations of them. The neural responses to variation in the acoustic and emotional properties of laughter tokens are focussed in auditory cortex, further suggesting that perceiving emotion in the voice requires the detection of characteristic acoustic markers of emotion-related state changes in the vocal tract. The medial prefrontal responses to emitted laughter reported in McGettigan et al. (2013) may indicate a later stage in the evaluative process, which may become more strongly engaged when these key acoustic markers of emotional authenticity are absent or ambiguous.

A8 Profiles of age-related structural decline and stability in neuroanatomical systems supporting vocal emotion processing *Cesar Lima[1,2], Nadine Lavan[3], Samuel Evans[1], Zarinah Agnew[5], Pradheep Shanmugalingam[1], Jane Warren[4], São Luís Castro[2], Sophie Scott[1]; [1]Institute of Cognitive Neuroscience, University College London, [2]Center for Psychology, University of Porto, [3]Royal Holloway, University of London, [4]Faculty of Brain Sciences, University College London, [5]UCSF School of Medicine*

Humans use a multitude of nonverbal cues to infer others' emotional states in social interactions, such as facial expressions, body postures, touch, or vocal information. Being effective at perceiving these cues is crucial for everyday interpersonal functioning at any age – is has been shown that emotion recognition competence is associated with personal and social adjustment. Although a number of studies report age-related decrements in emotion recognition accuracy, most of these studies resort to still facial expressions. Much less is known about the auditory expression of emotions and, crucially, it remains to be determined whether and how behavioural decrements in emotion recognition result from age-related grey matter loss. In this study, we focussed on nonverbal emotion vocalizations, such as laughs, screams and sighs, and examined how the processing of these emotion signals change across the adult life span at behavioural and neuroanatomical levels. A cross-sectional sample of 61 healthy adults aged between 20 and 81 years was tested (younger, 20-39 years, n = 22; middle-aged, 40-59 years, n = 21; older, 60-81 years, n = 18). Participants were also assessed for hearing thresholds and general cognitive functioning. The emotional stimuli consisted of a set of vocalizations previously validated to communicate two

positive emotions, amusement and pleasure, and two negative ones, disgust and fear. A multidimensional rating procedure was implemented in which participants rated how much each vocalization expressed the intended emotion as well as all the other emotions. As expected, increasing age was associated with decrements in ratings and in a derived measure of accuracy. These decrements were similar across positive and negative emotions, and they were not mediated by hearing and cognitive losses. Participants also underwent a magnetic resonance imaging (MRI) scan; T1-weighted volumetric images were acquired in a Siemens Avanto 1.5 Tesla system, including 32-channel head coil. Voxel-based morphometry was performed and multiple regressions were conducted to assess the relationships between individual differences in grey matter volume, ageing, and individual differences in emotion recognition (statistical maps were thresholded at $p < .005$, cluster corrected with Family Wise Error correction of $p < .05$, while accounting for non-stationary correction). Age-related grey matter decrements in the right middle temporal gyrus and in the left middle orbital gyrus were found to mediate behavioural decrements in emotion recognition – the magnitude of grey matter decrements in these regions correlated positively with the magnitude of decrements in emotion recognition at older ages. On the other hand, clusters in the left and right inferior frontal gyri, right hippocampus, right amygdala, and left inferior parietal lobe correlated negatively with behavioural performance in emotion recognition, similarly in younger and in older adults. These results are discussed in relation to theoretical perspectives on emotional ageing, particularly positivity effects, general cognitive decline, and neurocognitive decline.

A9 Perceptual and Physiological Differences Between Genuine and Posed Emotional Vocalizations

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The ability to understand the thoughts and emotions of others is an important human behaviour. One aspect of this ability may be the skill to detect whether emotional expressions reflect a genuine emotional state or not. Indeed, a failure to distinguish genuine expressions from posed ones (i.e., non-genuine) may put one at a disadvantage in social interactions. In this study we recorded six speakers (three male) producing genuinely felt and posed positive (laughter) and negative expressions (crying), and asked a separate group of listeners to rate the recordings on a number of different scales. The emotional sounds were rated on 7-point Likert scales for their perceived authenticity, the frequency with which participants estimated they could encounter the sounds in everyday life, and the degree to which they perceived the speakers were in control of the expression. Eleven adult participants (nine female) rated 50 genuine and 50 posed laughs and 50 genuine and 50 posed cries. The ratings data were submitted to 2x2 repeated measures ANOVAs with factors: expression (positive/negative) and authenticity (genuine/posed). Authentic positive expressions were rated to be higher in authenticity than negative ones ($F(1,49)=102.305$, $MSE=0.062$, $p<0.001$), and genuine emotional vocalizations were rated as more authentic than posed ones ($F(1,49)=37.6$, $MSE=2.761$, $p<0.001$). However, laugh tokens were considered to be more genuine than crying tokens ($F(1,49)=6916.073$, $MSE=0.009$, $p<0.001$). Frequency ratings results showed that genuine emotional expressions were perceived to occur more frequently in everyday life than posed expressions ($F(1,49)=4.453$, $MSE=0.425$, $p<0.05$), and laughs were heard more frequently than cries ($F(1,49)=486.701$, $MSE=0.418$, $p<0.001$). Results of ratings of degree of control showed that the difference of control level between genuine and posed laughs were larger than that of cries ($F(1,49)=49.092$, $MSE=0.352$, $p<0.001$), also, genuine emotional tokens were perceived to be under less control than posed ones ($F(1,49)=166.464$, $MSE=0.592$, $p<0.001$). Our results suggest that listeners are indeed able to differentiate genuine from posed positive and negative emotional expressions. Cries were rated to be less genuine than laughs, which may be due to the fact that people are exposed to crying less frequently than laughter in everyday life. On-going work examining physiological responses with GSR, pupillometry and heart rate measurement to the described authenticity distinction will be discussed.

Auditory Perception, Speech Perception, Audiovisual Integration

A10 Cortical oscillations and spiking activity associated with Artificial Grammar Learning in the monkey auditory cortex

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Artificial Grammars (AG) can be designed to emulate certain aspects of language, such as the structural relationship between words in a sentence. Towards developing a primate model system to study at the neuronal level, we obtained evidence that monkeys can learn relationships in sequences of nonsense words generated from an auditory AG and used functional MRI (fMRI) to study the brain regions engaged (Wilson et al., Neurobiology of Language Meeting, 2014). Here, we ask how monkey auditory neurons evaluate the within-word acoustics and/or between-word sequencing relationships, and whether these aspects engage theta and gamma oscillations, which are critical for speech processing in human auditory cortex (e.g., Giraud & Poeppel, Nat. Nsci. 2012). We recorded local-field potentials (LFPs) and single-unit activity (SUA) from 4 fMRI localised auditory core (A1 & R) and lateral belt (ML & AL) subfields in two Rhesus macaques (124 sites). During each recording session, the monkeys were first habituated to exemplary sequences generated by the AG. We then recorded neuronal activity in response to identical nonsense words, either in the context of a sequence that followed the AG structure ('correct') or one that violated its structure ('violation'). In response to

nonsense words, the LFP power significantly increased in a broad range of frequency bands (4-100 Hz), including at theta (4-10Hz) and low (30-50Hz) and high (50-100Hz) gamma frequencies. We also observed a consistent increase in the inter-trial phase coherence, in particular in the theta band. Theta phase was associated with gamma power modulations in response to the nonsense words, in the correct or violation sequences, respectively, in 42% vs. 39% of sites. Moreover, a substantial proportion of the LFP sites showed differential responses to the nonsense words depending on whether the nonsense word was in the context of a 'correct' or 'violation' sequence in theta (35 /124 sites), low gamma (37/124) and high-gamma (25/124) bands. Lastly, the proportion of such sequence-context sensitive sites increased from core to lateral belt auditory fields (LFP: 18% vs. 82%; SUA: 39% vs. 61%). We provide evidence that monkey auditory neuronal responses, including theta and gamma nested oscillations, are associated with both the processing of nonsense words and the relationship between the words, as governed by an Artificial Grammar. These nonhuman primate results likely reflect domain general, evolutionarily conserved neuronal processes, rather than those that are language specific in humans.

A11 Relationship between individual differences in cognitive abilities and tone processing in the context of sound change

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How individual variations in auditory/speech processing may be related to cognitive abilities has attracted much interest among psycholinguists in recent years (e.g. Bidelman et al., 2013; Ho et al., 2003; Kraus et al., 2012; Strait et al., 2010). While many studies have found a relationship between cognitive performance and auditory processing, they vary in terms of whether the relationship is modality-specific or modality independent. Moreover, many of these studies have focused on contrasting the processing of non-linguistic stimuli by individuals differing in musical training. Alternatively, a few studies have explored the relationship between cognitive functions and variability in speech processing in a context that has ecological validity and high impact, i.e. sound change (Law et al., 2013; Pabery-Clark et al., 2011; Yu, 2010). Studies of sound change at the individual level could shed light on why various patterns of sound perception and production exist in a relatively linguistically homogeneous community, setting aside the influence of language contact and socio-economic factors. The present investigation aimed to systematically assess the relationship between tone processing and various components of attention and working memory in the auditory and visual modalities among normal Cantonese-speaking individuals exhibiting the patterns of (i) good perception and production (control), (ii) good perception but poor production (partial merger), and (iii) good production but poor perception (near merger). A total of 117 native speakers of Cantonese were assessed on their ability to discriminate and produce the six contrastive tones in the language in an AB discrimination task and a reading aloud task. Based on their performance, 51 of them were classified into the control, partial-merger, and near-merger groups. The participants' response latencies to tone discrimination were measured, and a series of published tasks evaluating attention and working memory in the visual and/or auditory domains were administered, including Test of Everyday Attention (TEA) (Robertson et al., 1994; auditory and visual attention), Attention Network Test (ANT) (Fan et al., 2002; visual executive control), Test of Attentional Shifting (Lallier et al., 2009; auditory attention switching), digit span backward (auditory working memory), and subtests in WAIS-IV measuring visual working memory (WM). A MANOVA test was used to analyze differences among participant groups in RTs of tone discrimination and scores of the five cognitive batteries/tests. Stepwise multiple regression was employed to identify which cognitive component(s) are related to performance on tone perception. The results of MANOVA revealed significant differences among participant groups in RTs of discrimination, visual TEA and ANT. Controls were faster than both partial-mergers and near-mergers in discriminating tone contrasts. For the cognitive tests, pairwise comparisons found that in both cases, it was the near-merger group showing lower performance than the others. Both visual WM and auditory TEA significantly predicted speed of tone discrimination. Further analyses identified Symbol Search of WAIS-IV and Elevator Counting with Distraction in auditory TEA as measures significantly contributing to perception latencies. Our overall findings have demonstrated the role of domain general cognitive abilities in speech processing and raised problems for some models of sound change.

A12 Compensatory mechanisms for processing speech in noise in older adults

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Adults often report that they find listening to speech in the presence of background noise more effortful as they get older. Indeed, studies have shown that older listeners sometimes perform more poorly in speech in noise tasks than would be predicted by their pure-tone thresholds. Whilst a small number of studies have examined the neural basis of perception in noise in older adults, these studies have tended to examine neural responses to a single type of noise background. However, in our everyday life we encounter many different kinds of background noise, for example noise from machinery and the speech of others, and these different kinds of masking sounds have been shown to draw upon different cognitive and neural mechanisms. Here we compared neural responses between younger (n = 20, mean age = 25, s.d. = 5.25, range = 19-34) and older adults (n = 13, mean age = 68, s.d. = 5.01, range = 63-82) with normal hearing (as measured by pure-tone thresholds) using functional Magnetic Resonance Imaging. In the scanner participants listened passively to

short spoken narratives presented either without noise or in the presence of different masking sounds that had been equated for intelligibility but differed "parametrically" in their similarity to speech: speech modulated noise (SMN), rotated speech (Rot) and intelligible speech (Sp). Functional images were submitted to a whole brain 2 x 3 mixed ANOVA with factors: group (young vs. old) and masking condition (SMN, Rot and Sp) and thresholded at $p < 0.005$ peak level (uncorrected) with a voxel extent = 20. Whilst the groups performed similarly on speech in noise tasks in post-scanner testing, their neural responses were shown to differ within the scanner. Our initial results suggest that the bilateral superior temporal and precentral gyri showed an increasing response as masking sounds became more similar to speech, whilst the left caudate and right cingulate exhibited the reverse effect. A reduced response to masking was identified in the older (relative to the younger) group within subcortical regions, including the thalamus and putamen, as well as in the left superior temporal gyrus, whilst an increased response was found within the bilateral middle frontal gyri. An interaction between condition and group was found within the left supplementary motor area and inferior parietal lobule, and the right cingulate and inferior frontal gyrus. This interaction effect was characterised by increasing responses to masking sounds that were increasingly more "speech like" in the older group and the reverse pattern in the younger group. Our results suggest that whilst this group of older and younger adults performed similarly on a speech in noise task, this equivalent performance was achieved using different neural mechanisms. Older individuals exhibited reduced responses in regions associated with the encoding of masking sounds and showed likely compensatory increases in activation in frontal regions associated with cognitive control. Furthermore, the response in a number of regions indicated that older adults processed non-speech maskers in a manner that was associated with responding to speech maskers in the younger group.

A13 Tracking the time course of the processing of reduced infinitives: An ERP study

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In spontaneous speech, speakers often produce words in a reduced form, with fewer speech sounds. Examples of reduced pronunciation variants are the English words s'pose and yeshay for suppose and yesterday, respectively. Native listeners understand reduced pronunciation variants effortlessly. Nevertheless, recent behavioral studies show a processing advantage for the unreduced variants of words, especially when words occur in isolation (e.g., Ernestus and Baayen, 2007). The question is whether this processing advantage remains when words are presented in a more natural context, namely in sentential context. We investigated this question in three ERP experiments. We compared the brain response to reduced and unreduced variants of words in three different contexts: in isolation (Experiment 1), and in a full sentence at either sentence-final position (Experiment 2) or mid-sentence position (Experiment 3). In all experiments, native speakers of Dutch listened passively to 200 Dutch stimuli while their brain activity was recorded, and they made comprehension questions after blocks of stimuli. Target words were 80 prefixed infinitives such as bedriegen ('to betray') realized with or without a schwa in the prefix. Schwa reduction was expected to affect the N400, an ERP component reflecting difficulty of lexical-semantic activation and integration within a given context. We expected that the processing advantage for unreduced variants in isolation, as observed in the behavioral literature, would translate into delayed N400s for reduced variants in Experiment 1.When the words are presented in sentences (Experiments 2 and 3), this advantage may be lost and no delay in the N400 may be expected. In Experiment 1, the N400 occurred significantly later for reduced than for unreduced variants in isolation. This suggests that it takes more effort to activate the appropriate meaning in the lexicon when the word is reduced in a situation in which it is seldom reduced. We thus replicated the processing advantage for unreduced variants in isolation. Experiment 2 showed large differences among participants. For most participants, the N400 peaked earlier for reduced than for unreduced variants. At sentence-final position, the occurrence of a prefixed infinitive may have been predictable, and therefore the reduction of the prefix may not have delayed the recognition process. In contrast, the reduction led to shorter words and therefore, participants could access the mental lexicon more quickly. In Experiment 3, the N400 did not differ significantly for sentences with unreduced and reduced variants. In mid-sentence position, the infinitive could not be predicted. Nevertheless, the reduction did not result in a significant delay because it occurred in a situation in which it is natural to occur. In conclusion, the time course of the processing of a reduced variant depends strongly on whether the reduction occurs in a natural position and on the predictability of the word. References Ernestus, M., & Baayen, R. H. (2007). The comprehension of acoustically reduced morphologically complex words: The roles of deletion, duration and frequency of occurrence. In Proceedings of ICPHS, Saarbrücken, Germany (pp. 773–776).

A14 Attention to speech sounds within auditory scenes modifies temporal auditory cortical activity

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Introduction: In natural listening environments, humans are efficient and rapid in attending and reacting to behaviorally relevant auditory features such as speech. Complex speech-related processes in healthy brain are still largely uncovered, as most imaging studies on speech processing have applied simplified experimental conditions and stimuli with highly-controlled physical properties. Experiments applying increasingly natural auditory environments are, however, needed for understanding the cortical mechanisms during real-life speech processing. The present study used superimposed speech and environmental sound excerpts. We hypothesized that, in accordance with intracranial

recordings (Mesgarani and Chang 2012), the cortical activation pattern would reflect the attended and perceived component of the complex auditory stimulus. Methods: In our combined magnetoencephalography (MEG) and functional magnetic resonance imaging (fMRI) study, 11 native Finnish-speaking subjects were presented with auditory "miniscenes" that consisted of superimposed speech and environmental sound stimuli with varying (-18 dB, 0 dB and +18 dB) speech-to-environmental sound intensity ratios. At these intensity ratios, both sound excerpts within stimuli were clearly distinguishable. The combined sounds were presented in blocks of four with stimulus-onset-asynchrony of 3600 ms; the speech-to-environmental sound intensity varied between blocks. The subjects were instructed to attend to either speech or environmental sound excerpts within the stimuli in separate runs, and respond with a finger lift if the last two stimuli in each block had the same spoken word/environmental sound (10% of the blocks). The responses were measured with a 306-channel neuromagnetometer (Vectorview, Neuromag Ltd) and a 3-T MRI scanner (Siemens Magnetom Skyra). Results: Attention to speech sound excerpts within the combined sounds influenced the MEG response durations at the supratemporal auditory cortices: The sustained response (> 200 ms) duration was increased with decreasing speech-to-environmental sound ratio, i.e. with increasing difficulty to distinguish the speech sounds. The response durations were prolonged from 454 ms ± 62 ms (+18 dB; mean ± SEM) to 732 ms ± 68 ms (-18 dB) in the left hemisphere ($p < 0.001$), and from 496 ms ± 66 ms (+18 dB) to 626 ms ± 65 ms (-18 dB) in the right hemisphere ($p < 0.01$). No such effects were observed when subjects were attending to the environmental sound excerpts ($p = 0.7$). The fMRI responses to all experimental sounds showed bilateral activation extending from the Heschl's gyri to the planum polare anteriorily and to the planum temporale posteriorily, without significant differences between the speech-to-environmental sound ratios (-18 dB, 0 dB and +18 dB) nor the focus of the subjects' attention (speech/environmental sound). Conclusions: The present results suggest stronger top-down modulation for speech than environmental sounds in demanding listening situations, possibly in the form of attention allocated for selecting the behaviorally relevant features among the auditory environment. Our results suggest such processes to rely on the activation of the bilateral auditory cortices at around 500-800 ms after the stimulus onset.

A15 Differential Lateralization of Linguistic Prosody in Comparison to Speech and Speaker Processing

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Introduction: Prosody plays an important role in human communication not only providing information about the speaker's emotional state (emotional prosody) but also about the speech message (linguistic prosody). How the brain processes linguistic prosody has been investigated by a number of neuroimaging and lesion studies [reviewed by e.g., 1-4]. Nonetheless, the degree to which functions of right and left hemispheres support recognition of linguistic prosody remains a controversial issue: while it is commonly assumed that linguistic and emotional prosody are preferentially processed in the right hemisphere [e.g., 1], neuropsychological work directly comparing processes of linguistic and emotional prosody suggests a predominant role of the left hemisphere for linguistic prosody processing [5,6]. Here, we used two functional magnetic resonance imaging (fMRI) experiments to clarify the role of left and right hemispheres in the neural processing of linguistic prosody. Methods: In the first experiment, we sought to confirm previous findings showing that linguistic prosody processing compared to other linguistic processes predominantly involves the right hemisphere. Unlike previous studies [e.g., 7,8], we controlled for stimulus influences by employing a one-back prosody and a one-back speech task using the same speech material. The second experiment was designed to investigate whether left-hemispheric involvement in linguistic prosody processing is specific to contrasts between linguistic and emotional prosody or whether it also occurs when linguistic prosody is contrasted against other non-linguistic processes, namely speaker recognition. As in the first experiment, one-back prosody and speaker tasks were performed on the same stimulus material. Results: In both experiments, linguistic prosody processing was associated with activity in temporal, frontal, parietal, and cerebellar regions. However, activation in temporo-frontal regions showed differential lateralization depending on whether the control task required recognition of speech or speaker: linguistic prosody predominantly involved right temporo-frontal areas when it was contrasted against speech recognition (Exp. 1); when contrasted against speaker recognition, linguistic prosody predominantly involved left temporo-frontal areas (Exp. 2). Conjoined activity for both contrasts was located in left supramarginal gyrus and bilateral inferior frontal gyri. Conclusion: Our results are consistent with the predictions of two influential theories on the lateralization of linguistic prosody [1,9]. Taken together, the results suggest that recognition of linguistic prosody is based on a dynamic interplay of both hemispheres in which the right hemisphere is specifically involved in tracking pitch variations over speech segments and the left hemisphere in associating such pitch variations with linguistic meaning. References: [1] Friederici & Alter, Brain Lang (2004). [2] Wildgruber et al., Prog Brain Res (2006). [3] Witteman et al., Neuropsychologia (2011). [4] Wong, Brain Res Bull (2002). [5] Pell & Baum, Brain Lang (1997). [6] Wildgruber et al., Cereb Cortex (2004). [7] Meyer et al., Hum Brain Map (2002). [8] Strelnikov et al., NeuroImage (2006). [9] Van Lancker, Res Lang Soc Interac (1980).

A16 Differences in Language and Music Processing: Auditory, Motor and Emotional Networks

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Music and Language share a number of traits; both have rules for production, exist in the auditory domain and occur in similar timeframes. Music processing has traditionally been presumed to be largely similar to language processing, at least at the structural level, with some studies suggesting overlap in the neural substrate, particularly in Broca's area. However, a recent study that compared single-note melodies and jabberwocky sentences only showed overlap in low-level auditory areas. One possible explanation for this lack of overlap was the fact that the musical stimuli used in that study were too simple. The present study used more complex musical stimuli, consisting of chord progressions. In addition, given conflicting data on the role of Broca's area in music processing, we chose to incorporate musical pitch violations into our experimental paradigm to investigate whether violations may drive Broca's area activity. Subjects were presented with four types of stimuli: two language conditions consisting of jabberwocky sentences and scrambled versions of the same sentences as well as two music conditions consisting of short chord progressions with or without pitch violations. As expected, primary auditory cortices are universally recruited for the tasks. However, a number of dissociations occur between music and language activation. In a conjunction analysis, musical stimuli were shown to have activated more midline areas: the cingulate, parahippocampal gyri, some parietal loci, as well as temporal polar areas while language stimuli activated more frontolateral regions, especially IFG and MFG, bilaterally. Violations of musical pitch rules elicited a pattern of activation that is distinct from consonant music. Parahippocampal gyri, precuneus, cuneus and temporal polar regions responded differentially to these pitch violations in a musical context. These regions are all associated with emotional networks. The effects of pitch violations observed in the present study was consistent with past investigations of consonance and dissonance- that is, dissonant chords activated areas associated with negative emotional states. Several parietal areas and precuneii/cuneii activated in response to musical pitch violations, which also suggests that musical pitch hierarchies may be stored in a space analogous to visuospatial data. Within the language conditions, scrambled sentences elicited more activation in right hemisphere areas compared to the grammatical sentences, especially right IFG and right STG. Scrambled sentences did not elicit greater activation in Broca's Area, which lends more credence to the hypothesis that Broca's area is not simply handling grammatical computations. Although both music and language exist in the auditory domain and have rules for production, musical processing is distinct from language processing at higher levels. Whereas language has rich semantic content, music efficiently communicates emotional information. The role of Broca's area in grammatical computations is also called into question.

A17 I thought that I heard you laughing: Contextual facial expressions modulate the perception of authentic laughter and crying *Nadine Lavan[1], Cesar F Lima[2,3], Hannah Harvey[1], Sophie K Scott[3], Carolyn McGettigan[1,3]; [1]Department of Psychology, Royal Holloway, University of London, [2]Centre for Psychology, University of Porto, [3]Institute of Cognitive Neuroscience, University College London*

It is well established that contextual cues (e.g. from the voice or body) can modulate the perception of emotional facial expressions (Wieser, & Brosch, 2012; de Gelder & Vroomen, 2000) and the neural responses to emotional faces (Mueller et al.,2010, Etkin et al., 2004). Whether this sensitivity to context generalizes to the perception of vocal expressions of emotion is, to date, only poorly explored, particularly with respect to nonverbal emotional vocalizations. Here, we report an experiment examining the perception of auditory laughter and crying in the context of emotionally happy, neutral and sad facial expressions. In a behavioural experiment, 38 adult participants rated 30 genuine laughs and 30 cries (produced by 3 adult females and 2 adult males) on three 7-point Likert scales of perceived happiness, sadness and arousal. On each trial, the auditory stimulus was paired with a static image of a face that was either (i) emotional and congruent (e.g. laughter with a smiling face), (ii) emotional and incongruent (e.g. laughter with a sad face) or (iii) neutral. Importantly, using authentic expressions of genuine emotional experience allowed us to take advantage of the natural perceptual ambiguity that exists between intense laughter and crying, rather than having to use morphed continua (e.g. de Gelder & Vroomen, 2000). We observed consistent effects of visual context on the evaluations of the auditory vocalizations: For both laughter and crying, the perception of perceived happiness and sadness was significantly biased towards the information expressed by the face. For example, laughter paired with a sad face (incongruent pairing) was perceived as less happy than laughter paired with a happy face (congruent pairing), while laughs paired with neutral faces gave ratings intermediate between the congruent and incongruent contexts. The same pattern of results emerged for crying. These biases were independent of response latencies and were larger for more ambiguous vocalizations. No effects of context were found for arousal ratings. These findings suggest that visual context is automatically encoded during the perception of specific emotions in nonverbal vocalizations, but not during arousal in laughter and crying. This is the first demonstrations to show that visual contextual modulation of the perception of emotions in non-verbal vocalizations is particular to the evaluation of emotional content and not to general affective judgements. In line with Barrett and Kensinger's hypothesis (2010), we conclude that isolated expressions of emotions may provide sufficient information about general affective state, but that the integration of contextual information may be required for an optimal understanding of specific emotional states. An fMRI study using this behavioural paradigm, is currently underway. This will allow us to identify the neural systems supporting the processing of authentic laughter and crying, and how these are affected by accompanying visual cues.

A18 Temporal locus of interaction of phonetic and talker processing in speech perception: An ERP study

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Speech signals contain two important sources of information: the phonetic information of the linguistic content and the talker's voice. Importantly, phonetic and talker processing appear to be interdependent, which is evidenced by the behavioral findings that increased variability in talkers' voices interferes with classification of phonetic categories, and that increased variability in phonetic categories interferes with classification of talkers' gender. However, the temporal locus of such interaction in the neural pathway of speech processing remains an unresolved question. A previous event-related potential (ERP) study has found that such interaction may have an early temporal origin, as shown by a greater negativity elicited 100-300 ms after the stimulus onset in conditions with task-irrelevant interference (i.e., interference of talker/phonetic variability in the phonetic/talker classification task) compared to baseline conditions. It suggests that phonetic and talker information may be encoded integrally in early processing stages. However, this finding is likely confounded by differences in neuronal refractory effects, due to the unmatched stimulus probabilities between the interference and baseline conditions. In this ERP study, we reexamined this question by controlling the stimulus probabilities. We presented three types of deviants (speech stimuli that change in talker's voice, in phonetic category, or in both) in a stream of standards in an oddball paradigm (standard=81.25%, each deviant=6.25%). Listeners were instructed to silently count the stimuli with phonetic change in the phonetic task, and to silently count the stimuli with talker change in the talker task. We found the earliest interaction effects in the time-window of a posterior P3b and a frontal negativity (500-800 ms), with the talker deviant eliciting a reduced P3b and frontal negativity compared to the other two deviants in the phonetic task, and the phonetic deviant eliciting a reduced P3b and frontal negativity in the talker task. It suggests that the deviants with task-irrelevant interference increase the categorization difficulty, which further indicates that the interference between phonetic and talker processing persists from early processing into the categorization stage.

A19 The melody of speech: what can event-related potentials tell us about emotional prosody processing?

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Introduction: Human social communication is a complex process that relies on the dynamic interaction between verbal and non-verbal cues. The process of communicating in a social context involves, among other abilities, the detection of emotional salience from a voice signal. Even though, in the last decades, the study of social communication was revolutionized by neuroscience methods, the brain mechanisms underlying social communication are not yet well understood. Previous event-related potential (ERP) studies suggested that the first operations that allow assigning emotional valence to a speech signal happen within the 200ms from the onset of that signal (Paulmann & Kotz, 2008; Pinheiro et al., 2013, 2014). In a series of three ERP studies, we aimed to clarify how vocal emotional salience is detected at both the involuntary change detection and attention orientation stages of auditory processing. Methods: Experimental stimuli were selected from the Montreal Affective Voices set (Belin et al., 2008). One exemplar of neutral, happy and angry vocalizations was selected based on affective ratings obtained in a previous study. These stimuli were presented both as standard and deviant stimuli (Experiments 1-2) and as novel stimuli (Experiment 3). Twenty one healthy volunteers participated in the experiments (12 female; mean age: 22.86 ± 2.97 years). In Experiment 1, participants were asked to watch a silent movie and to ignore the vocal sounds. In Experiment 2, participants were asked to count the number of low-probability target vocalizations. Neutral, angry and happy vocalizations were used as both standards and deviants in different blocks in order to reduce the effect of the acoustic differences between the neutral and the emotional conditions and to allow each sound to operate as its own acoustic control. In Experiment 3, participants were asked to count the number of target tones (350 Hz, 336 ms duration, 10 ms rise and fall times or 500 Hz, 336 ms duration, 10 ms rise and fall times), while vocalizations were presented as novel stimuli. Mismatch negativity (MMN - Experiment 1), P3b (Experiment 2) and P3a (Experiment 3) ERP components were analyzed. Results: In experiment 1, more negative MMN amplitude was found for happy and neutral vocalizations relative to angry vocalizations ($p<0.001$). In experiment 2, happy vocalizations elicited more positive P3b amplitude than angry and neutral vocalizations ($p<0.01$), and angry vocalizations elicited more positive P3b amplitude than neutral vocalizations ($p<0.01$). In experiment 3, more positive P3a amplitude was found for happy vocal targets relative to angry and neutral targets ($p<0.01$). Conclusion: These experiments demonstrated a modulatory role of emotion on both MMN and P3 amplitude. The findings suggest that detecting emotional salience from vocal cues is a rapid and highly automatic process and that emotional information cannot be ignored even when it is not task-relevant. This is particularly relevant for the understanding of social communication, in which emotional signals are often processed in an implicit way and without full conscious awareness.

A20 On the lateralisation of pitch processing: language makes the switch from right to left

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Although prosody processing has been assumed to predominantly involve the right hemisphere (e.g., Friederici and Alter, 2004), there is an on-going controversy in the literature with respect to left-hemispheric functions in linguistic prosody processing. A recent study (Kreitewolf et al., in revision) showed in two fMRI experiments that predominantly right- or left-hemispheric involvement during prosody discrimination depended on whether the control task required phonemic or speaker discrimination respectively. Differences in the stimulus material between the two experiments could have contributed to the differential lateralization of prosody processing: (1) length in terms of the number of syllables, (2) lexicality and (3) syntactic structure. The present fMRI study was designed to directly test the influence of these parameters on hemispheric lateralization of linguistic prosody. The experiment comprised two one-back tasks which were performed on sequences of six stimuli: a prosody task in which participants discriminated between question and statement intonation (with a rising or falling F0 contour respectively) and a speaker task which required discrimination between speakers differing in voice pitch only. Sophisticated vocoder software (Kawahara et al., 2008) was used to generate differences in intonation and differences in voice pitch according to the glottal pulse rate. Furthermore, stimuli varied in length (monosyllabic vs. disyllabic nouns/pseudonouns), lexicality (real words vs linguistically matched pseudowords), and syntactic structure (disyllabic nouns/pseudonouns vs disyllabic sentences composed of a monosyllabic pronoun and a monosyllabic inflected verb/pseudoverb). The results showed stronger activation in left inferior frontal gyrus (IFG) and bilaterally in the anterior insulae during the prosody task compared to the speaker task. Activation in left IFG during prosody processing was found for both real words and pseudowords suggesting that the left IFG is involved in prosody processing irrespective from the presence of lexical information in the stimulus material. However, lateralization of the insular activation varied with the amount of linguistic material. Both syntactically more complex stimuli and real words (as opposed to delexicalized pseudowords) showed a more pronounced right-lateralization of the anterior insula. On the one hand, these results corroborate the important role of the left hemisphere in the processing of linguistic pitch information, in line with the functional lateralization hypothesis (Van Lancker, 1980) and previous findings (Wildgruber et al., 2004; Kreitewolf et al., in revision). On the other hand, the results showed an involvement of the anterior insula in the processing of linguistic prosody as opposed to (non-linguistic) speaker processing. This might indicate that the anterior insula is relevant for a specific attentional switch in function of the presence linguistic information. The right hemisphere, especially the superior temporal cortex, has been shown to be crucial in the processing of sentential prosody (Friederici, 2011). The increasing presence of linguistic information can activate the right insula, which would in turn recruit the ipsilateral fronto-temporal network for prosodic processing. References: Friederici & Alter, Brain Lang (2004). Kawahara et al., Int Conf Acoust Spee (2008). Kreitewolf et al., NeuroImage (in revision). Van Lancker, Res Lang Soc Interac (1980). Wildgruber et al., Cereb Cortex (2004). Friederici, Physiol Rev (2011).

Orthographic Processing, Writing, Spelling

A21 Delineating Picture and Chinese Character Recognition: An ERP Approach

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The logographic nature of the Chinese script has often been compared to alphabet scripts and argued that more visual-spatial analysis is required, given that character components are arranged in a fixed square shape (Tan et al., 2001). The analogy between characters and pictographs or line-drawings has led to some discussion of whether the two are similar or distinct in visual-spatial analysis particularly in the right occipital hemisphere (e.g Yum et al., 2012; Zhang, et al., 2011). Using ERP's method, this study aimed to address whether visual-spatial analysis of characters is dissociable from line drawings, particularly focusing at the initial occipital P100 component known to reflect visual feature detection, and the N170 component where object and word processing are discriminated along the ventral stream of the brain. Twenty-five right-handed native Chinese speakers performed a repetition detection task where participants were asked to respond when the same stimulus was repeated over consecutive trials, whilst collecting their electrophysiological data. Non-repeated trials consisted of stimuli varying by Domain (line-drawn objects vs. Chinese characters) and Well-formedness (Real, pseudo vs. non-items), giving six conditions (1) real objects, (2) pseudo objects, (3) non-objects (4) real characters, (5) pseudo characters, and (6) non-characters. Pseudo objects were constructed by randomly combining parts of the real objects to make non-existing but plausible objects, and pseudo characters by randomly combining sub-lexical components (radicals) whilst following their positional orthographic rules. Non-objects and non-characters were constructed by random combinations of the same units to form illogical pictures or with the orthographic rules violated, respectively. The ERP results revealed that pictures and Chinese characters are processed distinctively as early as 100ms post-stimulus at the P100 component, and across all subsequent ERP components, with line-drawings of objects generally eliciting greater amplitudes than characters (at the occipital P200 and N400 components). Domain effects were also found at the N170, with characters eliciting a larger N170 than pictures particularly in the left occipital electrodes. Furthermore, the well-formedness of characters was distinguished earlier than pictures at the bilateral occipital N170 component whereby real and pseudo characters elicited greater amplitudes than ill-formed non-characters. Differences in well-formedness of objects were observed at the later occipital P200 component

with ill-formed-objects evoking greater positivity than well-formed objects. Lastly, the central-frontal N400 showed independent effects of domain and well-formedness, with line drawings of objects and ill-formed items eliciting greater negativity and effort in accessing semantic features than real characters and well-formed items, including pseudo objects and pseudo characters. The results suggest that although Chinese is considered more visual during orthographic analysis compared to alphabetic scripts, it is nonetheless fundamentally distinct from the processing of line-drawings. More importantly, the left-lateralized N170 is an indicator of orthographic sensitivity across orthographic systems. The overall findings also suggest the great potential of applying the repetition detection paradigm, given its simplicity, to study word processing in less skilled readers and impaired readers.

A22 Letter position sensitivity in the VWFA: Evidence from multivariate searchlight analyses in MEG-EEG source space

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It has been hypothesized that reading, a fairly recent activity in human evolution, recycles visual object recognition processes such as identification of lines and shapes to detect letters, combinations of letters, and words. Neural activity in inferior occipitotemporal areas differs when processing words, symbols or objects, with the region labeled the "visual word form area" (VWFA) thought to play a critical – though not fully understood – role in this process. In this study, we investigate the spatio-temporal dynamics of the neural systems involved in mapping from visual input to orthographic representations, delineating two features of visual words which reflect coding of visual and orthographic properties over time. Searchlight-based multivariate pattern analysis (Representational Similarity Analysis/ RSA; Su et al., PRNI, 2012) was applied to combined magneto- and electroencephalography (MEG-EEG) data, mapped into MNE source space, to tease apart early stages of visual and orthographic processing, and to investigate the selectivity of VWFA. We analysed a set of visually-presented words matched for length, and used Searchlight RSA to test: (a) visual models based on pixel-level overlap between word images and (b) orthographic models based on the number of shared letters between words (and pseudowords), contrasting position-specific models (where scan and scar share three letters, but bake and beak share only one) with position-nonspecific models (where bake and beak now share four letters). RSA successfully delineates regions in the ventral stream that are sensitive to visual word form properties captured by the proposed models. The visual model reveals bilateral occipital regions involved in early visual processing, beginning at 70 ms in right and left occipital poles and ending at 180 ms. The position-specific orthographic model for words reveals strongly left-lateralised effects in posterior fusiform gyrus including VWFA and posterior ITG, with these effects starting to emerge at 200 ms, and activity in VWFA peaking at 210 ms. This cluster also extends into left posterior MTG between 240 and 420 ms. When pseudowords are included, early activation involving VWFA is unaffected, again peaking in VWFA at 210 ms, but the more dorsal and anterior activations, presumably related to lexical representations, are no longer seen. The position-nonspecific model, in contrast, does not engage VWFA and adjacent posterior fusiform areas, and generates significant model fits later and bilaterally – from 260 ms in L ITG and MTG, and (more weakly) in RH angular gyrus. These results provide direct evidence for the type of orthographic process supported by the VWFA. These processes evidently preserve letter position in the input stream, but do not seem to do so in terms of specifically lexical representations. Lexical effects are seen 50 ms later, in left inferior temporal and middle temporal areas, where we also start to see position-nonspecific effects, likely to reflect interactions between whole word representations at this later stage in the access process. Additionally, we are able to dissociate activity in VWFA from simple visual feature processing, which emerges earlier in time and in bilateral occipital cortex.

A23 Neural dissociation between letters and digits writing: Evidence from coupled kinematics and fMRI recordings

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The visual brain can distinguish between arbitrary symbols issued from distinct domains of knowledge, such as letters and digits, in particular through the tuning of a left fusiform region to letters. Interestingly, this type of functional specificity could also apply to writing, as attested by intriguing neuropsychologial dissociations where agraphic patients are severely impaired for writing letters whereas they write digits nearly normally. Here, we tested the hypothesis that the motor patterns for writing letters are coded in specific regions of the cortex. We recorded the fMRI BOLD signal while 18 right handed native french speakers were instructed to write pairs of letters or pairs of digits under dictation. In order to ensure that possible effects at the brain level are not driven by low-level aspecific factors related to the execution and control of complex hand movements, we recorded writing kinematics with an MRI compatible graphic tablet. We found a set of 3 regions, 2 of whom are part of a motor control network (left dorsal premotor cortex and supplementary motor complex), that were more strongly activated for letters than for digits and whose response was not explained by low-level kinematics features of the graphic movements. The left premotor activation belongs to what is considered in the literature a key area for handwriting. This constitutes the first neuroimaging evidence of functional specificity related to linguistic symbols in the cortical motor system.

A24 The Temporal Dynamics of Visual Word Recognition in Deaf Adults

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Reading presents a significant challenge for those who are born profoundly deaf because they cannot hear the language that is encoded by print. The majority of deaf children begin reading instruction without the spoken language foundation of their hearing peers. Nonetheless, despite generally poor reading outcomes, some deaf people do achieve high levels of reading proficiency. One important question then is what are the underlying neurocognitive mechanisms used by deaf readers and are they the same or different from those used by hearing readers? Nineteen deaf adults (mean age 30.5 years, 8 male) were run in a standard visual masked priming paradigm using a go/no-go semantic categorization task (detect occasional animal words). Each trial consisted of the following: (1) 500 ms fixation cross; (2) a 300 ms forward mask (########); (3) brief five letter prime word in lowercase (50 or 100 ms); (4) 20 ms backward mask (random consonant string); (5) 300 ms five letter target word in uppercase; (6) 700 ms blank screen; and (7) a trial ending 1800 ms "blink" stimulus. There were 60 word pairs in each of four experimental conditions in a 2 x 2 factorial design: Repetition (repeated vs. unrelated; e.g., table-TABLE vs. plant-TABLE) and Prime Duration (50 vs. 100 ms). Artifact free ERPs were averaged at each of 29 scalp electrodes time-locked to the onset of target words. Data from the deaf readers (mean reading level = 9th grade; range: 5th grade – post college) were compared to 24 hearing adult readers (run in an earlier study but only with 50 ms primes). While the hearing readers showed the now standard pattern of visual masked priming effects with larger N250 and N400s for unrelated compared to repeated target words, deaf readers showed a very different pattern with 50 ms primes. Deaf readers showed this pattern with 100 ms primes, but they showed the reversed pattern with 50 ms primes, with significantly larger positivities for unrelated compared to repeated targets. This pattern might index the relatively poorer reading skills of the deaf participants, but such "reversed" priming is not observed in less-skilled hearing readers. Alternatively, this pattern could indicate a qualitatively different priming mechanism in deaf readers, one possibly linked to altered early visual processes resulting from congenital deafness. In addition, strong correlations for deaf readers between ERP components and spelling ability were observed, starting with a focal effect at left temporal-occipital sites in the earliest phase of the N250 (150-250 ms r = -.70; p = .001) and extending to a broader swath of central and posterior sites during the N400 epoch (300-500 ms, r = -.70). Phonological awareness scores for deaf readers did not correlate significantly with any ERP component. The early N250-spelling correlation suggests that spelling ability indexes orthographic precision for deaf readers, rather than precise mappings between sublexical orthographic and phonological representations. The strong correlation between spelling ability and N400 priming indicates a resonance between fine-grained sublexical orthography and whole-word orthography for deaf readers.

Phonology, Phonological Working Memory

A25 Contributions of phonetically- and phonologically-driven alternations in speech perception: an ERP study

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Whether through slips of the tongue or lawful alternations, the phonological content of spoken language is rife with variability. We see variation not only in domains such as lexical stress and speech rate, but also in the phonemic realizations of specific speech sounds. This novel study examines the brain's electrophysiological response to effects of phonetic and phonological variability in English. We examined the processing of morphologically complex stimuli using two English prefixes: 'in-' and 'un-'. These prefixes provide an informative pairing because one assimilates the place of the nasal as part of a productive phonological process ('i[m]perfect' vs. 'i[n]tolerant'), while the other maintains a static representational form ('u[n]predictable', 'u[n] tenable') that lacks assimilation. Nevertheless, in these later cases it is not uncommon to observe phonetic assimilation (i.e., pronouncing 'u[m]predictable') (Gaskell & Marslen-Wilson, 1996; Gow, 2004). To test whether the brain distinguishes phonological from phonetically-driven alternations, 32-channel EEG was collected while subjects (N = 15) were presented a set of words and modified nonwords and asked to identify those which sounded correctly pronounced. The stimulus set consisted of 60 'un-' and 'in-' prefixed words, and a matched set of items in which the place of the nasal has been altered. This results in four distinct nonword types: 'in-' stimuli which have non-assimilated nasals in either labial (INP: 'inperfect') or coronal environments (IMT: 'imtolerant') and 'un-' stimuli with assimilated (UMP: 'umpredicted') or non-assimilated (UMT: 'umtained') nasals. We might expect the processing of the modified UMP forms to be easily accommodated as the 'un-' prefix exhibits frequent phonetic variation in this context. However, based on phonological theory (cf. Inkelas, 1995) listeners may better tolerate deviations to the 'in-' prefix as it exhibits a regular phonological alternation. Alternatively, both prefix sets may be processed indiscriminately as nonwords. In all participants we find an N400 for non-word items in parietal sites, consistent with prior ERP research (Kutas & Federmeier, 2011). Crucially, the results further show a distinction in N400 amplitude based both on the identity of the prefix (larger for UMP/UMT than IMT/INP) and the phonetic context (larger for UMT than UMP/IMT/INP). This suggests the brain is sensitive to alternations in word forms at two levels. Expected assimilations, a phonetically-driven effect in the modified 'un-' set, exhibit a reduced N400 relative to the non-assimilated items, suggesting they disrupt processing less. In addition, knowledge of

phonological variation is also marshaled when processing modified word forms, as we see reflected in the reduced N400 in for the 'in-' stimuli compared to the 'un-' stimuli overall. These data are important for theoretical accounts of language perception which strive to understand how speech variability influences lexical processing. This experiment further adds to a small but growing literature evaluating the utility of phonological underspecification in models of speech perception (cf. Eulitz & Lahiri, 2006; Friedrich et al., 2008; Scharinger et al, 2010).

A26 Sound of emotion in written words *Susann Ullrich[1], Sonja A. Kotz[2], David S. Schmidtke[1], Arash Aryani[1], Arthur M. Jacobs[1], Markus Conrad[3]; [1]Freie Universität Berlin, Germany, [2]University of Manchester, England, U.K., [3]Universidad de La Laguna, Tenerife, Spain*

Linguistic theory posits an arbitrary relation between signifiers and the signified (de Saussure, 1916) but a recent analysis of a large scale database containing affective ratings of words revealed that certain phoneme clusters occur more often in words denoting negative arousing meaning. To test the psychological reality of such sound-to-meaning correspondences, we registered the EEG signal in a lexical decision task in which semantic emotional meaning of words was orthogonally crossed with a novel manipulation of their putative sub-lexical sound emotion: valence and arousal values for single phoneme clusters computed as a function of respective values of words from the database these phoneme clusters occur in. Typically, negative/high-arousing phonological segments tend to be less frequent and more structurally complex than neutral ones. To investigate potential contributions of this formal salience to perceived sound emotionality, we constructed two experimental sets, one involving this natural confound, while controlling for it in the other. We report main effects of emotional sound in the two stimulus sets focusing on the P2 component (200-260 ms) of the event-related brain potential, known to respond to emotional sound quality in audition. In both sets a comparable P2 effect in response to sound emotion was present. Further, in the confounded set, negative/high-arousing segments produced an extended negativity (compared to neutral ones) between 260-660 ms. These results suggest that the organization of a language´s vocabulary involves systematic sound-to-meaning correspondences at the phoneme level that influence the way we process language. Formal salience of sub-lexical units seems to make the respective effects generally more pronounced, but seems not necessary for sub-lexical units to acquire the character of signs denoting attributes of emotional meaning.

A27 Fractional anisotropy of the arcuate/superior longitudinal fasciculus predicts verbal-working-memory span in a large sample *Benedict Vassileiou[1,2], Lars Meyer[1], Claudia Männel[1], Isabell Wartenburger[2], Anna Strotseva[1], Angela D. Friederici[1]; [1]Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany, [2]University of Potsdam, Germany*

Verbal working memory (VWM) is assumed to involve sub-systems of storage and rehearsal, the latter keeping stored items from rapid decay. Research on the neural correlates of VWM has suggested left posterior temporo-parietal cortex supporting storage and left inferior frontal cortex supporting rehearsal. While it is often tacitly assumed that the left arcuate/superior longitudinal fasciculus (AF/SLF) enables joint processing of temporo-parietal and inferior-frontal cortex during VWM tasks, to date no diffusion-weighted-imaging study has focused on the microstructural relevance of the left AF/SLF for VWM. In the present study, we hypothesized that behavioural performance on standardized VWM tests might be partially predicted by microstructural diffusion properties of the left AF/SLF. Elucidating on this hypothesis, we acquired diffusion-weighted magnetic-resonance images from 78 healthy adults, alongside measuring their behavioural performance on reading span, forward and backward digit span, and non-word-repetition tests. By applying deterministic tractography, we first manually delineated the left AF/SLF in each participant. We then masked and averaged the individual participant's fractional anisotropy (FA) across the AF/SLF. The average FA was then regressed against a composite score of VWM span, as computed by a principal component analysis on the individual VWM tests. Our results show a significant positive correlation between FA across the AF/SLF and VWM span, controlling for age, gender, whole-brain FA, and total intracranial volume. These findings suggest a strong relationship between white-matter integrity and/or axonal myelination of the left AF/SLF and an individual ability to efficiently coordinate the storage and rehearsal sub-systems of VWM. Our findings may be interpreted as indirect evidence of the coordinating role of the left AF/SLF in the cortical circuitry of VWM.

A28 Talking sense: multisensory integration of Japanese ideophones is reflected in the P2. *Gwilym Lockwood[1,2], Jyrki Tuomainen[2], Peter Hagoort[1]; [1]Max Planck Institute for Psycholinguistics, [2]University College London*

Sound-symbolism, or the direct link between sound and meaning, is well-attested across languages, both typologically and behaviourally. However, there has been limited neuroimaging research into sound-symbolism, and models of language rarely take sound-symbolism into account. Previous sound-symbolism ERP research has mostly focused on sound-symbolic non-words, and has shown that native speakers are sensitive to sound-symbolism at 140-180ms (Kovic et al., 2010) or 200ms (Arata, Imai, Kita, et al., 2010) post-stimulus. This study uses EEG to investigate the effect of Japanese ideophones, or sound-symbolic lexical words, during a language processing task. This study provides new neuroimaging evidence that ideophones modulate the P2 component, and argues that this reflects a multisensory integration process triggered by the distinctive phonology of ideophones. 21 Japanese participants were presented with short sentences one word at a time. 35 sentences contained sound-symbolic adverbs, and 35 contained arbitrary adverbs. They were instructed to make

sensibility judgements on the sentences, unaware that the experiment was in fact designed to measure their responses to the different types of adverbs. The ERP data showed that the sensibility judgement task did not affect the data, and revealed different brain signatures elicited by sound-symbolic and non-sound-symbolic conditions in two windows; the P2 in the 220-280ms window, and the late effect between 350ms and 550ms. Firstly, we argue that the significant difference in the 220-280ms timeframe is a modulation of the P2 component, which is related to phonological processing and multisensory integration (Bien et al., 2012; Dien, 2009). Both of these are important factors when it comes to analysing the processing of ideophones, as ideophones have distinctive phonological structures (Bodomo, 2006; Dingemanse, 2012; Hamano, 1998) and typically depict sensory imagery in a quasi-synaesthetic way (Dingemanse, 2012; Hinton et al., 2006; Kita, 1997). The distinctive phonology of Japanese ideophones is what allows native speakers to recognise them as sound-symbolic; this then precipitates a multisensory integration process of sound and sensory information embodied by the ideophone. It is this multisensory integration which results in the semantic vividness of ideophones; this multisensory integration effect is also consistent with the sound-symbolism-as-synaesthesia literature (Arata et al. 2010, Osaka 2009; 2011). Secondly, we argue that the late effect is a sustained negativity in response to arbitrary words, and represents the downstream processing consequences that arbitrariness has. Behavioural experiments show that sound-symbolic words facilitate semantic comprehension, due to both the highly specific semantic frames which sound-symbolic words encode and the semantic associations which speakers have with certain sounds. In this study, we theorise that the distinctive phonology of ideophones triggers a multisensory integration process of sound and the sensory information which the ideophone depicts, which elicits the higher P2 effect; this very likely involves temporal and parietal areas where multisensory integration is known to take place. In contrast, the extra processing load for arbitrary adverbs results in a later sustained negativity.

Language Development, Plasticity, Multilingualism

A29 Brain activation to human vocalisations and environmental sounds in infancy and its association with later language development

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Being able to recognise human voices in our auditory environment is the first necessary step to speech recognition and language learning. Using functional near infrared spectroscopy (fNIRS) and functional magnetic resonance imaging (fMRI), we have previously shown that an area of the anterior temporal cortex of young infants activates preferentially to human voices in comparison to other environmental sounds (Blasi, Mercure et al, 2011, Lloyd-Fox et al., 2012). Does this cortical sensitivity to human vocalisations in infancy relate to later language development? To address this question, infants were followed longitudinally at two time points. At 4 to 7 months, they participated in an fNIRS study in which brain activity was recorded while they were presented with two categories of sounds: Vocal sounds (human non-speech vocalisations, such as cries, laughter, sneezes, etc), and Non-vocal sounds (non-vocal environmental sounds that babies are likely to be familiar with, such as toy sounds and water sounds). The multi-channel NIRS sensor pads were placed over an area covering part of the temporal and inferior frontal cortices (bilaterally). At 14 months, these infants' primary caregiver completed the MacArthur-Bates Communication Development Inventory to assess their receptive and expressive language development. We are reporting data from 52 infants. FNIRS results showed voice-sensitive activation in the anterior temporal cortex. The degree of voice-sensitivity in this region increased with age between 4 and 7 months but did not correlate with CDI scores at 14 months. However, infants with higher vocabulary scores at 14 months showed more widespread activation to vocal and non-vocal sounds at 4 to 7 months. These results suggest that a neural reactivity to sounds in infancy, rather than voice-sensitivity, may lead to better language development in toddlerhood.

A30 Predictive coding mediates word recognition and learning in 12- and 24-month-old children

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For children, the second year of life is a period of rapid word learning. However, the neural mechanisms for recognizing familiar word forms and detecting unfamiliar word forms during this period are not fully understood. It has been proposed that adults identify spoken words using predictive coding, whereby upcoming speech sounds in words are predicted on the basis of long-term memory word representations, which are activated by previous speech sounds encountered in those words. We hypothesize that similar mechanisms are used by children who are constantly confronted with novel word forms and need to rapidly activate existing word representations, which requires an efficient neural mechanism for distinguishing between familiar and unfamiliar word forms. To determine whether predictive coding mediates word recognition and learning in young children, we collected 12- and 24-month old children's (N=10 and 14, respectively) vocabulary scores with communicative development inventories and recorded their auditory event-related brain potentials (ERP) to the same target syllables in isolation (e.g., [k□]) and within context (e.g., [ku] [k□], together forming the word [kuk:□]). In the context condition, the target syllables completed either a familiar or an unfamiliar word form ([kuk:□] 'flower' or [kuk:e] with no meaning, respectively). As compared to no context condition, the context condition was hypothesized to allow more

efficient processing of the target syllables due to word-level predictive coding, which was expected to be reflected in ERP response patterns. Consistent with this hypothesis, the results show that 12- and 24-month olds' brain responses to syllables are faster and more robust when the preceding word context predicts the word ending, and that these brain responses differ in both latency and polarity for familiar and unfamiliar word forms. These findings suggest that predictive coding mediates word recognition in children. For unfamiliar, novel word forms, however, predictive coding results in a word-expectancy violation and generates a prediction error response, the strength of which significantly correlates with children's vocabulary scores at 12 but not 24 months. Based on these results, we argue that predictive coding serves as the neural mechanism not only for word recognition, but also for the early learning of novel word forms, suggesting the same learning mechanisms in humans and non-human animals.

A31 Fading out a foreign language *Jon Andoni Duñabeitia[1], Manuel Carreiras[1,2,3], Alejandro Pérez[1]; [1]Basque Center on Cognition, Brain and Language (BCBL); Donostia, [2]Ikerbasque, Basque Foundation for Science; Bilbao, [3]University of the Basque Country; Bilbao*

Neuronal oscillations play a key role in auditory perception of verbal inputs. Recent research has shown that the oscillatory rhythms of the brain synchronize with specific frequencies of speech in native language contexts. The current electrophysiological study investigated the synchronization patterns of non-balanced bilinguals' neural oscillatory activity associated with the spontaneous perception of native speech compared to non-native speech, in order to shed light on the similarities and differences between speech-brain synchronization under different intelligibility conditions. Neural synchronization to the native language (Spanish) as measured by spectral power was compared to neural synchronization to a known and to an unknown foreign language context (English and French, respectively) in a group of non-balanced Spanish-English bilinguals. Participants completed a visual discrimination task while the auditory input was orthogonally manipulated, including long speech segments in Spanish, English and French (as well as a silent context condition for control purposes). The speech segments were matched for length, content and phase patterns. Behavioral results showed that participants spontaneously paid attention to the auditory content in the native and known foreign language contexts, as attested by their discriminability indices in a recall test performed at the end of the experimental session. Electrophysiological results showed local synchrony exclusively to native speech in frequency ranges corresponding to the theta and beta-low bands. Critically, no synchronization was found for both known and unknown non-native speech contexts, and the results from the two foreign language contexts did not differ from those obtained in the silent context. Furthermore, a correlation analysis between the relative synchronization in theta and beta-low bands for the native and for the known foreign language conditions and the results in the recall test showed that higher discriminability indices were associated with larger synchronization values exclusively in the native language context. These results constrain recent neurobiological models of speech processing demonstrating that the neural synchronization pattern of non-balanced bilinguals' brain is markedly different for the native and non-native language, and suggest that a native-like level of proficiency may be needed in order to elicit neural synchronization.

A32 Eye-tracking reveals incremental processing of words in 18-month-olds *Angelika Becker[1], Ulrike Schild[2], Claudia Friedrich[2]; [1]University of Hamburg, [2]University of Tübingen*

Former research showed that already 6–month-olds use word onset syllables to predict upcoming words in spoken word onset priming (Becker et al, 2014). However, there were no ERP signs of adult like lexical access in the first two years of life. The question emerges whether word onset priming in infants reflects access to word forms and their meaning, or whether word onset priming basically reflects phonological expectancy and matching mechanisms in infancy. In the present eye tracking study, 18-month-olds heard spoken word onsets, which were directly followed by visual displays of two objects. One of the depicted objects was the primed target; the other object was a distractor item. Children's eye movements showed a bias towards the target object. That is, the prime appears to pre-activate the target word in the children's lexicon up to a meaning level. This is evidence for incremental word processing in very young children. Together with our previous ERP findings the present eye tracking data suggest comparable incremental access processes but pre-mature lexical representations in very young children.

A33 Out of use, out of mind? First language processing in a Dutch emigrant population in Anglophone North America *Bregtje Seton[1], Susanne M. Brouwer[2], Laurie A. Stowe[1], Monika S. Schmid[1,3]; [1]University of Groningen, [2]Utrecht University, [3]University of Essex*

Research in bilingual language processing often focuses on the second language of a bilingual population. The first language (L1) of these bilinguals is less well studied. The current study addresses the question of whether first language processing changes due to emigration to another country, and when the second language has become the dominant one, leading to language attrition. Previous research has focused mostly on language production and has used only behavioral methods. L1 attriters have for example been shown to have difficulties with lexical access, and to make more mistakes and have longer reaction times in picture naming tasks. In the present study we used an Event-Related Potential (ERP) paradigm to investigate the language processing of a group of Dutch attriters, who used English as their dominant language. A group of Dutch attriters (N=50, age of emigration: 5 - 48 years old, length of residence: 5 - 56 years) and a control group of Dutch native speakers in the Netherlands (N=28) took part in an auditory ERP experiment, in which they were presented with sentences that contained violations in grammatical gender

(e.g.,het/*de huis, the house) or in non-finite verb forms (e.g., lopen/gelopen, to walk/has walked). Data were analyzed employing standard ERP analysis methods. The Dutch native speaker control group showed the typical P600 response to both types of violations. In a preliminary analysis of the attriters, the results show that processing the Dutch language is still very native-like in most of the attriters who arrived in Canada after age seventeen, although all of the participants had become dominant in English and did not speak much Dutch anymore. In a small subgroup of attriter participants who arrived between the ages of six and twelve, the lack of a systematic P600 effect in the grammatical gender condition suggested that their processing was less native-like. This could be due to incomplete acquisition of Dutch and a lack of entrenchment of the language. A shift in language dominance from the first to the second language does not apparently mean that language processing of the first language becomes less native-like, even if a change can be detected behaviourally. However, there is large individual variation between participants in our data. The data set is being analyzed with respect to a large amount of background variables on language use and attitudes which have been shown to affect attrition in earlier studies. With this, we hope to tease apart the effect of these different variables on the data.

A34 Neural reflections of individual differences in artificial grammar learning

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How does the brain reflect the process of learning a new language? In numerous studies, the effects of artificial grammar or natural language learning on the state of the brain have been investigated, but mostly after learning was completed. In the present study, neural activation during auditory exposure to an artificial grammar containing non-adjacent dependencies was measured using functional Magnetic Resonance Imaging (fMRI), thus enabling us to study learning from mere exposure in real time. Twenty right-handed, healthy adults (12 male, mean age: 28 (range: 18-43)) participated in the present study. In a two-phase fMRI experiment, participants first listened to an artificial grammar and a control language, which were presented through headphones while a GE-EPI time-series was acquired. The artificial grammar contained non-adjacent dependencies, while the control language had the same syllable structure and phonology, but lacked these dependencies. This exposure phase was followed by a task where participants were asked to make grammaticality judgments on items that either belonged to or violated the grammar, thus testing learning and generalization of the artificial grammar. In addition, resting state data were acquired before and after the exposure phase in order to determine the influence of artificial grammar learning on functional connectivity between brain areas known to be involved natural language processing. Regression analyses showed a correlation between the success with which individual subjects were able to reject violations of the grammar and neural activation in the bilateral Inferior Frontal Gyrus (IFG) and the bilateral Superior Temporal Gyrus (STG) in response to the grammar containing non-adjacent dependencies compared to the control condition. This result was confirmed by the main effect of condition, which was only present for the group of participants that most successfully rejected the violations. Furthermore, resting state data showed connectivity differences between more and less successful learners in the network where the correlation was shown. The correlation between discrimination success and brain activation is unlikely to result from explicit learning in part of the participants, because scores on the post-exposure test were around or just above chance, which shows the grammar was never fully learned. In accordance with previous studies (McNealy et al., 2006; 2010), these results show neural reflections of artificial grammar learning before any learning can be detected with behavioral methods. Because activation was not only linked to learning success in the left IFG, but also in its right hemisphere homologue and the bilateral Temporal lobes, our study indicates that these areas are also involved in artificial grammar learning. Furthermore, the individual differences in activation as well as functional connectivity in an experiment where exposure times are short indicate that individual differences in language learning might result from differences in neural recruitment that develop early in the learning process.

A35 Infants can perceive audiovisual speech asynchrony (if it's asynchronous enough)

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Speech perception is multimodal, such that when hearers receive information from speakers, it is in both the auditory and visual modalities. Extensive research has been done to establish the window of audio/visual offset which adult hearers will tolerate; this is called the temporal-binding window. Until recently, however, little was known about the developmental changes that take place prior to reaching the adult-like state. Recent research has demonstrated that audiovisual integration develops relatively slowly; children are much less sensitive to asynchrony between the audio and visual signals than are adults (Hillock et al., 2011). However, research on the youngest perceivers—infants—has employed the simplest of stimuli, such as single CV-syllables (Lewkowicz, 2010), to assess their temporal binding sensitivity. In the current study, we used more realistic (i.e., longer) stimuli (trisyllabic pseudowords) to providing a more ecologically-valid test of infants' sensitivity. Twenty-four infants, 5-to-9 months of age, were presented with two counter-balanced video blocks, one synchronous and the other asynchronous. For synchronous blocks, audio and visual signals were simultaneous. In asynchronous blocks, the audio signal preceded the visual signal by 300ms. Infants were median-split into younger (M = 5.94 months) and older (M = 8.02 months) age groups. A 2 (age: younger, older) x 2 (word type: visible, less visible) x 2 (proportion of looking: synchronous, asynchronous) mixed-model

ANOVA was conducted. There was a main effect of word visibility and age, with both groups of infants preferring to look at visible articulations regardless of audiovisual synchrony and younger infants looking more overall, $p < .05$. The older infants looked longer to asynchronous presentations when the word was highly visible, $p < .05$. We suggest that infants' emerging sensitivity to audiovisual timing is driven by the causal relationships between articulators and the sounds produced. This supports the view that the window of tolerance for audiovisual signal offset increasingly tightens in developmental time. Future work will focus on changes in the neural architecture that allow multiple streams of information to be bound into a single percept.

A36 Adult listeners shift their established phoneme boundaries after 9 minutes of distributional training: evidence from ERP measurements

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Humans learn from statistical distributions of sounds (Maye and Gerken, 2001; Maye et al., 2008; Escudero et al., 2011). Previous studies usually exposed one group of listeners to a bimodal and another to a unimodal/none distribution and found that after training, the bimodal group discriminated the 'trained' dimension more successfully than the others. However, when acquiring a language, learners not only have to create new categories, but often need to adjust their already existing category boundaries, a scenario that has not yet been addressed in distributional training studies. In addition, most distributional learning studies have focused on dimensions with contrastive status in the listeners' native language, and have not usually considered non-native novel dimensions (but see Goudbeek et al., 2008). We therefore tested whether distributional training can lead to adjustment of native categories along an old dimension, and to creation of novel categories along a non-native novel dimension. 40 Spanish listeners participated: 20 were trained to shift their native category boundary along a native dimension, namely vowels' first formant (F1), while the other 20 were trained to create categories on a novel dimension, namely vowel duration. An oddball paradigm measured listeners' pre-attentive discrimination before and after training. For the F1-oddball, the Standard had F1 values representative of the Spanish /i/-/e/ boundary, while the two Deviants had F1 values typical for Spanish /i/ (Deviant1) or /e/ (Deviant2). For the duration-oddball, the Standard had duration values representative of a perceptual boundary between a short and a long [I]-vowel (non-native), while the two deviants were a short (Deviant1) and a long (Deviant2) version of this vowel. During training, listeners were exposed to a bimodal distribution of sounds along F1 or duration. Within either dimension-group, half of the participants listened to a bimodal distribution with a trough (corresponding to a category boundary) at low F1 or duration values, and the other half listened to a bimodal distribution with a trough at high F1 or duration values ('low-boundary' and 'high-boundary' groups, respectively). If listeners learn from these distributions, the trough locations should affect listeners' pre-attentive discrimination of stimuli at post-test. Specifically, for the low-boundary training groups, Standard and Deviant2 should be perceived as one category and Deviant1 as the oddball, while for the high-boundary training groups, Deviant2 should be the oddball. MMR was computed as post-test minus pre-test responses to physically identical stimuli. MMR amplitude was measured in a 100-200ms window post deviation-onset. We found a significant three-way interaction of Dimension, BoundaryLocation and DeviantType ($F[1,36]=4.418$, $p=.043$). The trained boundary locations were reflected in the MMR responses for F1 (i.e. the old dimension): Deviant1 yielded larger MMR than Deviant2 for the low-boundary training group, and vice versa for the high-boundary group. For duration, both deviants elicited comparable MMRs irrespective of the trained boundary-location. These findings demonstrate that adults successfully learn to shift their native phoneme boundaries after short pre-attentive distributional training. Creation of categories on novel dimensions seems viable but the acquisition of exact boundary locations may be more demanding for novel than for old dimensions.

A37 Auditive training effect in children using a dichotic listening paradigm. A pilot study.

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Introduction. Along with language development, there is a gradual shift in brain lateralization dominance for language towards the left hemisphere. A frequently asked question is to what degree atypical brain lateralization interacts with developmental language impairments such as specific language impairment (SLI) and dyslexia. If there is a significant interaction, one may speculate that early intervention to stimulate language lateralization should be applied in these impairments. Due to the predominance of the contralateral neuronal pathways, a right ear advantage (REA) in the dichotic listening (DL) task reflects the superior processing capacity for the right ear stimulus in the left hemisphere. DL analyses can be carried out according to correct scores, a laterality index (LI) and ear advantage. This study examined the effects of auditory training in typical children with DL involving consonant-vowel (CV) syllables. A new mobile device (MD) version made it possible to carry out training with DL using iPods. The aim was to see if training with DL would alter the response pattern in children. Method. Participants in the study were 30 eight-year-olds assessed with the DL using the MD version with headphones and touch screens. The subjects listened to 36 stimuli combinations of the CV-syllables /ba/, /da/, /ga/, /pa/, /ta/, /ka/, including six homonym pairs, presented simultaneously in both ears using the three classical conditions non-forced (NF), forced right (FR) and forced left (FL). A control group (M/F: 10/5) and a training group (M/F: 8/7) were tested pre and post a training period. The training group trained collectively once a day (10 minutes) for five days using the earlier

described paradigm. Controls received no training. The scores were subjected to factorial analyses of variance (ANOVA) with the design group (Control, Training) by ear (right, left) by test (pre, post). Also, ear advantage pre and post testing was reported. Results. The training group showed a significantly higher posttest left ear score in the FL condition compared to their pretest scores and also to the pre- and posttest scores of the control group. This effect was also seen in the LI scores but not in the NF and FR scores. Thus, the results showed significant training-related effects for the FL "top-down" (cognitive-driven control) training, but not for NF "bottom-up" and FR (stimulus-driven attention) training. Discussion. The results indicate that training with the DL paradigm can modulate children's cognitive control. Although SLI and dyslexia are impairments associated with left hemisphere language functions, studies also point to impaired executive functions in these impairments. One may speculate that a longer period of DL training could improve not only the "top down" but also the "bottom-up" driven language function in these impairments. Also, as pragmatic language impairments are seen in attention deficit disorders, one may speculate that auditory training could be beneficial to these groups as well.

A38 Functional connectomes in monolingual and bilingual infants during resting state

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Resting state functional connectivity networks reflect synchronized spontaneous activity of spatially distant areas in the human brain and are essential to understand the intrinsic relationship between brain regions that are functionally related. Additionally, spontaneous resting state brain activity is linked with certain cognitive functions (such as attention, working memory, executive control, etc) in monolingual adults. Moreover, a limited number of studies have demonstrated that resting-state networks of young monolingual infants are adult-like. Recent behavioral and neurophysiological investigations with infants have shown that early exposure to one vs. two languages affects infants' performance in both linguistic and non-linguistic (cognitive) tasks. These findings suggest that certain environmental factors, such as bilingual or monolingual language exposure, affect not only language development but cognitive development as well. Currently, it is unclear whether bilingual language exposure, as an environmental factor, would also modify the early development of spontaneous brain activity. In our laboratory, we previously found that Spanish monolingual and Spanish-Basque bilingual infants respond differently to their native speech as reflected by hemodynamic responses measured using near-infrared spectroscopy (NIRS). For instance, bilingual infants demonstrate temporal responses across both hemispheres when listening to their native languages; however, monolingual infants' show a significant activation in the left hemisphere only in response to their native language (Spanish). Therefore, it is a possibility that certain resting-state activity as well (e.g., involving the bilateral auditory cortex) are calibrated differently across monolingual and bilingual infants in order to adapt to different linguistic environments (monolingual vs. bilingual) during development. In the present study, using NIRS, we measured temporal correlations in hemoglobin changes between brain regions during resting state (while the infant was awake but not engaged in any specific task) in 4-month-old Spanish monolingual and Basque-Spanish bilingual infants. A functional connectome for each infant was created by computing measures of signal correlation across 52 channels. Parametric and permutational non-parametric statistics were used to infer significant differences between the average functional connectomes of each group. Our preliminary results indicate that monolingual and bilingual infants, already at 4 months of age, exhibit different resting state activities. Specifically, analyses for bilingual infants showed a large number of intra-hemispheric and inter-hemispheric connections especially over frontal and temporal regions; while monolinguals showed less connections and a different connectivity pattern with most connections being localized in frontal and occipital regions. Our results suggest that early and continued exposure to a bilingual environment might require the participation of additional brain areas and that this extra activation might influence the configuration and the development of the resting state functional brain networks.

A39 White matter disruption and language processing in traumatic brain injury

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Objective Diffuse axonal injury is a common finding after traumatic brain injury (TBI). Consequently, diffusion tensor imaging (DTI) has been considered as a potential biomarker in TBI as it can detect white matter changes. People with a TBI often have cognitive- communication deficits that significantly impair their lives. Cognitive-communication processing depends not only on grey matter, but also on the white matter fiber bundles that connect the language related cortical regions. To date, little is known about white matter disruption and how this relates to language. We undertook an MRI study to investigate this relationship in moderate to severe TBI patients. The primary objective of the study was to characterize white matter integrity using DTI in a group of TBI compared to a group of healthy controls. A secondary objective was to examine the relationship between white matter integrity and cognitive-communication skills. Methods We used diffusion tensor imaging in 16 individuals: 8 moderate to severe chronic TBI patients and 8 controls, matched on age (aged between 18 and 62 years-old). Cognitive-communicative skills were evaluated using the Protocole MEC (1) (conversation; orthographic, semantic and

without constraint fluency tasks; indirect speech acts; narrative discourse comprehension) and LaTrobe questionnaire (2). DTI were acquired on a 3T Siemens Trio scanner with an eight-channel coil. DTI parameters consisted of 65 noncollinear directions (b value= 1000, one unweighted image, TR=9500 ms, TE=93 ms, 120 X 120 matrix, 240 mm FOV, 2 mm slice thickness). Probabilistic tractography (performed using FSL) was used to identify the inferior longitudinal fasciculus (ILF) and uncinate bilaterally. Regions of interest were defined in the native diffusion space on the fractional anisotropy (FA) and colour-coded maps using the seed regions proposed by Galantucci et al. (3). We compared the tracts' mean fractional anisotropy (FA) as well as mean and radial diffusivities using the Mann–Whitney U test (non-parametric). Partial correlations were also calculated between the DTI metrics in significantly impaired tracts and cognitive-communication skills in the TBI patients. Results At the behavioural level, TBI patients showed impairments in all cognitive-communicative measures (conversation TBI patients showed diffusivity abnormalities in the ILF bilaterally whereas diffusivity measures were not significantly different than controls in the uncinate bilaterally. Moreover, FA was significantly lower in the right ILF in the TBI patients compared to controls. However, none of the diffusivity or FA measures in the ILF bilaterally were correlated with the cognitive-communication measures in the TBI patients. Conclusion These findings suggest that both FA and diffusivity are important to reflect differences in the white matter pathology in TBI patients. Furthermore, probabilistic tractography provides evidence that structural compromise to bilateral tracts is associated with cognitive-communication impairments in TBI patients. 1. Joanette Y., Ska B., & Côté H. Protocole MEC. Isbergues, France: Ortho Édition, 2004. 2. Douglas J. M. et al. (2000). Measuring perception of communicative ability: the development and evaluation of the La Trobe communication questionnaire. Aphasiology, 14(3), 251-68. 3. Galantucci S. et al. (2011). White matter damage in primary progressive aphasias: a diffusion tensor tractography study. Brain, 134(10), 3011-29.

A40 Depth of encoding through gestures in foreign language word learning

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Laboratory research has demonstrated that gestures enhance memory for verbal information compared to audio-visual learning in native and foreign language (L2). The enhancement produced by gestures is often discussed in terms of depth of information encoding. However, the neural base of depth of encoding is poorly understood. The literature in the field considers mainly two possibilities: one attributes depth of encoding to increased activity in brain areas specialized in semantic processing; the other, to the recruitment of multiple cortical areas, including motor regions. A recent review provides evidence for the thesis that word encoding leads to immediate neocortical involvement, i.e., to the formation of a memory trace in which, critically, the hippocampus is not involved. Accordingly, in L2 learning with gestures, depth of encoding could be specified in terms of involvement of sensorimotor brain areas. Here we employ magnetic resonance imaging to investigate encoding of L2 words. We hypothesize that encoding novel words with different modalities leads to the immediate formation of experience-related word networks in the cortex; topographically they reflect the kind of stimulus processed. In the scanner, 32 participants learned 30 words of Vimmi, an artificial corpus created for experimental purposes in order to avoid associations with languages known to participants. The words were presented according to three learning conditions (10 items each): 1) visual (V): written word in Vimmi and written word in German; 2) audio-visual (AV): written word in Vimmi, written word in German, acoustic presentation of the Vimmi word; 3) sensorimotor (SM): written word in Vimmi, written word in German, acoustic presentation of the Vimmi word, and video showing an actress performing an iconic gesture. All contrasts among conditions provided evidence for the recruitment of stimulus-specific cortical areas during encoding. Specifically, the contrast between the baseline (silence) and V shows besides the involvement of the left Broca's area visual areas. In the contrast AV versus V, we found activity in auditory cortices. Finally, in contrasting brain activity between the SM and AV-conditions, we detected significant activity in pre-motor cortices. Our fMRI study showed experience-dependent processing that possibly leads to the immediate formation of experience-dependent word networks; however, we also found hippocampal activity. After scanning, participants completed a free-recall test. Words encoded in the SM-condition were significantly better memorized than words encoded visually and audio-visually. Our behavioral results confirm previous studies on the positive effect of gestures on memory for words in L2. Our fMRI data provide evidence that mere observation of gestures engages sensorimotor brain areas during encoding of verbal information. Accordingly, depth of encoding through gestures involves recruitment of multiple brain areas, specifically sensorimotor cortices.

Lexical Semantics

A41 An electrophysiological investigation of the distractor frequency effect in picture-word interference

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The 'distractor-frequency effect' refers to the the finding that high-frequency (HF) distractor words slow picture naming less than low-frequency distractors (HF) in the picture-word interference (PWI) paradigm. Two rival accounts for the effect place its locus at lexical and post-lexical levels of processing, respectively. The first is a competitive lexical selection account that implements an early attentional distractor blocking mechanism sensitive to lexical frequency to ensure the picture name response is selected [1], while the second account assumes

distractors enter an articulatory buffer as phonologically well-formed responses, and a decision mechanism (most likely the verbal self-monitor) excludes the HF distractor representations more quickly (e.g., [2]). Using high density (128 channel) electroencephalography (EEG), we tested hypotheses from these rival lexical and post-lexical selection accounts. In addition to conducting stimulus- and response-locked whole-brain corrected analyses, we targeted the correct-related negativity (CRN), an event-related potential (ERP) observed on correct trials at fronto-central electrodes that has been associated with response monitoring. Analysis of naming latencies revealed pictures were named significantly slower with LF than HF distractor words. The whole-brain ERP analysis of the 500 ms following stimulus onset a revealed significant effect of distractor frequency at two right inferior frontal (C6 and C7) and one right temporal site (B25). The Laplacian-transformed ERPs started to diverge at around 100 ms post-stimulus onset and the difference remained until around 300 ms post-stimulus. Although the topographies of the difference-wave showed earlier left frontal and temporal foci, no significant differences were found at those sites. Response-locked region of interest (ROI) analyses of fronto-central electrodes revealed a component starting 121 ms before and peaking 125 ms after vocal onset on the grand averages. Irrespective of distractor frequency condition, its slope was significantly different from zero on the 200 ms time-window centered on vocal onset. The slope analysis also revealed a significant difference between HF and LF distractor words, with the former associated with a steeper slope than LF distractor words on the time-window spanning from 100 before to 100 ms after vocal onset. The relatively late time-window for these results is consistent with a post-lexical account of the distractor frequency effect. However, the presence of early ERP effects spanning the time-window typically attributed to lexical selection processes suggests the distractor frequency effect is most likely associated with more than one physiological mechanism. The right frontal topography of these effects may be in agreement with an early inhibition mechanism of the distractor words [3]. [1] Roelofs, A., Piai, V., & Schriefers, H. (2011). Selective attention and distractor frequency in naming performance: Comment on Dhooge and Hartsuiker (2010). Journal of Experimental Psychology: Learning, Memory, and Cognition, 37, 1032-1038. [2] Dhooge, E., & Hartsuiker, R. J. (2010). The distractor frequency effect in picture-word interference: Evidence for response exclusion. Journal of Experimental Psychology: Learning, Memory, and Cognition, 36, 878-891. [3] Xue, G., Aron, A. R., & Poldrack, R. A. (2008). Common Neural Substrates for Inhibition of Spoken and Manual Responses. Cerebral Cortex, 18, 1923-1932.

A42 Investigating the processing of conceptual components in language production

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According to frame-theory, concepts can be represented as structured frames that contain conceptual attributes (e.g., 'color') and their values (e.g., 'red'). A particular color value can be seen as a core conceptual component for high color-diagnostic (HCD) objects (e.g., bananas or tennis balls) which are strongly associated with a typical color, but less so for low color-diagnostic (LCD) objects (e.g., bicycles or tulips) that exist in many different colors. Theories of language production differ with respect to whether conceptual components or attributes can affect lexical access. To investigate whether the availability of a core conceptual component (color) affects lexical access in language production, we conducted two experiments on the naming of visually presented HCD and LCD objects. Confirming previous findings in the literature, Experiment 1 showed that, when naming latencies were matched for color versions of HCD and LCD objects, achromatic versions of HCD objects were named more slowly than achromatic versions of LCD objects. In Experiment 2 we recorded ERPs from 32 participants while they performed a picture-naming task, in which achromatic target pictures were either preceded by an appropriately colored box (primed condition) or a black and white checkerboard (unprimed condition). We focused on the P2 component, which has been shown to reflect difficulty of lexical access in language production. Results showed that color priming and high color-diagnosticity resulted in slower object-naming and a more pronounced P2. ERP waveforms on the P1, P2 and N300 components showed a priming by color-diagnosticity interaction, the effect of color priming being stronger for HCD objects than for LCD objects. The effect of color-diagnosticity on the P2 component suggests that the slower naming of achromatic HCD objects is (at least in part) due to more difficult lexical retrieval. Hence, the color attribute seems to affect lexical retrieval in HCD words. The interaction between priming and color-diagnosticity indicates that priming with an attribute hinders lexical access, especially if the attribute is a core attribute of the target object.

A43 Classifier Information Affects Speech Production: Electrophysiological Evidence from Overt Speech in Mandarin Chinese

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The current study investigated the role of classifier selection in speech production in Mandarin Chinese, i.e. how is a nominal classifier retrieved and encoded in speech production? does it behave as a functional or semantic element? This study asked native Mandarin speakers to name pictures using the picture-word interference paradigm in bare noun naming and noun phrase naming tasks while measuring their reaction times and electroencephalogram. Semantic category congruency and classifier congruency between distractor words and target pictures were manipulated. Reaction time results of bare noun naming yielded the semantic interference effect, i.e. longer naming latencies were observed when the distractor word was from the same

semantic category as the target picture, compared to the unrelated condition; no classifier effect was observed in the first task. Participants also named the same pictures in a noun phrase consisting of the elements "one + classifier + noun". In this task, the distractor words that had the same classifiers as those of the target pictures facilitated picture naming, showing a classifier congruency effect. Bare naming showed stronger N400 effects when the distractor (e.g. duck) and the picture name (e.g. hand) belonged to different semantic categories, compared to when the distractor (e.g. foot) was from the same category as the picture name. Furthermore, stronger N400 effects, starting slightly later than the semantic category effects, were also observed when the classifier of the distractor was incongruent (e.g. classifier-ge4, head) with the picture name (e.g. classifier-zhi1, hand), compared to the congruent condition (e.g. classifier-zhi1, duck). These results provide evidence supporting a semantic account for nominal classifiers in Mandarin Chinese and the hypothesis that our brain retrieves and encodes linguistic information in a sequential manner – semantic congruency occurs at an earlier stage whereas classifier congruency affects a later stage in speech production.

A44 Visually perceived spatial distance modulates an early neural response to different semantic relations

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Evidence from recent behavioral studies suggests that visually perceived distance can modulate how people process conceptual similarity. For instance, written words presented farther apart were rated as less similar compared to those presented closer together (Casasanto, 2008). More recently, an eye-tracking study showed that first-pass reading times for sentences expressing similarity between two abstract nouns were faster when preceded by two objects presented close together (vs. farther apart), and the opposite pattern was observed for sentences expressing dissimilarity (Guerra & Knoeferle, 2012). These behavioral data suggest a link between spatial distance and conceptual similarity, which can affect offline and online conceptual processing. However, the nature of these perceptual effects on conceptual processing remains unclear. We capitalized on the temporal precision of event-related brain potentials (ERPs) to examine how and when perception of spatial distance modulates online processing of conceptual similarity. Specifically, we evaluated the electrophysiological response to word pairs with different semantic relations (SYNONYMS, ANTONYMS, or UNRELATED) preceded by objects moving apart vs. closer together. Studies have shown that compared to unrelated word pairs, opposites and related words exhibit reduced amplitudes at the N400, a component sensitive to the semantic fit of words with their contexts (Federmeier, Kutas, & Schul, 2010; Kutas & Hillyard, 1989). Thus, we predicted an overall reduction in N400 amplitude for OPPOSITES relative to all other conditions and for SYNONYMS relative to the UNRELATED condition. Additionally, we expected modulations of electrophysiological responses to word pairs based on the spatial distance manipulation. To the extent that these effects are driven more by differences in perceptual and/or attentional processing, we would expect an interaction of card and word type in an early ERP component, sensitive to perceptual/attentional processes (e.g., P2); if effects are driven largely by differences in conceptual processing, we would expect this interaction to occur somewhat later (e.g., at the N400). We recorded the electroencephalogram at 26 scalp locations as participants (N=25) viewed probe-target word pairs from three experimental conditions, (SYNONYMS, ANTONYMS, or UNRELATED target words relative to a common probe word) and decided whether or not they were antonyms. Each word pair was preceded by two playing cards moving from a fixed starting point either apart or closer together. ERPs time-locked to target words were analyzed using a repeated-measures ANOVA with card type, word-pair type, and channel (26 levels) as factors in critical time windows: P2 (150-250 ms) and N400 (300-500 ms). We replicated the expected main effect of word-pair type on N400 amplitude but observed no reliable effect of spatial distance or interactions between word-pair type and distance in this time window. However, the spatial distance manipulation did modulate the amplitude of the P2 component, an earlier, visually-evoked component sensitive to attention to (as well as predictability of) visual word form features. The spatial distance effect on P2 amplitude differed between word-pair types, but only when the cards moved closer together. These preliminary results suggest that attention to spatial distance might affect early brain responses to words, depending on the semantic relationship between them.

A45 Interference from related actions in spoken word production: an fMRI study

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The majority of behavioural and neuroimaging investigations of lexical access in spoken word production have employed object naming paradigms. Relatively few have investigated the processes and neural mechanisms involved in action naming. These latter processes are likely to be more complex, due to the ways in which the conceptual features and grammatical properties of action words are represented. In the present study, we employed the blocked cyclic naming paradigm to determine whether action naming would demonstrate a semantic interference effect similar to that observed for categorically-related context objects. In order to avoid a potential confound with transitive actions and related object categories, we employed pictures of intransitive actions involving the face, arm, leg or whole-body (e.g., shouting, running, waving, resting). Our results show intransitive actions were named significantly slower in homogenous vs. heterogeneous contexts from the second cycle onward. We replicated this interference

effect during a perfusion fMRI experiment that revealed significant perfusion signal decreases (i.e., homogeneous < heterogeneous) in a large left hemisphere, temporo-parietal network. This network comprised both mid and posterior portions of the left middle temporal gyrus (MTG), the left supramarginal (SMG) and angular gyri (AG) in the inferior parietal lobe (IPL), and the posterior hippocampus. These results are consistent with a proposed role for the left IPL in the representation of action features, and could be accommodated within existing models of spoken word production based on object naming that attribute relatively persistent semantic interference effects to an incremental learning mechanism operating in the connections between conceptual features and lexical-level representations.

A46 Neural dynamics of lexical-semantic processes during word production: Action verbs, action nouns and object nouns

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Numerous studies reported category-specific neural modulations during comprehension of words from different semantic categories. The spatial topographies and time-course of these effects were taken to suggest that lexical-semantic processes are mediated (in part) by category-specific sensory/motor areas of the brain. In word production, the counterpart of such effects is found in the dissociation between action verbs and object nouns in brain-damaged patients and in brain-imaging studies showing differential activations in healthy subjects. However, although action verbs and object nouns differ in semantic attributes, they also belong to different grammatical categories. Theories of lexical access have attempted to specify the relation between syntactic, semantic and word form representations, yet, whether the dissociation observed pertain to lexically (grammatically) or semantically driven processes is still a matter of debate. Determining the locus and nature of the dissociation between action verbs and object nouns is thus of crucial interest. A valid way to explore this issue is to manipulate the grammatical class within a fixed semantic category. Hence, using a picture naming task, we investigated event-related potentials (ERP) modulations to action verbs (naming a verb from the picture of an action), action nouns (naming a noun from the picture of an action) and object nouns (naming a noun from the picture of an object). Action and object pictures were balanced on pre-linguistic psycholinguistic factors such as image agreement, conceptual familiarity, image variability or visual complexity and the corresponding action verbs/nouns and object nouns were matched on lexical frequency, length and first phoneme. We found significant longer production latencies for action nouns compared to action verbs and object nouns. Interestingly enough, ERP analyses (stimulus-aligned and response-aligned) did not show any difference between action verbs and action nouns. By contrast, waveform amplitudes significantly differed between action verbs and object nouns in the time-window ranging from 280 to 400 ms after picture presentation principally over left lateralized temporal electrodes. The topographic analysis using spatio-temporal segmentation also indicated different topographies in the 320-400 ms period. Altogether, our results show that production of action verbs and object nouns differed in a time-window ranging from 300 to 400 ms that was not sensitive to grammatical manipulation as evidenced by the absence of difference between action verbs and action nouns. This suggests that the dissociation between action verb and object noun in word production seems to be semantically driven while grammatical class might not be encoded as such.

A47 Similarities and differences in the semantic representations of words and objects: evidence from multi-voxel pattern analyses

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Understanding the meaning of words and objects (e.g. "apple") requires the activation of underlying conceptual representations. The view that such representations are invariant with respect to the nature of the stimulus is supported by neuroimaging evidence of activation in common regions for both words and objects (Bright et al. 2004; Martin, 2007; Vandenberghe et al. 2007). However, common activation is not sufficient to conclude that these regions represent and process the same information for words and objects. A stronger test for modality-invariant semantic representations is provided by multivoxel pattern analysis (MVPA), which, further to identifying regions involved for both words and objects, also allows us to characterize the similarity of information content in those regions across modality. We ask whether representations are invariant across modalities in an fMRI study where words and pictures representing 60 concepts were presented. For both modalities, participants responded with a category-level name for each item (e.g. "fruit"). Activation maps for each word and object were extracted and used as input to three searchlight-based MVPA techniques, which aimed to relate the representational structure for both modalities to each other as well as to visual and semantic models. We first used representational similarity analyses (RSA). In this model-driven approach, representational dissimilarity matrices (RDMs) were computed which captured visual properties of the words and objects and the semantic category structure common to both. These were then correlated with searchlight activation RDMs. The second analysis also used RSA, but tested seed activation RDMs taken from one modality against the independent data for the other modality. The final analysis was a novel data-driven method, using cluster analysis to identify regions of shared information content across modalities. RSA revealed correlations between the visual model RDMs and the dissimilarity patterns in visual cortex for both words and objects. For the semantic RDM, there was an extensive left-lateralized network of significant correlations for the object data, including the left fusiform gyrus, left lateral occipital complex, left posterior middle temporal gyrus (LpMTG) and left intraparietal sulcus (LIPS). The word data showed significant correlations more anteriorly into left MTG, but no significant correlations in the fusiform. There were also significant

correlations in LpMTG and LIPS, as for the objects, suggesting these regions may form part of a core semantic network activated during semantic processing of both words and objects. However, a more nuanced view emerged with the seed-based RSA, revealing important differences in LpMTG and LIPS: whilst LIPS representations for words and objects were relatively invariant, word and object RDMs in LpMTG were uncorrelated. This was confirmed by the data-driven cluster analysis, which showed that the representations computed in LpMTG did not cluster together across modality. These results suggest that whilst LpMTG may be involved in semantic processing for both modalities, it may play different functional roles in the semantic processing of words and objects. The results go beyond identifying regions involved in semantics and show how the computational properties of a region vary as a function of the processing in which it is engaged.

A48 Oscillatory responses to highly predictable words differentiate between expectations based on semantic or associative contextual constraints. *Irene Fernandez Monsalve[1], Alejandro Perez[1], Nicola Molinaro[1,2]; [1]Basque Center on Cognition, Brain and Language (BCBL), [2]Ikerbasque, Basque Foundation for Science*

During language comprehension, semantic contextual information is used to generate expectations about upcoming items. This has been commonly studied through the N400 event-related potential (ERP), as a measure of facilitated lexical retrieval. However, the associative relationships in multi-word expressions (MWE) may enable the generation of a categorical expectation, leading to lexical retrieval before target word onset. In this case, processing of the upcoming word would thus reflect a target-identification mechanism, possibly indexed by a P3 ERP component. However, given their time overlap (200-500 ms post-stimulus onset), differentiating between N400/P3 ERP responses (averaged over multiple linguistically variable trials) is problematic. In the present study, we re-analyzed EEG data from a previous study (Molinaro et al., 2013), which compared ERP responses to highly expected words that were placed either in a MWE or a regular non-fixed compositional context, thus contrasting the nature of the anticipation whilst keeping predictability constant. We focused on oscillatory dynamics in order to explore responses not phase-locked to the stimulus, and single-trial statistical analyses in order to see if individual item variability dissociated between the expectation-related responses. Mixed-effects models were built with power over selected time-frequency-channel windows as the dependent variable, and several item-level variables (such as frequency, or length) and their interaction with condition as predictors. The interaction between condition and word position was found to be a significant predictor of power in the theta band (7-9 Hz). This is taken as evidence for the presence qualitative differences between the two high expectancy conditions. Power levels within this band were lower for MWE than compositional contexts, suggesting that in the former lexical retrieval had taken place before word onset. On the other hand, gamma-power was equally modulated by predictability of the item in all conditions. This suggests that qualitatively different top-down modulation processes could be in place in the two conditions, as reflected by the detected differences in theta-band, whilst also encompassing a common binding process between an expected representation and the external input, as reflected by the detected gamma band synchronization patterns. Incorporating item-level variables into the analysis thus allowed us to detect the presence of qualitative differences between conditions, but more generally, can contribute to richer interpretation and understanding of the cognitive processes leading to the identified effects.

A49 Ventral and dorsal reading networks are modulated by task demands and language orthography: Regional and functional connectivity evidence. *Myriam Oliver[1], Manuel Carreiras[1,2,3], Pedro. M. Paz-Alonso[1]; [1]Basque Center on Cognition, Brain and Language (BCBL), Donostia-San Sebastián, Spain, [2]IKERBASQUE, Basque Foundation for Science, Bilbao, Spain, [3]Departmento de Lengua Vasca y Comunicación, UPV/EHU, Bilbao, Spain*

Neuroimaging and neuropsychological evidence suggests that left-lateralized ventral and dorsal neural routes are implicated in reading (Dejerine, 1891; Turkeltaub et al., 2002). Whereas the ventral reading network seems to be recruited more for orthographic processing, the dorsal pathway seems to be more engaged during phonological processing (Schlaggar & McCandliss, 2007). However, it is still under debate how the two pathways are modulated by the type of information processed and the role of key areas within these routes, such as the visual word form area (VWFA), inferior frontal gyrus (IFG) and superior temporal gyrus (STG). Theoretical accounts highlighting the specialized role of the VWFA in processing pre-lexical representations of visual word forms (Dehaene et al., 2001) have been challenged by evidence indicating that the VWFA is primarily involved in integrating visuospatial features abstracted from sensory inputs with higher-level phonological and semantic associations (Price & Devlin, 2011). There is also evidence suggesting that opaque versus transparent orthographies may require stronger modulation of the VWFA during reading, due to their less consistent mapping between letter strings and sounds (Paulesu et al., 2001). The present fMRI study investigated functional changes in regional patterns of activation within ventral and dorsal pathways structures and connectivity between the VWFA and regions within these networks, as a function of reading demands (perceptual, semantic), language orthography (transparent, opaque) and stimuli (words, pseudowords, consonants). Thirty-seven right-handed native Spanish-speaking late bilinguals who either have an opaque (English; n=19) or transparent (Basque; n=18) L2 participated. Participants had similar proficiency levels between their L1 and L2 and minimal exposure to other languages. During scanning, they performed two separated Go/NoGo tasks, where they were asked to press a button when they saw a colored letter within a given string (perceptual task) or when they

saw an animal word (semantic task). VWFA regional activation was characterized by extracting parameter estimates from ROIs identified individually (Glezer et al., 2013). This analysis revealed that the VWFA was more strongly recruited for L2 words in the semantic than in the perceptual task. Similarly, IFG activation was modulated by language and task demands, being more strongly engaged for words than pseudowords in the L2, and also for words in the semantic relative to words in the perceptual task. In contrast, STG showed greater activation across readable stimuli for the group with a transparent L2 (Spanish-Basque) than for the one with an opaque L2 (Spanish-English), supporting the implication of this region in phonological processes. Functional connectivity analysis revealed stronger VWFA-IFG coactivation for the group with opaque L2 relative to the one with transparent L2. In contrast, tighter VWFA-MTG coupling was observed in the group with transparent L2 compared to the group with an opaque L2. These results revealed different regional activation profiles in areas within the ventral and dorsal networks, as well as differential VWFA-IFG and VWFA-STG coupling as a function of L2 orthography, supporting a division of labor between reading networks and evidence suggesting that the neural dynamics of the VWFA are modulated by task demands and language orthography.

A50 Do semantic representations automatically activate their corresponding phonological and orthographic representations?

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When we think about an object, or when we perceive an object, do we automatically activate its name? According to cascaded models of lexical access, conceptual units automatically activate their corresponding names. By contrast, in two-stage models, word form access is restricted to selected units. To examine whether concepts automatically activate their names, the current study utilized a semantic relatedness task with non-verbal stimuli. In the first experiment, Hebrew native speakers were asked to decide whether two pictorial probes were semantically related. We compared response latencies and accuracy for semantically unrelated pairs in two conditions: In the ambiguous condition, each pair represented two distinct meanings of an ambiguous word (e.g., a picture of a flying bat and a picture of a baseball bat). In the unambiguous condition, the first picture was replaced with an unambiguous control (e.g., an eagle and a baseball bat). The ambiguity effect is the difference between these conditions, and reveals the automatic excitation of the linguistic label. In order to disentangle phonological and orthographic effects, three types of Hebrew ambiguous words were used: Homonyms (bat), Homographs (tear), and Homophones (plain/plane). If concepts automatically activate both their spoken and written lexical forms, than larger ambiguity effects are expected for homonyms which are both orthographically and phonologically related, than for homophones which are only phonologically related, or homographs which are only orthographically related. Alternatively, if phonological effects are stronger than orthographic effects, then larger ambiguity effects are expected for homophones than for homographs, and vice versa. Results indicated that response latencies for ambiguous pairs were significantly slower than for unambiguous pairs. However, a significant interaction between Ambiguity and Type of Ambiguity indicated that response times to ambiguous pairs were significantly slower in the homonym group, but not in the homophone and homograph groups. This suggests that concepts automatically activate both phonological and orthographic representations, since an ambiguity effect only emerges when both lexical forms are shared. Ambiguous pairs were also significantly less accurate than unambiguous pairs. A significant interaction between Ambiguity and Type of Ambiguity indicated that responses to ambiguous pairs were significantly less accurate in the case of homonyms and homophones, but not in the case of homographs. This suggests that phonological effects may be stronger than orthographic effects. In the second experiment, native Hebrew speakers and native monolingual English speakers were asked to rate the semantic relatedness of the same picture pairs on a 5 point scale. Hebrew speakers rated ambiguous pairs as significantly more related than unambiguous pairs and this ambiguity effect was found to be stronger for Homonyms. In contrast, English speakers rated the unambiguous pairs as more related and no difference was found between the three types of ambiguity. Taken together these findings suggest that concepts automatically activate their word forms. Since lexical effects are observed even when no linguistic processes are required, these findings provide support for cascaded models of lexical access. In addition, differences between the three types of ambiguity suggest that semantic-phonological connections may be stronger than semantic-orthographic connections. .

A51 Semantic conflict resolution abilities among adults with and without ADHD

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Attention Deficit/Hyperactivity Disorder (ADHD) is a developmental neurological disorder of childhood onset, characterized by inattention, impulsiveness, and hyperactivity accompanied in many cases by a variety of cognitive impairments including language deficiencies. While the language difficulties of children with ADHD were reviewed in details, less emphasise has been placed on the language characteristics of adults with ADHD, though it is well known that ADHD can persist into adolescence and adulthood. The aim of our study was to examine the way adults with and without ADHD resolve semantic conflicts during metaphor processing and to understand the relations between semantic conflict resolution and attention functioning. In order to address this issue we assessed the language

abilities, the phonological short term memory capacities and the non verbal cognitive abilities of 26 adults with ADHD (mean age of 26 years) and compared them to 24 control participants (mean age of 25 years). In addition, we assessed the attention functions of all participants using computerized attention assessment based on the four functions of attention model (Tsal, Shalev, and Mevorach, 2005). Likewise, semantic conflict resolution was examined using a computerized priming paradigm that included conflicts between metaphoric and literal meanings of conventional metaphors. Consistent with previous studies, we found that adults with ADHD were less capable of maintaining attention on a non attractive task over time (i.e. poor sustained attention as assessed by a Conjunctive Continuous Performance Test (CCPT)) compared to controls. The ADHD group was also less efficient in resolving conflicts between conflicting aspects of a two-dimensional visual stimulus (i.e. poor executive attention as assessed by a location-direction Stroop-like task). We also found that individuals with ADHD were significantly less efficient (slower and inaccurate) in resolving conflicts between the metaphoric and the literal meanings of metaphoric expressions compared to controls. In addition, we found that the performance on the metaphor processing task did not correlate with language abilities, but with performance in the executive attention task. Several possible explanations for the results and their theoretical and clinical implications are discussed.

A52 Semantic association and categorical relatedness of semantic processing in youths with autism spectrum disorder

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Introduction: Communication and semantic processing deficits in individuals with autism spectrum disorders (ASD) have been demonstrated by behavioral deficits and aberrant neural activity during semantic judgments. However, the distinction of semantic knowledge including semantic association and categorical relatedness has not been made clear in previous studies of semantic processing. Methods: The present study used functional magnetic resonance imaging (fMRI) to examine the neural correlates of semantic processing to further investigate the roles of semantic association and categorical relatedness. Thirty-two male youths with ASD (mean age = 12.7 years, SD = 1.0) and twenty-five age-, sex-, and handedness-matched typically developing (TD) youths (mean age = 12.3 years, SD = 0.8) participated in this study. Participants were asked to decide whether two visually-presented Chinese characters were semantically related. For the related pairs, association strength and categorical rating were item-level parametric modulators in order to differentiate semantic relatedness and categorical relatedness, respectively, as two continuous variables. Results: For the ASD group, the high categorical relatedness produced greater activation in the right middle occipital gyrus. For the TD group, the stronger and the weaker semantic association produced greater activation in the left inferior parietal lobule and left inferior frontal gyrus (IFG), respectively. Moreover, for the TD group, the higher and the lower categorical relatedness produced greater activation in the left precuneus and left middle temporal gyrus, respectively. Conclusion: This study reveals differential semantic knowledge in neural mechanism between the ASD and the TD groups. The ASD group tends to include primary visual cortex to process lower-level orthography processing in order to compensate the deficits of higher-level semantic processing. The TD group may integrate highly shared features for stronger association and have increased demands on selecting features for weaker association. Moreover, the TD group may use mental imagery to search overlapping features to have more efficient access to semantic information for categorical relatedness pairs.

A53 Feature co-occurrence is central to the representation of conceptual knowledge: Evidence from feature verification tasks, using true and false features

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Conceptualization is fundamental to how humans understand and interact with the world around them. Many models of conceptual knowledge assume that concepts are represented in terms of semantic features in a distributed feature-based system. Features vary in their frequency of co-occurrence across concepts (for example, a concept with the feature <has_eyes> is likely to have the feature <has_ears>). Co-occurrence has been hypothesised to play an important role in conceptual processing, with highly correlated features mutually co-activating within a concept. In feature verification tasks, people perform better on those features of a concept that co-occur often with the concept's other features (McRae et al., 1997, 1999). For example, the feature <is_hunted> is more correlated with the other features of DEER than those of DUCK, and thus people are faster to verify that DEER is hunted, than DUCK is hunted (McRae et al., 1997). Current evidence for feature co-activation in a distributed system is based on true features – that is, features of the presented concept. However, claims about feature co-activation lead to strong predictions regarding activation of features not in the target concept. Strong correlations can exist between a concept's features and false features, which, although strongly correlated with other features, are not true of the concept itself. For example, the concept OSTRICH does not include <does_fly> although this is strongly correlated with other features of the concept (<has_wings>, <has_feathers>, etc.). If feature correlation is a key mechanism in concept activation, then the co-activation of highly correlated false features will make these features more difficult to reject. We tested this hypothesis with two feature verification experiments, where 50% of features were true and 50% were false. The stimuli in Experiments 1 and 2 were presented at different SOAs in order to

tap into earlier and later stages of feature activation. In Experiment 1 subjects were presented with a concept in upper case (e.g. DOG) for 750ms followed by a feature phrase in lower case ("has a tail"). In Experiment 2 we presented items with a common relation in blocks (e.g. has – DOG (has) tail) to enable us to present the feature as a single word and speed up presentation of the stimuli (Randall et al., 2004). In both experiments, participants pressed the 'yes' button if the feature was true of a concept, and the 'no' button if it was false. Reaction times and error rates were analysed with linear regression, with feature length, feature word frequency, and strength of correlation between the presented feature and the features in the concept as independent variables. In line with previous findings, in both experiments feature correlation facilitated "yes" responses to true features. Crucially, when the features were false, high correlation led to slower RTs and more errors. The results provide new evidence for a distributed feature-based system. In particular the finding that false features are rejected more slowly when they are highly correlated indicates that semantic features – or a more primitive equivalent – are the basic building blocks of conceptual knowledge.

Discourse, Combinatorial Semantics

A54 The dynamics of information integration in the brain during story reading

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Reading a story requires gradually building a representation by keeping track of the aggregated meaning and integrating the incoming words with the previous context. We build a Recurrent Neural Network Language Model (RNNLM) to represent the textual content and predict the incoming word in a story. We use the learned representations from this model and the fMRI data of subjects reading this story to distinguish between (1) brain regions that are coding the context of the words previously seen, (2) the regions that represent the properties of the incoming word and (3) the regions that deal with integrating the word with the context. We also propose a timeline of these different processes using the MEG analog of the experiment. FMRI data was acquired from 9 subjects while they read chapter 9 of "Harry Potter and the Sorcerer's Stone" using a rapid serial visual presentation paradigm. MEG data was acquired from 3 subjects using the same paradigm. Our RNNLM attempts to predict the next word in a passage from the sequence of words up to now. It was trained on a large subset of a Harry Potter fan fiction database. The RNNLM requires three different word feature vectors. (1) For every incoming word, it computes a latent vector, which corresponds to the model's summary of the relevant context of the story read up to this point, before seeing the word. (2) The model computes an embedding for every different word in the vocabulary, this can be thought of as a vector of the properties of a given word, and is the same every time this word is encountered. (3) The model computes the probability of the current word given the history; we think of this quantity as a measure of the effort required for integrating the word. Secondly, we discover which type of information a brain region is coding by finding which type of feature best predicts the activity in that region. Using the three different feature sets independently, we trained a second model to predict the time series of neural activity at each voxel (or sensor in the MEG experiment). This second model takes as input one of the word feature sets and outputs predicted brain activity. After training, we predict the brain activity associated with reading passages of chapter 9 that were not used for training, via ten-fold cross-validation. We find the voxels that have activity that is predicted accurately by computing the average R2 score of every voxel and performing the necessary corrections. Analogously, for the MEG experiment, we find which time-windows correspond to activity that is predicted accurately. We find multiple regions in the bilateral temporal cortices that are modulated by the three different types of features. We also find that the properties of the current word predict the signal best between 200-500ms after stimulus onset, while the probability of the current word predicts the signal best during 300-400ms, reflecting that every word's N400 response is graded by how predictable the word is.

A55 How minds meet: Cerebral coherence between communicators marks the emergence of meaning

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Human sociality is built on the capacity for mutual understanding, but its principles and mechanisms remain poorly understood. A recent and influential suggestion holds that communicators are primed by each other's behaviors, with associative mechanisms automatically coordinating the production of communicative signals and the comprehension of their meanings. An alternative suggestion posits that mutual understanding requires shared conceptualizations of a signal's use, i.e. 'conceptual pacts' that are abstracted away from specific experiences. We reasoned that it is possible to empirically distinguish between these theoretical accounts by considering the neural dynamics supporting mutual understanding. Namely, both accounts predict coherent neural dynamics across communicators, aligned either to the occurrence of a signal or to the dynamics of conceptual pacts. This study distinguishes between these two predictions by experimentally manipulating the dynamics of mutual understanding across communicators, while simultaneously tracking the inter-personal coherence of pairs of participants (using dual-fMRI and coherence-spectral-density analysis). Mutual understanding was manipulated with an experimentally controlled communicative task that precludes the use of pre-existing shared representations (e.g. a common idiom, body emblems, facial expressions), thereby gaining control over the communicative environment and the history of that environment. Twenty-seven pairs of participants were asked to jointly create a goal configuration of two geometrical tokens,

using the movements of the tokens on a digital game board as the only available communicative channel. One member of a pair knew the goal configuration, and he moved his token on the game board with his right hand to inform the other member where and how to position her token. Cerebral activity of each pair was simultaneously monitored with BOLD-sensitive fMRI, during the performance of two types of communicative problems (42 trials each). There were problems in which the pairs already had previously established mutual understanding ('Known' trials, with stable performance), and problems in which shared meaning yet had to be established ('Novel' trials, with logarithmically increasing communicative success). The left sensorimotor cortex (MNI [-38,-19,55]) showed stronger inter-personal cerebral coherence within real communicative pairs than within random pairs at 0.05Hz (20sec period) with a phase-lag of 0.7π (7sec). These parameters reflect the dominant experimental frequency and the average temporal gap between the movements of the participants in a pair. Crucially, the right superior temporal gyrus ([63,-6,9]) showed significantly stronger real-pair cerebral coherence at 0.01-0.04Hz (25-100sec) with zero phase-lag. These parameters indicate a temporal synchronization of BOLD changes confined to pairs with a shared communicative history, over a time scale spanning several communicative trials. Furthermore, this pair-specific temporal synchronization was driven by communicative episodes in which communicators needed to mutually adjust their conceptualizations of a signal's use, but not when communicators used stereotyped signals. Taken together, these findings indicate that mutual understanding cannot emerge from mutual priming linking production and comprehension of individual communicative signals. Rather, these findings suggest that establishing mutual understanding is cerebrally implemented through simultaneous in-phase fluctuations across communicators, consistent with the notion that pair members temporally synchronize their conceptualizations of a signal's use ('conceptual pacts').

A56 The Truth Before and After: Temporal Connectives Modulate Online Sensitivity to Truth-value

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Whereas people represent time as a sequential and unidirectional order of events, temporal connectives ('before/after') allow event-sequence description that defies chronological order. However, this flexibility may come at a cost to comprehenders, who by default assume that described order matches chronological order (the 'iconicity assumption'; [1]). Children and adult sometimes show comprehension difficulties for non-chronological sentences ('Before [Event2], [Event1]) [2]. Moreover, ERP results suggest that this cost is immediately incurred by sentence-initial 'before' and lasts throughout a sentence [3]. This begs the question whether temporal connectives impact the incremental processes by which people relate unfolding sentence meaning onto world knowledge. Is online sensitivity to truth-value reduced in non-chronological before-sentences? This question is addressed by comparing N400 truth-value effects [4] in before/after sentences about commonly known facts with explicit verification instructions (N=30) or without (N=30). Methods: Materials were 120 sentence quadruplets conditions differed in temporal connective or critical word (True/False Before/After, e.g. "Before/After the Great Depression started, the world economy was booming/disastrous, relatively"), with matched conditions, BF/BT/AF/AT Cloze=0/38/0/37, pre-rated truth-value (1/5 false/true)=2.1/3.8/2.2/3.8. CWs matched on length, frequency and semantic relatedness (LSA). Fillers were 200 sentences without temporal connectives. Sentences were presented word-by-word (300/200ms). 64-channel EEG data was collected. Verification EEG data used trials with condition-consistent responses (1/5 false/true, +/-27 correct trials in all conditions). Results: N400 analysis (300-500ms, 16 electrodes in 4 quadrants) showed a main N400 effect of truth-value (false>true, $F(1,56)=5.4$, $p<.05$), and a 2(distribution: anterior, posterior) by 2(connective: before, after) by 2(truth-value: true, false) 3-way interaction ($F(1,56)=4.8$, $p<.05$). Pairwise tests showed a robust truth-value effect at posterior electrodes for after-sentences ($M=-1.4$, $p=.007$), but not for before-sentences ($M=-.8$, ns.). No effects of instruction and no main effect of connective were observed. The observed interaction reflected reduced N400 for false-before versus false-after sentences. (N.B., A multi-word analysis following [3], 'Before' revealed a robust long-lasting negative shift compared to 'After', but at central-parietal instead of frontal electrodes). Conclusion: The results partially support the iconicity assumption. Incremental interpretation was not generally affected by 'before', as true-before and true-after n400s did not differ, and there was no main effect of connective. However, reduced N400s to false-before sentences suggests asymmetry in the online impact of temporal connectives. One potential explanation draws an analogy with momentary semantic illusions [5-6]. Whereas words that render after-sentences false ('booming') have poor contextual-semantic fit and immediately incur a perceived coherence-break, words that render before-sentences false ('disastrous') have a strong contextual-semantic fit and may momentarily be perceived to be coherent. Importantly, such semantic illusions may have occurred during online processing only, as false-before and false-after sentences received identical falsification responses. In sum, the temporal terms 'before' and 'after' appear to have asymmetric impact on the incremental processes by which people map language onto the world. References: [1] Zwaan (1996), JEPLMC; [2] Mandler (1986), LCP; [3] Münte et al. (1998), Nature; [4] Hagoort et al. (2004), Science; [5] Sanford & Sturt (2002), TiCS; [6] Sanford et al. (2011), JOCN

A57 Time for prediction? The effect of presentation rate on the implementation of anticipatory language comprehension mechanisms

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Predictive use of context during language comprehension results in pre-activation of features of likely upcoming stimuli at several levels of language processing. Event-related brain potential (ERP) studies have demonstrated effects of semantic or orthographic similarity on the N400 component: implausible words related to words that are predictable from the context elicit a smaller N400 compared to unrelated words. The N400 reduction is taken as evidence of facilitated semantic processing for the related words, due to the overlap with predicted (but not presented) words. Recent evidence suggests that while predictive processing is a core component of normal language comprehension, the brain may not engage in prediction to the same extent in all circumstances. For example, when predictions for specific words are frequently violated with unpredictable words (synonyms) that nevertheless keep to message-level expectations, ERP effects associated with predictive processing are diminished for even the most predictable words. Thus, the success of a predictive mode of comprehension in a particular situational environment may be continuously evaluated, leading to dynamic adjustment of language processing mechanisms. This study investigates the effects of timing on anticipatory comprehension mechanisms. ERPs were recorded while participants read two-sentence mini-discourses previously shown to elicit effects of semantic similarity for implausible items ('They wanted to make the hotel look more like a tropical resort. So along the driveway they planted rows of PALMS/PINES/TULIPS.'). The first sentence of every pair was presented in its entirety; participants advanced the trial with a button-press. The second sentence was presented word-by-word with a fixed stimulus onset asynchrony (SOA) that was manipulated in a within-subjects blocked design. In one block, the SOA was 500 ms (a replication of prior studies) and in the other block the SOA was 250 ms. Order of SOA was counterbalanced. At 500 ms SOA, implausible words related to predictable words elicited reduced N400 amplitudes compared to unrelated words (PINES vs. TULIPS); thus, the effect of semantic similarity was replicated. At 250 ms SOA, N400 effects depended on block order. Participants who first read sentences in the 500 ms SOA block showed an N400 semantic similarity effect in the 250 ms SOA block. However, participants who first read sentences in the 250 ms SOA block showed no effect of semantic similarity for this SOA, though these same participants showed the effect in block 2 with 500 ms SOA. These findings are consistent with results suggesting that the utility of predictive processing is evaluated and dynamically updated within a situational environment. Furthermore, timing is a factor in determining the extent to which anticipatory mechanisms are engaged, consistent with the idea that predictive comprehension is resource-dependent, and that processing benefits associated with prediction may be less apparent at fast presentation rates. However, importantly, prediction can be engaged even under speeded presentation rates, if comprehenders already realized the benefits of predictive processing within the experimental context at a slower rate. These findings add to the evidence showing that the brain flexibly allocates resources to most effectively achieve comprehension goals given the current processing circumstances.

A58 Impairments in cognitive control modulate adaptation during comprehension of cartoon-like stories

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In order to make sense of cartoon-like stories, the listener has to be able to quickly adapt to violations of semantic and world-knowledge (e.g., "The grouchy hairpiece decided that he wanted to go to the mall today."). The present study examined whether deficits in cognitive control affect this ability to adapt to violations of previously stored information when required by the discourse. Impaired cognitive control is one of the hallmark cognitive deficits in schizophrenia, which has been related to hypo-activity in the DLPFC (e.g., MacDonald & Carter, 2003), and the ACC (Carter et al, 2001). In a previous study we found that deficits in the controlled maintenance of context relevant information affects the ability of SZ patients to effectively process global discourse information when this information is not primed by the local (sentence-level) context (Swaab et al., 2013). In the present study we examined whether impairments in the ability to flexibly adjust to errors in a cognitive control task correlated with the ability to adapt to animacy violations in four sentence stories. Fourteen schizophrenia patients (mean age: 23.96) and twelve age and education matched healthy control subjects (mean age: 21.39) participated in the experiment. All patients were stable and taking anti-psychotic medication. All participants completed a cognitive control task (the AX-continuous performance task or AX-CPT. All participants were asked to listen to four sentence stories that contained animacy violations (80 stories). Critical words in the last sentence of each story were either consistent with the story, or consistent with the animacy constraints of the preceding noun phrase. For example (critical words underlined): The grouchy hairpiece decided that he wanted to go to the mall today. The hairpiece had plans to buy some new clothes to wear at his sister's birthday party. But when he looked around nothing seemed interesting enough. The hairpiece was irritated/artificial and did not buy anything ERPs were measured to the critical words in the last sentence of the stories. Healthy control participants showed effects of adaptation: a reduced N400 to the discourse-consistent, animacy-inconsistent critical words (irritated) vs. the discourse-inconsistent, animacy- consistent critical words (artificial). In patients, this N400 adaptation effect was significantly correlated with their performance on control demanding trials of the AX-CPT; more errors on this task predicted greater reliance on animacy constraints of the local context and no adaptation to the cartoon-like discourse context ($R2=0.57$; $p<.0005$). These results suggest that intact functioning of brain areas that support cognitive control (DLPFC and ACC) is associated with the ability to adapt to animacy violations in discourse context.

Syntax, Morphology

A59 Music and language syntax interact in Broca's area: an fMRI study

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Previous studies suggest that syntactic processing is shared between music and language. In the present study, the fMRI data of 19 participants listening to sung sentences revealed that the processing demands of musical syntax (harmony) and language syntax interact in Broca's area in the left inferior frontal gyrus. In contrast to previous studies, our design allows us to rule out a number of alternative explanations: (1) the shared brain location is not due to an agglomeration of functionally independent syntactic resources, (2) the interaction is not due to general attention mechanisms, as a psychoacoustic auditory anomaly behaved unlike the harmonic manipulation, (3) the stimuli in the present study did not include errors, showing that the results are not due to error-related processing. The findings thus provide direct evidence for the recruitment of the same high level syntactic integration resources in Broca's area for two different cognitive domains, language and music.

A60 Neurophysiological evidence for whole form retrieval of complex derived words: a mismatch negativity study

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Complex words can be seen as combinations of elementary units, decomposable into stems and affixes according to morphological rules. As an alternative, these complex forms may be stored as single lexical entries, similar to monomorphemic words, and accessed as whole forms. This study uses the earliest ERP brain response capable of indexing both whole-form retrieval and combinatorial processing, the Mismatch Negativity (MMN) (latency: 100-200 ms), to investigate auditory processing of morphologically complex, derived words in German. Using an orthogonal design controlling exactly for any acoustic and psycholinguistic features of the speech stimuli, we presented complex words consisting of stems "sicher" (secure), or "sauber" (clean) combined with abstract nominalising derivational affixes –heit or –keit, to form either well-formed derived words: "sicherheit" (security) and "sauberkeit" (cleanliness), or mal-formed derived words: *"sicherkeit", and *"sauberheit". With this design, it was possible to record brain responses for –heit and –keit in both well- and mal-formed contexts, therefore completely balancing all acoustic variance. Previous research has shown that mal-formed combinations of symbols elicit a stronger MMN than well-formed combinations, but that whole-form single words and constructions elicit a stronger MMN than pseudowords and non-existent constructions. We found in this study that well-formed derived words elicited a stronger MMN than mal-formed derived words, about 150 milliseconds after perception of the critical morpheme. This pattern of results is consistent with the lexical pattern, or "whole-form storage" of morphologically complex derived words. Distributed source localisation of the MMN enhancement found the MMN enhancement for well-formed words primarily in the left inferior temporal gyrus. In addition, neurophysiological results appeared to be sensitive to the frequency of the derived forms, which is also consistent with whole form storage, but not consistent with a combinatorial strategy.

A61 Competition and prediction in the auditory processing of morphologically complex words

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Prediction is pervasive in language comprehension. Predictability effects have been most extensively documented at the word level (Kutas & Federmeier, 2011), but words are often not unanalyzable units. The word "killer", for example, is composed of two morphemes: the stem "kill" and the suffix "-er". Recent magnetoencephalography (MEG) work has shown that listeners use the first morpheme to make predictions about the second during spoken word processing. Specifically, auditory cortex activity is reduced in response to predictable suffixes (Ettinger, Linzen & Marantz, 2014). The present study investigates how competition among potential suffixes affects the predictions that listeners make about the suffix. If all potential suffixes are activated at the stem, higher suffix competition should result in increased activity during the first morpheme. The opposite effect is expected if listeners instead commit to a single predicted suffix when competition is low, but refrain from making strong predictions when competition is high. Additionally, competition may modulate the effect of predictability at the suffix: if listeners strongly commit to a single predicted high probability suffix in low competition scenarios, an unexpected suffix may be more surprising in low competition than in high competition cases. A total of 280 bimorphemic words were selected in four conditions: high vs. low suffix competition and high vs. low suffix predictability (70 items in each condition). The degree of competition among suffixes was quantified using the entropy of the suffix distribution, which captures the intuition that competition is stronger when there are more potential affixes and when their distributions are more balanced. Predictability was quantified using the negative log conditional probability of the suffix (its surprisal). The four conditions were matched for whole word frequency. An additional 100 filler items with various properties were included. All words were recorded by a native speaker of American English. Participants (n = 24) listened to the words while MEG data were recorded. About 15% of the words were followed by comprehension questions. Neural activity was time-locked to one of two anchors: 1) the morpheme boundary, i.e., the point in time at which the stem ends and the suffix begins; 2) the end of the word. Distributed source solutions were obtained using the MNE-Python

package. Activity was averaged in a region around the left auditory cortex, identified based on grand average activity. Two time windows were considered for each of the two anchors: the 100 ms time window prior to the anchor, and the 100 ms time window following it. Averaged activity in each time window was submitted to a mixed-effects ANOVA. Higher competition led to increased neural activity in the pre-morpheme-boundary window ($p = 0.01$). Competition and predictability interacted in the pre-word-end window ($p = 0.01$). Planned comparisons revealed that the predictability effect was observed only in the high-competition condition. These results confirm that predictable morphemes elicit reduced neural signals. They support the hypothesis that higher competition leads to increased neural activity, and do not support the hypothesis that lower competition leads to stronger commitment to a single strong prediction.

A62 OSCILLATORY DYNAMICS OF SYNTACTIC UNIFICATION

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The brain generates oscillatory activity in specific frequency bands. These oscillations index the state of cortical networks with millisecond precision and have been found to be involved in various cognitive processes. We investigated the oscillatory activity underlying the unification, or binding, of syntactic information. To target syntactic unification and eliminate the influence of semantic unification, we developed a new task using nonwords. Dutch verb-like nonwords (e.g. dispen, gonken, dunfen) were presented auditorily in a syntactic unification context (U+: critical word is preceded by a pronoun, e.g. 'ik disp') vs. a non-unification context (U-: critical word is preceded by a nonword, 'gonk disp'). Behavioral pretest results confirmed syntactic unification for nonwords is possible: participants detected unification (person agreement) mistakes (e.g. 'hij disp') with 90% accuracy (SE=1.69). EEG was recorded using an equidistant 64-channel electrode montage (N=20). We presented: fixation cross (t=0), word 1 (t=0.5 sec), word 2 (t=1,7 sec), response window (t=3.1 sec). Participants were instructed to detect reversed speech. We calculated time-frequency representations (TFRs) of oscillatory power (1 to 30 Hz). Statistical significance of power differences between conditions was assessed at each time point across the trial by means of a cluster-level randomization routine which controls for multiple comparisons. Results showed that there was a significant alpha/beta power (8-18 Hz) increase for U+ compared to U- for two separate clusters of channels: a central midline cluster preceding the critical word (time=1.3 to 1.65 sec, $p<.019$) and a frontal cluster following the critical word (time=1.75 to 2.1 sec, $p<.034$) (Monte Carlo P values, corrected for multiple comparisons). We interpret our results as follows. The alpha/beta power increase preceding the word that needs to be syntactically unified could index the increased involvement of control regions, since the pronoun signifies the requirement for unification to follow. The alpha/beta power increase in frontal regions occurring in response to the critical word likely subserves syntactic unification operations. Our results taken together suggest that oscillations in the alpha/beta range play a crucial functional role in the processes essential to the unification or binding of syntactic information (in line with results of Davidson and Indefrey (2007) and Bastiaansen et al. (2010)). These findings are in line with recent claims that the lower-beta frequency is particularly suited for maintaining information on-line and for binding information at the sentence level (Weiss and Mueller, 2012).

A63 'Semantic blocking' solved at last: ERP evidence challenging syntax-first models

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Whether basic syntactic analyses systematically precede semantic processing or not is still heavily debated. According to Friederici's (2002) influential syntax-first model of sentence processing, syntactic phrase structure violations should (1) elicit early negativities (ELANs) during the first 100-300 ms after the violation and (2) prevent semantic integration of that word, thereby blocking semantic N400s between 300-500 ms ('semantic blocking'). Using a probe verification task, Friederici et al. (1999) found that pure semantic violations in German ("The priest was *asphalted.") yielded large N400s, whereas both pure syntactic and combined syntactic-semantic double violations ("The priest was in-the *asphalted") elicited only 'syntax-related' ERP components (small ELAN-like negativities and P600s), but no N400s. After illustrating that many ELAN findings may be artifacts, Steinhauer & Drury (2012) concluded that semantic blocking effects may be the strongest remaining ERP evidence supporting syntax-first models. However, the authors also offered an alternative explanation for the absent N400 that does not involve syntactic violations or semantic blocking: unlike in the pure semantic condition, the pure syntactic and the combined violation carry a prepositional phrase ("in-the …") in which the participle ("asphalted") should be interpreted as an adjective modifying the NEXT (still unavailable) noun rather than the subject "The priest". As "priest" and "asphalted" are not semantically integrated in this scenario, no enhanced N400 is elicited on "asphalted". The present ERP study (n=46) set out to test this alternative hypothesis in the most conservative way possible; we used the exact same German stimuli as Friederici et al. (1999), but also included conditions that continued grammatically after the combined violation, thereby ruling out any semantic blocking due to syntactic violations ("The priest was in-the asphalted street robbed"). Subjects performed an acceptability judgement. Surprisingly, even the original, unchanged conditions now showed a strikingly different pattern challenging Friederici et al.'s semantic blocking account: in addition to the N400 for the semantic violation, N400s were elicited in the combined, and even in the pure syntactic violation, independent of the baseline used. Our data are in line with previous N400 findings questioning the

semantic blocking hypothesis (van den Brink & Hagoort, 2004; Pauker & Steinhauer, 2009; Zhang et al., 2013), but extend those data by demonstrating (a) that previous inconsistencies between German and other studies are not due to cross-linguistic variability and (b) that N400s can be elicited by pure phrase structure violations (i.e., in absence of additional semantic anomalies). As a whole, these results suggest that Friederici et al.'s (1999, 2004) original interpretation of their German data in terms of semantic blocking was likely wrong, and that ERP data do not support syntax-first models. One factor that may have contributed to Friederici et al.'s (modality-independent) 'blocking' pattern may have been the use of a probe verification task; this hypothesis will be tested soon in our lab. Our replication of strategy effects modulating the N400 (e.g., Hahne & Friederici, 2002) underlines that task instructions and their respective interpretation by participants may be as important as the linguistic materials.

A64 Neurobiological attention mechanisms of syntactic and prosodic focusing in spoken language

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In spoken utterances important or new information is often linguistically marked, for instance by prosody or syntax. Such highlighting prevents listeners from skipping over relevant information. Linguistic cues like pitch accents lead to a more elaborate processing of important information (Wang et al., 2011). In a recent fMRI study, Kristensen et al. (2013) have shown that the neurobiological signature of pitch accents is linked to the domain-general attention network. This network includes the superior and inferior parietal cortex. It is an open question whether non-prosodic markers of focus (i.e. the important/new information) function similarly on the neurobiological level, that is by recruiting the domain-general attention network. This study tried to address this question by testing a syntactic marker of focus. The present fMRI study investigates the processing of it-clefts, which highlight important information syntactically, and compares it to the processing of pitch accents, which highlight information prosodically. We further test if both linguistic focusing devices recruit domain-general attention mechanisms. In the language task, participants listened to short stories like "In the beginning of February the final exam period was approaching. The student did not read the lecture notes". In the last sentence of each story, the new information was focused either by a pitch accent as in "He borrowed the BOOK from the library" or by an it-cleft like "It was the book that he borrowed from the library". Pitch accents were pronounced without exaggerated acoustic emphasis. Two control conditions were included: (i) sentences with fronted focus like "The book he borrowed from the library", to account for word order differences between sentences with clefts and accents, and (ii) sentences without prosodic emphasis like "He borrowed the book from the library". In the attentional localizer task (adopted from Kristensen et al., 2013), participants listened to tones in a dichotic listening paradigm. A cue tone was presented in one ear and participants responded to a target tone presented either in the same or the other ear. In line with Kristensen et al. (2013), we found that in the localizer task cue tones activated the right inferior parietal cortex and the precuneus, and we found additional activations in the right superior temporal gyrus. In the language task, sentences with it- clefts elicited larger activations in the left and right superior temporal gyrus as compared to control sentences with fronted focus. For the contrast between sentences with pitch accent vs. without pitch accent we observed activation in the inferior parietal lobe, this activation did however not survive multiple comparisons correction. In sum, our findings show that syntactic focusing constructions like it-clefts recruit the superior temporal gyri, similarly to cue tones in the localizer task. Highlighting focus by pitch accent activated the parietal cortex in areas overlapping with those reported by Kristensen et al. and with those we found for cue tones in the localizer task. Our study provides novel evidence that prosodic and syntactic focusing devices likely have a distinct neurobiological signature in spoken language comprehension.

A65 Distribution of grammatical functions across bihemispheric and left fronto-temporal networks

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Language comprehension engages functionally distinct large-scale networks in both hemispheres. Converging evidence indicates that they form two neurobiologically separable systems: one distributed across bilateral fronto-temporal regions, and another encompassing fronto-temporal regions in the left hemisphere (Marslen-Wilson & Tyler, 2007; Bozic et al, 2010). Currently dominant models of language comprehension link all grammatical processes to the combinatorial mechanisms supported by the left hemisphere (LH) system, and while the link between complex grammatical strings and the LH system seems unambiguous, evidence suggests that the processing of syntactically simple utterances need only involve bilateral temporal structures. This raises the question of the distribution of grammatical functions across the language processing network. What aspects of grammatical function can be supported bilaterally? What defines the grammatical computations that engage the LH system, and are they better characterised in terms of the type of combination (simple-linear vs. complex-non-linear) or of the processing demands associated with their computation? Defining combinatorial simplicity as linear left-to-right grammatical strings, we contrasted three linear sequences of increasing processing demands - (1) minimal two-word strings (They listen); (2) longer three-word strings (I go home); (3) strings with non-adjacent dependencies (We often walk) - with (4) structurally non-linear sequences (Today I work) and (5) inflectionally complex minimal strings (You agreed). These spoken sequences were mixed with acoustic baseline and silence trials, and presented in a fast-sparse fMRI experiment.

Participants listened attentively and occasionally performed a one-back semantic task. Data were analysed using both univariate and multivariate techniques. Univariate results confirmed that simple linear two-word combinations (They listen) engage only bilateral temporal regions. All other grammatical stings triggered additional activation in the left inferior frontal areas BA 45/44. Subsequent multivariate analyses revealed that both the type of grammatical combination (linear / non-linear) and their processing demands influence these condition-specific activation patterns. These results confirm that the bihemispheric system can support structurally simple grammatical computations, and further suggest that the type of grammatical combination and the processing demands they elicit interact to determine the distribution of grammatical functions across bihemispheric and LH processing systems.

A66 What happened to the crying bird? – Differential roles of embedding depth and topicalization modulating syntactic complexity in sentence processing.

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"The rat the cat the dog bit chased escaped." Previous studies provide evidence that the processing of such hierarchical syntactic structures involves a network including the IFG and temporo-parietal regions (1,2,3) as two key players. While most studies locate the processing of syntactically complex sentences in BA44/45, some studies also report the involvement of BA47 or BA6 (4), and temporo-parietal areas (5). Why is there so much variation in localizing the syntactic complexity effect? The interpretation of multiple embedded sentence structures represents a particular challenge to language processing requiring syntactic hierarchy building and verbal working memory. Thereby syntactic operations may differentially tax general verbal working memory, preferentially relying on TP-regions (6), and more syntax-specific working memory, preferentially relying on IFG structures (7). To disentangle the specific contribution of each subsystem, we developed material that contrasts syntactic complexity and working memory aspects. The goal of our project is to use this material in facilitation (tDCS study) and impairment (lesion study) to allow ascribing causal roles of the above brain areas to these three aspects of syntax processing. Methods: 20 healthy participants (Ø age: 24) performed an auditory sentence–picture-matching task. In pilot studies (each 10-15 participants), complexity was varied (number of choice options, distractors, presentation order). Our stimulus set is based on material used in previous studies (1,2) and consists of 132 German transitive sentences. It has a 2x3-factorial design tapping argument order (A: subject- vs. B: object-first) and depth of syntactic embedding (0: no, 1: single, 2: double embedding): A0: %Der Vogel ist braun%,$ER wäscht den Frosch$, §und er weint§. B0: %Der Vogel ist braun%, $IHN wäscht der Frosch$, §und er weint§. A1: §Der Vogel§, %der braun ist%, $und DER DEN Frosch wäscht$, §weint§. B1: §Der Vogel§, %der braun ist%, $und DEN DER Frosch wäscht$, §weint§. A2: §Der Vogel§, $DER DEN Frosch$, %der braun ist%, $wäscht$, §weint§. B2: §Der Vogel§, $DEN DER Frosch$, %der braun ist%, $wäscht$, §weint§. Results: In healthy subjects only successive presentation of auditory presented sentences and the ensuing pictures (3 distractors) yields robust behavioral differences. As a function of both (i) embedding-depth and (ii) topicalization, we find highly significant effects in terms of increasing reaction times (embedding: $F(2,32) = 46.610$, $p = .000$; topicalization, $F(1,16) = 25.003$,$p = .000$) as well as decreased accuracy(embedding depth, $F(2,32) = 20.826$, $p = .000$; topicalization, $F(1,16) = 10.559$, $p = .005$). These factors do not interact, suggesting partially independent factorial influence on syntactic processing. Currently the paradigm is used in a study with facilitatory transcranial direct current stimulation (tDCS) of either key area (IFG vs. TP-region). Additionally patients with circumscribed acquired brain lesions are tested on different versions of the paradigm adapted to the requirements of language-compromised patients. (1) Antonenko,D et al. (2013). NeuroImage 83:513-523. (2) Fengler, A., et al. (2014) submitted. (3) Friederici, A.D. (2009). TICS 13(4):175–181. (4) Friederici, A.D. (2011). Physiological Reviews 91(4):1357–1392. (5) Shetreet, E. et al. NeuroImage 48(4):707–716. (6) Meyer, L. et al. (2012). NeuroImage 62(3):1987-1998. (7) Makuuchi, M. et al. (2009). PNAS 106(20):8362–8367.

A67 Multivariate pattern of inflectional and phrasal computations revealed by combined MEG-EEG

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The dynamic interpretation of spoken grammatical utterances requires complex combinatorial computations, engaging a distributed fronto-temporal processing network (Marslen-Wilson & Tyler, 2008). Combinatorial computations that support the processing of inflectionally complex words (play+ed) were shown to trigger activity in the LH perysilvian network. By contrast, simple phrases (I play) have been shown to activate ventral inferiofrontal gyrus (IFG) and temporal regions bilaterally (Friederici, 2011). This raises fundamental questions about the distribution of grammatical computations within the language network. In the present study we used combined magnetoencephalography (MEG) and electroencephalography (EEG) to track down the activation for inflectional and phrasal combinatorial processing across the language system. Participants listened to spoken stimuli that were either simple stems (play), inflected words (played) or phrasal sequences (we play, we played), and performed an occasional 1-back memory task. We investigated the distribution of two types of combinatorial grammatical sequences using a multivariate pattern analysis (Kriegeskorte et al., 2008). Information represented in space and time is characterized by means of Searchlight RSA (Representational Similarity Analysis; Su et al., 2012). Data were aligned to the time point reflecting the occurrence of the suffix. Two theoretically

motivated models were tested against the MNE source reconstructions (Hämäläinen et al., 1993): 1) activation patterns due to the presence of an inflectional marker 2) activation patterns for phrasal markers. The results show that inflectional and phrasal computations engage overlapping, yet distinct processing mechanisms. Both computations activate bilateral posterior and anterior temporal areas with a similar time course, but differ within IFG (BA44, BA45, BA47 and frontal operculum). The presence of an inflection marker engaged the left IFG. Before the suffix onset, inflectionally-specific processing is seen at -70ms in BA44; at -60 ms in FOP and -40 ms in BA45. After the suffix onset, all 4 LIFG regions (BA44, BA45, BA47 and frontal operculum) show inflectionally-specific activation patterns. Data further show that the early activity in BA44 is mainly due to the presence of an inflection in words in isolation (play/played), while the late activity in frontal operculum is driven by the presence of an inflection in phrases (we play/we played). By contrast, phrasal markers activated IFG bilaterally. Before the suffix onset, the activity is seen in R BA44 at -100 ms, and then spreading to all other R IFG regions after the suffix onset. The presence of a phrasal marker generates activity in left BA44 only if the stimuli were inflectionally marked (we played/played). No effect on the left IFG is significant when contrasting words with no inflection (we play/ play). In conclusion our results suggest that left IFG (BA44/45) is specifically engaged by inflectional combinatorial processing, while phrasal marker seems to trigger the right homologues. This reveals the dynamic interaction of temporal and frontal activity during spoken language comprehension and confirms the role of the left-lateralised fronto-temporal system in supporting complex grammatical computations.

A68 Attention modulates explicit knowledge of language structures reflected in encoding differences during learning

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In natural circumstances with no formal teaching, learning of linguistic structures occurs implicitly and it is often considered to occur without intended attention. Nevertheless, in implicit learning research outside the language domain, attention oriented to features correlated to the information to be learned improves perceptual learning. In addition orienting attention to this information can turn knowledge explicit after learning despite this learning developing implicitly. In the current investigation we studied the role of orienting attention to information correlated with the linguistic structural dependency in the encoding and explicit learning of these structures. Participants were presented with utterances composed by three bisyllabic nonce-word (e.g. tagi male sira). Unbeknown to the subjects three non-adjacent dependencies were present (A1_C1: tagi_sira; A2_C2: jupo_runi; A3_C3: pine_ladu; with 18 middle "_" elements (i.e., cilu, mego, lofa, tadi, nuso, pume, male, rosu, foli, vidu, supa, pevo, ture, medi, catu, gupe, defa, nogi). Participants were instructed to listen to each utterance and to answer as fast as possible whether a target nonce-word was present (e.g. SIRA), therefore manipulating the amount of attention given to the nonce-word that was part of one of the three non-adjacent structural dependencies. Event-related potentials were measured during this learning phase. Both the structures with and without the embedded target showed reaction time facilitation in the online implicit measure compared to streams with no structure indicating implicit learning of the dependency in both conditions. However, only structures containing the target nonce-word showed significant learning in a post-learning explicit recognition test. The event-related potentials measured during online learning showed clear processing differences for the first element of the explicit or only implicitly learned structures. Structures learned explicitly showed greater negativity in the 400-500 ms time-window compared to unstructured streams. Implicitly learned structures showed an increased positivity earlier in the 180-220 ms time-window. These findings reveal that orienting attention to the nonce-word embedded in the linguistic structure modulates its encoding leading to explicit knowledge of this specific structural dependency. However, faster attention-related modulations are present when learning occurs only implicitly possibly reflecting the engagement of a more "passive" orienting of attention (Roll etl 2011) reported previously in natural language.

A69 Reference to the past visualized in the brain

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Background: In agrammatic aphasia, past time-reference morphology has been claimed to be a particular source of prominent tense inflection problems (Bastiaanse et al., 2011). In contrast to non-past time-reference, using a verb with past time-reference requires additional processing, because it requires linking to the event in discourse. There is evidence of discourse-related electrophysiological processing differences in non-brain-damaged speakers (Bos et al., 2013). Tense does not always correspond with time-reference, which is why this theory is about discourse-linked verb forms, regardless of tense. It is for example possible to refer to the past by simple past tense ('V-ed'), or by an auxiliary in present tense and a participle; the periphrastic past ('has+V-ed'). For Dutch aphasic speakers both types of past time-reference are more difficult than simple present (Bos & Bastiaanse, 2014). The left inferior frontal gyrus (IFG) and supplementary motor area (SMA) are engaged in processing grammatical morphology for simple past versus simple present tense (Sahin et

al., 2006). We studied if and where discourse-linked reference to the past yields additional brain activation for periphrastic verbs forms that have the same tense of the auxiliary, but that differ in time reference. Methods: Twenty healthy Dutch speakers (mean age 24) took part in an event related fMRI-study at the Dahlem Institute for Neuroimaging of Emotion. We presented them with a picture denoting the target verb action followed by a written sentence to be completed with non-past or past time-reference. We indicated single or periphrastic target verb forms with one or two series of dots, respectively. We contrasted (1) simple past versus simple present tense (pushed–pushes) and (2) periphrastic past versus future time-reference (has pushed–will push). We used a factorial design (time-reference x periphrasticity) to analyse DARTEL-normalised functional scans of response preparation from picture offset to response onset in SPM8. Results/discussion: For both types of past over non-past time-reference we found a greater BOLD signal change bilaterally frontal—the SMA and frontal superior medial gyrus. We relate this to increased difficulty in selecting past time-reference inflection, hence, discourse linking. The LIFG showed significantly increased activation for simple past over simple present, but not for periphrastic past over future. LIFG might be taxed for past tense inflection, but not specifically for past time-reference—both periphrastic verb clusters have a present tense auxiliary. Our results align with a fundamental difference between past and non-past time-reference demonstrated in non-brain-damaged speakers, and fits to the pattern described in agrammatism. References: Bastiaanse, R., et al. (2011). Time-reference in agrammatic aphasia: A cross-linguistic study. Journal of Neurolinguistics, 24, 652-673. Bos, L.S., & Bastiaanse, R. (2014). Time reference decoupled from tense in agrammatic and fluent aphasia. Aphasiology, 28, 533-553. Bos, L.S., Dragoy, O., Stowe, L.A. & Bastiaanse, R. (2013). Time reference teased apart from tense: Thinking beyond the present. Journal of Neurolinguistics, 2, 283–297. Sahin, N.T., Pinker, S., & Halgren, E. (2006). Abstract grammatical processing of nouns and verbs in Broca's area: Evidence from fMRI. Cortex, 42, 540-562. Acknowledgement: L.S.B. was supported by a short-term grant of the SFB632 (German Research Foundation).

A70 Time course of noun phrase production by German-French bilinguals

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Producing language requires coordinating the retrieval of various types of information. In this study, we focus on the time course of grammatical and phonological encoding processes in determiner noun phrases. We make use of the picture-word interference paradigm, a privileged tool in the chronometric study of noun phrase production. In this paradigm, participants are asked to name pictures while ignoring a written distractor superimposed on the picture. Several studies in Germanic languages have shown that latencies to pictures named with a determiner noun phrase are longer when the distractor and target words have different as opposed to the same gender (gender congruency effect). We tested between two alternative accounts of this effect. In the first, the effect arises during the utterance's syntactic processing and reflects a competition between the gender features of the target nouns and distractors (Schriefers, 1993). In the second account, the gender congruency effect arises during the phonological encoding process and reflects competition between determiner forms (Schiller & Caramazza, 2003). Twenty late German-French bilinguals named pictures in German. They were asked to use determiner noun phrases and to ignore written distractor superimposed on the picture. We manipulated the gender congruency and the phonological overlap between target and distractor. We recorded the participants' responses as well as their electroencephalogram. Results revealed shorter naming latencies for the gender congruent condition and for the phonological overlap condition. A single trial analysis of the event-related potentials (ERP) revealed effects of the gender and phonological manipulations in overlapping time windows. This finding favors the account in which the gender congruency effect arises during phonological processes, as the result of a competition between determiner forms. In addition, the participants performed a similar experiment in French, their second language. Response latencies were also influenced by gender congruency and phonological overlap, but no effects of these manipulations were apparent in the EEG data. Schiller, N. O., & Caramazza, A. (2003). Grammatical feature selection in noun phrase production: Evidence from German and Dutch. Journal of Memory and Language, 48, 169-194. Schriefers, H. (1993). Syntactic processes in the production of noun phrases. Journal of Experimental Psychology: Learning, Memory, and Cognition, 19, 841-850.

Control, Selection, Working Memory

A71 Older Adults Fail to Show Activity Increases for Inhibition on Hayling Task

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OBJECTIVE: In the Hayling Task, participants complete sentence stems either with a word making sense (Part A) or a word not making sense (Part B). The difference in reaction times (B minus A) is thought to reflect the time required for inhibition of the correct responses in favor of nonsensical ones. Similar differences in regional brain activity are thought to reflect inhibitory processes. The frontal lobes are implicated inhibitory processes, and frontal lobe changes are common in aging. The current study was designed to determine aging-related changes to inhibition using the Hayling Task. METHODS: Fifteen younger (7 F, mean age=23.3) and 15 older (8 F, mean age=76.7) adults participated in 6 blocks of 5 event-related Hayling A trials and 6 blocks of 5 event-related Hayling B trials during functional MRI (Philips Achieva

3 T scanner). Trials lasted 8 seconds. During the first 4 seconds, one word was added visually to sentence stems every .5 seconds; participants responded overtly during the last 4 seconds. Between trials, participants fixated on a cross for 10, 12, or 14 seconds. Reaction times (RTs) and response accuracy were compared between older and younger adults. Hemodynamic responses for Hayling A sentences and Hayling B sentences were separately deconvolved using Analysis of Functional NeuroImaging (AFNI) software, and area under the hemodymamic response curve (AUC) was calculated for analyses. Functional and structural (T1-weighted) images were warped into Montreal Neurological Institute (MNI) 152 space and resampled at 1 mm3 using FMRIB Software Library (FSL) tools. fMRI analyses were family-wise error corrected to p<.05). RESULTS: There were no differences between older and younger adult RTs or accuracy for Hayling A sentences. Correct responses for Hayling B sentences were significantly slower for older than younger adults t(28)=-3.524, df=28, p<.01, and older adults gave significantly fewer correct Hayling B responses than younger adults, t(28)=3.496, p<.005. AUC for Hayling A responses was subtracted from AUC for Hayling B responses to image inhibition-related changes in brain activity. For this comparison, younger adults showed significant positive activity in dorsolateral prefrontal cortex, superior frontal gyrus, orbitofrontal cortex, pre-SMA, posterior cingulate cortex, precuneus, and anterior cerebellum bilaterally as well as in the left supramarginal gyrus and right angular gyrus. In all these posterior cortical regions (i.e., posterior cingulate and precuneus bilaterally, left supramarginal gyrus, and right angular gyrus), older adults showed greater activity than younger adults on Hayling A. Younger adults showed significantly greater response to inhibitory demands of Hayling B (i.e., B minus A) than older adults in right dorsolateral prefrontal cortex, right orbitofrontal cortex, and the paracingulate gyrus bilaterally. CONCLUSIONS: Younger adults showed greater activity in response to the inhibitory demands of Hayling B in anterior and posterior cortices and the cerebellum. The lack of response to inhibitory demands in posterior cortices of older adults is likely due to the fact that these cortices already show a high level of activity in Hayling A. However, failure of at least some anterior cortices to respond to inhibitory demands may indicate aging-related frontal changes.

A72 Bilingual Language Control in Aging: Effects of Individual Differences in Executive Functions. An rTMS Study

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Background: Accumulating evidence from empirical and clinical studies has shown evidence suggesting that lexical selection is more difficult when there is greater cross-language competition. These studies further suggest that higher cognitive mechanisms, particularly inhibitory control, may play a crucial role in the regulation of languages in the bilingual brain. An important implication of this finding is that the process of lexical selection in a bilingual context may be particularly difficult for older adults for whom a vast body of literature has demonstrated a decline in cognitive functions required for language processing and production. However, benefits in executive functions (EF) conferred by life-long bilingualism may protect against age-related difficulties in language skills (1). Here, we sought to investigate whether older adults resolved within- and cross-language lexical competition differently from younger adults and whether factors such as word status (cognate and non-cognate word processing) and individual differences in domain-general executive control modulated cross-language interference resolution. Methods: In a picture-word interference paradigm, French-English bilingual younger and older adults named cognate and non-cognate pictures in English while ignoring within- and cross-language auditory distractor words (at varying SOAs). The distractors exhibited three different relations to the cognate target picture (Cactus): semantic (Thorn or Épine), phonological (Canvas or Cahier (notebook)) and unrelated control (Soap or Meuble (furniture)). An additional target-distractor relation was included for the non-cognate target pictures: phonological relation to the translation (Gâteau) of the target (Cake) – (Garden or Garçon (boy)). Additionally, to evaluate whether cross-language interference is modulated by individual differences in executive control, a battery of EF tests was administered. To further imply causality to EF and bilingual lexical selection, we employed high-frequency rTMS (10 Hz) to facilitate the region of the brain involved in EF (DLPFC) and measured post-stimulation RT and accuracy scores. Results: Our results correspond with previous findings of picture word interference effects in both younger and older adults. Pictures with cognate names were named faster than pictures with non-cognate names across SOA and distractor conditions. Additionally, both groups demonstrated greater within-language semantic interference and phonological facilitation effects and marginal between-language effects. As expected, older adults had more difficulty suppressing cross-language competitors than younger adults. Overall, older adults also demonstrated less efficient inhibitory control compared to younger adults measured by the Stroop and Simon tasks indicating that declining inhibitory control skills in healthy older bilinguals may underlie increased lexical competition. Of note, for our hypothesis regarding domain-general executive control, we expected to see decreased response times in EF and picture naming tasks post TMS stimulation, particularly in individuals with decreased EF skills as a consequence of aging, supporting the notion that individual differences in EF modulate bilingual lexical selection. References: Bialystok, E., Craik, F. I. M., & Luk, G. (2008). Cognitive Control and Lexical Access in Younger and Older Bilinguals. Journal of Experimental Psychology: Learning, Memory and Cognition, 34, 859-873.

A73 The Neural Correlates of Individual Differences in Bilingual Language Control *Brianna L. Yamasaki[1], Andrea Stocco[1], Chantel S. Prat[1]; [1]University of Washington*

Previous research has demonstrated the automatic co-activation of languages in bilinguals (e.g., Hermans et al., 1998). Thus, bilingual language use likely requires additional control mechanisms for managing cross-linguistic interference. Many researchers have used cross-linguistic priming and language switching paradigms to investigate the neural basis of bilingual language control, and have implicated a network of regions including the striatum (e.g., Crinion et al., 2006) and the prefrontal cortex (e.g., Hernandez et al., 2001). In a recent review, we proposed that the striatum functions as a gate that allow bilinguals to flexibly select and route target-language-appropriate signals to the prefrontal cortex (Stocco et al., 2014; Buchweitz & Prat, 2014). Interestingly, the success with which bilinguals manage cross-linguistic interference varies between individuals (e.g., Festman et al., 2010) and we hypothesized that such variability should be related to the functioning of these fronto-striatal loops. To investigate the neural basis of individual differences in bilingual language control, we conducted an fMRI investigation in 18 bilinguals (10 females), defined as individuals who were highly proficient in English plus one of 7 other languages (Chinese, Korean, Japanese, Spanish, Russian, Danish, or Portuguese), both of which were learned before adolescence. To quantify individual differences, participants completed a standardized reading test in English, and a test of non-verbal working memory before the fMRI session. In the scanner, participants completed a semantic decision paradigm in which they performed one of two semantic judgments (larger/smaller than a shoebox or natural/manmade) on a total of 160 visually presented high-frequency, concrete nouns, divided into 16 blocks. Within each block, either the language that the words were presented in, the semantic decision that was required, or both, "switched" from trial to trial. Results revealed that both language switching and task switching conditions recruited highly overlapping networks, which included the fronto-striatal loops. In addition, individual differences in English proficiency were positively correlated with greater recruitment of the putamen (part of the striatum) and bilateral prefrontal gyri during language switching. These results suggest that more skilled English speakers recruit more of the fronto-striatal loops during language switching. Interestingly, individual differences in English proficiency were also positively correlated with activation in the fronto-striatal loops during task switching, when the language input remained stable. Importantly, these relations remained significant even when working memory capacity was controlled for using a simultaneous multiple regression. These results support the hypothesis that bilingual language control relies on a general neural mechanism, the fronto-striatal loops, for flexibly controlling the flow of information to the prefrontal cortex.

A74 Shared neural processes support semantic control and action understanding *James Davey[1], Shirley-Ann Rueschemeyer[1], Alison Costigan[1], Nik Murphy[1], Katya Krieger-Redwood[1], Glyn Hallam[1], Elizabeth Jefferies[1]; [1]University of York and York Neuroimaging Centre, UK*

The automatic and unguided retrieval of conceptual knowledge is insufficient for successful semantic cognition, since we represent many features and associations for any given concept and only a subset of these are applicable to any given task: executive control processes are therefore crucial for focussing semantic processing on relevant aspects of meaning. Patients with semantic aphasia (SA) following left-hemisphere stroke have damage to executive-semantic processes: their verbal and non-verbal semantic retrieval is dominated by strong but irrelevant associations. In addition, these patients have disordered production of complex/sequential actions, suggesting that common cognitive and neural processes might support executive-semantic control and action understanding (Corbett et al., 2009). We sought convergent evidence for this hypothesis from fMRI by exploring how the brain's response to a feature matching task was modulated by task difficulty and the attribute to be matched: for visual and action features, we contrasted an easy condition, in which targets were drawn from the same category as the probe, with a difficult condition, in which targets sharing the relevant feature were globally unrelated and presented alongside semantically-related distracters. The recruitment of sensory and motor areas was modulated by task demands: visual decisions produced activity in bilateral occipital and right parietal areas, while action judgements recruited left prefrontal and temporoparietal regions. Harder judgements activated a distributed executive-semantic control network, encompassing left and right prefrontal and left posterior temporal areas, and this overlapped with the network for action judgements; in contrast, the response to visual decisions was more distinct. We propose that a distributed cortical network supports our ability to flexibly select aspects of knowledge, and this is crucial for both executive-semantic control and for retrieving actions that are appropriate for our current goals or context.

A75 Broca's region and visual word form area activation during a predictive stroop task *Mikkel Wallentin[1,2], Claus H. Gravholt[3,4], Anne Skakkebæk[3]; [1]Center of Functionally Integrative Neuroscience, Aarhus University Hospital, building 10-G-5, Nørrebrogade, 8000 Aarhus C, Denmark, [2]Center for Semiotics, Aarhus University, Denmark, [3]Department of Endocrinology and Internal Medicine (MEA), Aarhus University Hospital, 8000 Aarhus C, Denmark, [4]Department of Molecular Medicine, Aarhus University Hospital, 8200 Aarhus N, Denmark*

INTRODUCTION: Competing theories attempt to explain the function of left inferior frontal gyrus (LIFG) in single word processing. The region is found to be more active during processing of pseudo-words than real words and during infrequent words relative to frequent words and during Stroop conflict words than during Non-Stroop words. Two related theories explain these

findings as reflecting either "cognitive control" in the face of conflicting input (Novick, et al., 2010) or linguistic prediction error (Kristensen & Wallentin, in press). One difference between these two theories is that the latter is based on a predictive coding approach. This implies that processing cost refers to violations of expectations based on statistical distributions of input. In this fMRI experiment we attempted to disentangle processing cost originating from cognitive conflict and from prediction error. STIMULI AND PROCEDURE: Fifty-three males (three discarded due to artifacts or poor performance) participated in the experiment as controls in a larger patient study (see Skakkebæk, et al., 2014 for details). They responded to whether the word (either GREEN or RED) was displayed in green or red font (Stroop vs Non-Stroop). Half saw the green font three times as often (150 trials) as the red font (50 trials). The other half experienced the opposite distribution. This resulted in a 2 x 2 mixed effects design: Stroop/NonStroop x Frequent/ Infrequent. DATA ACQUISITION AND ANALYSIS: A 3T GE MR system was used to acquire 570 BOLD contrast EPI volumes per participant (36 slices; 3.5 mm thickness; 3.33 x 3.33 mm voxels. TR: 2200 ms; TE: 30 ms; 90 degrees flip angle). The experiment lasted approx. 20 minutes. All fMRI data pre-processing and data analyses were performed using a 2-level GLM approach in SPM8. 2nd level RFX results were thresholded at $p<0.05$, FWE corrected. BEHAVIORAL RESULTS: A 2 x 2 mixed effects ANOVA showed a significant response time effect for both Stroop ($F(1,49)=48.61$, $p<0.001$), and frequency $F(1,49)=20.63$, $p<0.001$). The low frequency font yielded longer response latency. No interaction was observed. fMRI RESULTS: A significant effect of Stroop vs NonStrop was found in LIFG. No effect of frequency was observed here and no interaction. Conjoined effects of Stroop and frequency were found in superior frontal regions, parietal regions as well as in the visual word form area (VWFA) in the left fusiform gyrus. DISCUSSION: Response time effects showed effects of both Stroop and frequency. We replicated previous findings showing Stroop effects in LIFG. However, we did not find any evidence for short-term prediction error effects built on frequency distributions during the experiment. This speaks against a strong version of the prediction error hypothesis in LIFG. The lack of frequency effect is not based on a lack of power since the experiment is extremely well-powered. The frequency effects observed elsewhere, including in the VWFA also suggest that the lack of LIFG activation is not due to power issues. Further studies are needed to elucidate if other (e.g. long-term memory based) types of linguistic prediction errors involve LIFG.

A76 Neural Basis of Sensitivity to Interference during Sentence Comprehension

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Poor sentence comprehension arises from an inability to suppress irrelevant information (e.g., Van Dyke & Johns, 2012). The cue-based retrieval model suggests that interference arises when retrieval cues do not uniquely identify the appropriate filler (e.g., Lewis, Vasishth, & Van Dyke, 2006; Van Dyke, 2007). For example, (2) is more difficult, as measured in eye-movements and comprehension accuracy, than (1) because the animate distractor, "visitor," matches both the syntactic and semantic cues from the verb "waited" (Van Dyke, 2007). A recent fMRI study suggests that this type of semantic-based retrieval interference invokes increased activation in left IFG, centered in BA47 and BA45, as well as left posterior STG (Glaser et al., 2013). The current study investigates this effect further, focusing on the relationship between interference control and reading ability. We created two conditions with identical syntactic structures, differing in potential for semantic interference (1, 2). A syntactically simpler baseline condition (3) was matched for semantics and number of clausal integrations. Ninety-six experimental trials (32 per condition) were presented with an equal number of filler. Comprehension questions were presented on 20% of trials. Presentation was word-by-word at a rate of 500ms + 100ms ISI. 1/2. The client who implied that the meeting/the visitor was important waited impatiently. 3. The scheduled meeting was very important and the client waited impatiently. We recruited 16-24 year olds (N=54; testing is ongoing) from New Haven, CT. Participants were screened using the Woodcock-Johnson Word Attack subtest to ensure word reading ability above the 8th grade level to avoid activations associated with poor decoding. We further divided the sample into subgroups of good comprehenders (GC; N=21), scoring above the 11th grade level on the Woodcock-Johnson Passage Comprehension subtest, and poor comprehenders (PC; N=10 at present), scoring below the 8th grade level. Comprehension ability was associated with distinct patterns of activation, with GC showing more diffuse and right lateralized activations. In skilled readers, contrasts of syntactic interference only (1) with baseline (3) revealed deactivation of LIFG, centered in BA45 and BA47, together with activations in areas associated with cognitive control (e.g., LIPL), bilateral anterior cingulate and cingulate gyrus). In contrast, PC revealed deactivations only, in bilateral IPL, left hippocampus, and right, but not left, IFG sites. Contrasting (2) with baseline (3) revealed bilateral activations like the previous contrast: GC showed activations in areas associated with memory retrieval and cognitive control (IFG, parahippocampal gyrus, and anterior cingulate and cingulate gyrus) while PC showed bilateral activations in MFG and in posterior regions (SMG, angular gyrus, posterior cingulate.) Contrasting (1 vs 2) revealed activations in medial frontal regions for GC but not PC. GC showed strongly left lateralized activation in MTG, and memory and control areas (IFG, cingulate gyrus and hippocampus.) In contrast, PC showed predominantly right, diffuse activations. Data collection is still ongoing. Additional brain-behavior correlations with Stroop and stop-signal tasks will be conducted on the entire sample.

Results will be interpreted with respect to theories of conflict control (e.g., Botvinik et al. 2004; Ye & Zhou, 2009).

Language Disorders

A77 Neurophysiological alterations during phoneme and word processing in the acute stage of aphasia

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Only a few studies have investigated neurophysiological substrates of phonological impairment in patients with aphasia (PWA) in the acute stage after stroke (Ilvonen et al., 2003; Nolfe et al., 2006). Behavioral evaluation is often problematic or even impossible in PWA in the acute stage, as some patients cannot be instructed due to severely impaired comprehension, reduced consciousness or confusion. Event-related potentials (ERPS) can circumvent such problems as they have already demonstrated their sensitivity and usefulness in measuring certain language processes in both a healthy and clinical population. The objective of the present study is to investigate neurophysiological substrates of phoneme and word processing in PWA with phonological disorders (PWA-PD) in the acute stage after stroke. Ten PWA-PD (5 men, 5 women; mean age 69.4 years +/- 3.46) are included and compared to 44 healthy control participants (HC) (20 men, 24 women; mean age 44.46 years +/- 13.76). All patients suffer from a first-ever stroke in the left hemisphere, are right-handed, have Dutch as native language and present with acute phonological disorders as established with the Psycholinguistic Assessment of Language Processing in Aphasia (Bastiaanse et al., 1995). PWA-PD admitted with a recurrent stroke, left handedness, indications for comorbid cognitive disorders and severe hearing deficits are excluded. Phoneme discrimination is studied in a pre-attentive (MMN) and attentive (P300) oddball task with respect to the phonemic contrasts place of articulation (PoA), voicing and manner of articulation (MoA) to explore whether a qualitative pattern of impaired phonemic contrast sensitivity can be determined. Word recognition is studied in a pre-attentive oddball task, which consists of differentiating real words from pseudowords. The electroencephalogram (EEG) is recorded through 23 Ag/AgCl-electrodes using a linked ears reference and an electrode placed on the forehead as ground. Further EEG analysis includes additional filtering, independent component analysis, segmentation, baseline correction and artifact rejection. Statistical analysis is performed on amplitudes and latencies specifically taking into account the large heterogeneity among PWA-PD. During phoneme discrimination, PWA-PD only show MMN amplitude reductions with voicing as phonemic contrast in the pre-attentive condition, whereas all three phonemic contrasts reveal smaller P300 amplitudes compared to HC in the attentive condition. PWA-PD show a larger response to PoA compared to MoA and voicing in the pre-attentive condition, whereas in the attentive condition only the difference between PoA and voicing remains. During word recognition, PWA-PD and HC display larger responses to pseudowords compared to real words from 100 ms onwards, continuing in the P200 and N400 time windows, despite the fact that responses to pseudowords show longer latencies in PWA-PD. In summary, this demonstrates a distinct pattern of impaired phonemic contrast sensitivity in PWA-PD, with PoA being the most resistant, voicing the most vulnerable and a substantial effect of attention. Moreover, PWA-PD suffer from a delay in lexical access due to a less efficient information transfer, which did not impair the response to pseudowords. For possible clinical implementation of ERPs, pre-attentive tasks seem to be more suitable than attentive tasks in the acute stage of aphasia.

A78 Abnormal cortical processing of speech and corresponding nonspeech sounds in preschoolers with Asperger syndrome

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Asperger syndrome (AS) is a neurodevelopmental disorder characterized by problems in social reciprocity, communication and behavioural flexibility. Problems in communication are usually in the area of pragmatics and in the social use of language. Children with Asperger syndrome often find it difficult to interpret the emotion of the speaker or, for example, those aspects in prosody which suggest the speaker is telling a joke. These problems, in turn, contribute to the social difficulties these children face in their everyday life. Previous research has shown that the early cortical processing of speech sound features is abnormal in school-aged (7-11 years) children with AS. To our knowledge, possible abnormalities in cortical speech sound processing have not yet been studied in younger children with AS, as it is rarely diagnosed before school age. In the current study we investigated the cortical processing of semisynthetic consonant-vowel syllables and their corresponding nonspeech counterparts in 6-year-old children diagnosed with either F84.5 AS or F84.9 Pervasive developmental disorder, unspecified, with Asperger traits. We used a multi-feature mismatch negativity (MMN) paradigm with five deviant features: consonant, vowel, vowel duration, frequency and intensity. The corresponding nonspeech standard and deviant sounds were derived from the speech sounds with an algorithm which corrupted the sound "speechness", making them sound more like buzzers or horns while conserving the complexity of the stimulus stucture. By the end of spring 2014, preliminary data was obtained from 8 children with AS and 8 control children. For the syllable standards, P1 and N2 amplitudes were larger but N4 amplitude was smaller in the children with AS than the control children. These effects were not seen for the nonspeech standard sound. The MMN responses, which reflect cortical discrimination ability, were smaller for the consonant, vowel, duration and frequency changes in the syllables in children with AS compared to control children. Furthermore, the MMN to frequency changes was elicited earlier in children with AS than control children. For the corresponding nonspeech changes, the MMN was smaller

for the vowel counterpart and the duration changes and elicited earlier for the frequency changes in the children with AS compared to the control children. These preliminary results suggest that the cortical encoding of speech, but not nonspeech sounds of equal complexity, is abnormal in preschool children with AS. Furthermore, the cortical discrimination of several syllable features, both phonetic and nonphonetic, is abnormal in these children. These effects can to an extent be seen also for nonspeech sounds, but the overall processing for auditory nonspeech material in children with AS is more similar to typically developed control children.

A79 fMRI reveals atypical processing of letters and speech sounds in beginning readers at family risk for dyslexia *Katarzyna Chyl[1,2], Anna Banaszkiewicz[1,2], Agnieszka Dębska[1,2], Magdalena Łuniewska[1,2], Agata Żelechowska[1,2], Marek Wypych[1], Artur Marchewka[1], Katarzyna Jednoróg[1]; [1]Nencki Institute of Experimental Biology, [2]University of Warsaw*

Learning to read is an important milestone in individual cognitive development characterized by the complex interplay of various kinds of skills and knowledge. The first critical step in reading development is to learn the correspondences between visual letters and auditory units of speech (speech sounds). It has been shown that dyslexic readers, both children and adults, underactivate superior temporal cortex for the integration of letters and speech sounds. Children also show reduced unisensory responses to letters in the fusiform gyrus and speech sounds in the anterior superior temporal gyrus and superior temporal sulcus. It remains unclear whether the reported effects are inherent to dyslexia or if they reflect the consequence of reading struggle. Here, we investigate functional networks during letter and speech sound integration in 57 beginning readers and compare those with a familial risk for developmental dyslexia (FHD+, n = 33, average age = 6.8 years) to age-matched controls (FHD-, n = 24, average age = 6.7 years). On the behavioral level the groups differed only in one test of phonemic analysis and there was a trend for difference in letter knowledge. We did not find significant differences in simple word or pseudoword reading. Children also did not differ in rapid naming tasks. Nevertheless, whole-brain functional neuroimaging analyses revealed significantly reduced responses to letters and speech sounds in the left posterior temporal sulcus and left fusiform gyrus in FHD+ compared to FHD- children. The former structure showed also increased response to letter and speech sound integration (congruent – incongruent condition) in FHD- children only. Our results suggest that differences in neural correlates of letter and speech sound integration in individuals with dyslexia are not a result of reading failure, but are present at the beginning of literacy acquisition.

A80 Self-monitoring after stroke: A case study *Sophie Meekings[1], Samuel Evans[1], Fatemeh Geranmayeh[2], Richard Wise[2], Sophie Scott[1]; [1]University College London, [2]Imperial College London*

Many aphasic patients show an impaired ability to monitor and repair errors in their own speech (Wepman, 1958). Puzzlingly, this deficit occurs even in patients with relatively intact comprehension abilities (Schlenck et al, 1987) and seems to apply only to on-line monitoring, since patients are able to detect errors in a recording of their own voice (Maher, Rothi & Heilman, 1994) In a unique variant of this problem, we report the case of a patient experiencing difficulties hearing his own voice following stroke. This patient, a 48-year-old man, presented with a frontal lesion caused by a left middle cerebral artery infarct. His language abilities were assessed using the Comprehensive Aphasia Test (Howard, Swinburn & Porter, 2004). He displayed difficulties with fluent and syntactically correct speech production, contrasted with relatively intact comprehension abilities. Although there was no evidence of hearing loss, the patient reported experiencing his own voice as either inaudible or occurring at a delay of up to half a second. We attempted to determine whether this was a general sound or speech perception deficit by administering a task that required him to hear and make fine temporal distinctions between sounds. In this task, we asked him to determine whether two sounds played in succession (with the delay between them adaptively determined by a staircase procedure) occurred at the same time or not. He was able to accurately complete the task with nonspeech sounds, another person's voice, and a recording of his own voice, confirming that his perception of externally generated sounds was in the normal range. When given delayed auditory feedback of a live speaker, he described the mismatch between seeing the person speak and hearing their voice as similar to his experience of his own voice. He reported an inability to perform tasks normally dependent on self-monitoring, such as singing and mimicry. In particular, his performance on a task involving speaking over noise is discussed and compared with Oomen, Postma & Kolk's (2001) finding that patients with Broca's aphasia find noise masking less disruptive than healthy controls.

A81 Neural coherence during natural story listening as a biomarker for Autism *Jonathan Brennan[1], Neelima Wagley[1], Margaret Ugolini[1], Annette Richard[2], Ioulia Kovelman[1], Susan Bowyer[3], Renee Lajiness-O'Neill[2]; [1]University of Michigan, [2]Eastern Michigan University, [3]Henry Ford Hospital*

A major thread in current neuroimaging research on Autism Spectrum Disorders (ASD) focuses on biomarkers sensitive to diagnostic status and/or treatment efficacy that can be passively measured in pediatric populations. Recent work on resting state brain activity has suggested that ASD may be associated with impaired functional connectivity between brain networks, raising the possibility that a short segment of electrophysiological activity, easily collected with minimal task demands, may provide clinically useful information. In parallel, neural responses to simple auditory stimuli and speech sounds also show atypical patterns that correlate with clinical language scores. This correlation raises the possibility that connectivity patterns during language processing may be more divergent between children with ASD and those with neurotypical (NT) development compared to resting state connectivity, where variance in brain states between individuals is expected to be high. Listening to

a short story is a simple, familiar and, for many children, enjoyable activity that requires minimal extraneous task demands. Accordingly, we tested whether neural coherence, measured using magnetoencephalography (MEG), during passive story listening could distinguish children with and without autism. Methods: 13 children (6 NT and 7 ASD), aged between 8 and 12, participated in a MEG study which included ten minutes of data collected while participants rested with their eyes open, and twelve minutes of data collection while participants listened to a segment of a children's audiobook also with eyes open. Diagnosis was confirmed with the Autism Diagnostic Observation Schedule (ADOS-2). Data were collected from 148 magnetometers (4D Neuroimaging) with a band-pass of 0.1 to 100Hz and sampling rate of 508.25Hz. After preprocessing to remove cardiac artifacts, data were band-pass filtered 30 and 80Hz and areas of brain activity were localized to a 4000 dipole source grid spanning the grey matter of a pediatric template using MR-FOCUSS that was morphed into each subjects digitized head shape. Sources were grouped in to 54 anatomical regions spanning both hemispheres and pairwise coherence was computed. A logistic classifier was constructed modeling group membership (NT or ASD) using a coherence subspace defined by the first two principle components from all pairwise coherence measures. Leave-one-out cross-validation was used to test the predictive power of each model. Results: A greater number of regions showed coherence differences in the story-listening condition, compared to the resting state between groups, with differences found in left superior temporal and middle frontal gyri, and other regions. The story-listening classifier showed 69% accuracy, and 67% positive predictive value. In contrast, the resting-state classifier showed only 31% accuracy and 38% positive predictive value. These data indicate that neuromagnetic activity collected during a simple passive story-listening task may be valuable in constructing neurophysiological biomarkers for ASD.

A82 Atypical skill acquisition in children with language impairment

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Introduction. Our memories are thought to be organized into separate and distinct systems: a declarative system dealing with memories for facts ("what") and a procedural system dealing with memories for skills and habits ("how to") (Cohen & Squire, 1980). The latter system is involved in the acquisition of motor skills (e.g., handwriting), as well as in the acquisition of language skills such as the implicit knowledge of language rules (Ullman, 2004). To date there is no available task for assessing consolidation and retention of skills in children younger than 8 years. Consequently, it is not possible to test whether children at risk for learning disabilities, such as kindergarteners with Specific Language Impairment (SLI), have deficient skill learning. First, we found that kindergarteners, second graders and adults display and retain consolidation gains for a simple, 2-segmrnt, grapho-motor symbol acquisition task. Then, we studied skill acquisition in kindergarteners with SLI using the same task as well as using a more complex grapo-motor symbol. Methods and Results. Twenty kindergarteners, 20 second graders and 20 adults participated in Exp. 1.Participants practiced the production of a 2-segment graphic symbol, and were tested 24 hours, 48 hours, and two weeks post-practice day (4 blocks each). Testing compromised 5 time-points, blocks 1-4, and 9-12 of day 1 and the 4 blocks of each of the subsequent days. Results indicated significant improvement in all three age-groups on the training (between time-points 1 and 2), and consolidation (between time-points 2 and 3) phases, as well as retention of performance level (between time-points 3 and 5). In each of the experiments 2 and 3, thirty-two kindergartners took part: sixteen with SLI and 16 matched peers. In Exp. 2 children practiced the production of the graphic symbol presented in Exp. 1, and were tested 24 hours and two weeks post-practice day. Only the comparison group exhibited delayed, consolidation, gains in speed 24 hours post-training; children with SLI became slower. Only at two weeks post-training, children with SLI improved, closing the gap in performance speed. Both groups maintained their accuracy scores (Adi-Japha et al., 2011). In Exp. 3 children practiced a complex, 3-segment, grapho-motor symbol over 4 days, then returned for retention assessment 10 days later. Findings revealed that children with SLI showed weaker initial learning, but closed the gap by the end of a practice day. Children with SLI increased their production speed at faster rates than their peers within practice sessions, but did not retain their learning to the same degree the following day. Accuracy results showed poorer performance in children with SLI, with these differences decreasing over time. Major findings related to speed could not be accounted for fully based on fine motor skill. Conclusions. There is considerable evidence that the performance of children with LI on a variety of motor tasks is slower (e.g., Hill, 2001). The current results suggest that improved performance is delayed, and that deficient or delayed consolidation processes exist. These results support the procedural deficit hypothesis in SLI (Ullman & Pierpont, 2005).

A83 The role of the right hemisphere in semantic control

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Despite neuroimaging evidence that semantic control processes are bilateral, neuropsychological research has focused on the left hemisphere's contribution (LH). Semantic aphasia (SA) following left prefrontal and/or temporoparietal infarcts is characterised by largely intact knowledge combined with deficient semantic access or control mechanisms. SA patients show: (1) poorer performance on semantic tasks with high executive demands, (2) high susceptibility to cueing, and (3) executive control impairments that correlate with the degree of impairment on semantic tasks. This study examined right hemisphere (RH) stroke patients, to see if they showed qualitatively similar deficits to the SA patients with LH lesions. There were three potential hypotheses: (1) Although a bilateral system is activated

in semantically demanding tasks in fMRI, only the LH is necessary for semantic control. (2) The LH and RH make qualitatively different contributions to semantic control. (3) Damage to the network – independent of where that damage is – causes similar deficits in LH and RH stroke patients (although these impairments may be of a different magnitude). We compared 8 right hemisphere (RH) stroke patients to healthy controls on a range of semantic tasks that manipulated semantic control demands. These patients had large MCA lesions following a RH stroke at least 6 months prior to our study. Although they performed at ceiling on assessments sensitive to semantic impairment following LH infarcts, they showed a qualitatively similar pattern to LH patients in more difficult semantic tasks tapping judgements about distantly related concepts and facial emotions (i.e., domains previously associated with the RH). In these tasks, they showed (i) cueing and (ii) semantic blocking or 'refractory' effects – i.e., a reduction in word-picture matching accuracy over repeating cycles, reminiscent of the effects seen in LH patients. As in SA, these effects were multimodal – the effect size was the same in picture and word modalities. This supports the view that the semantic control network is bilateral; however, there were marked differences in overall level of semantic performance and some subtle differences in the presentation of semantic deficits following LH and RH stroke. This leaves open the possibility of a division of labour between the hemispheres which is currently being explored.

A84 Neurophysiological changes associated with anodal, cathodal and sham tDCS in chronic aphasia

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Objective: To assess neurophysiological changes resulting from prolonged anodal, cathodal and sham transcranial direct current stimulation (tDCS) to the left hemisphere (1mA for 13 minutes, 5 days a week for 6 weeks) in combination with intensive speech and language therapy (SLT). Participants and Methods: Twelve participants (8M) with chronic aphasia (Mean (SD) TPO = 34.78 (41.98) weeks) were randomized to receive anodal, cathodal or sham tDCS to the left hemisphere for six weeks, concurrent with intensive SLT. Pretreatment fMRI scans from three tasks (a semantic decision task, oral reading of single words embedded within a sentence, and imitation of consonant-vowel combinations) were used to identify individualized sites for tDCS electrode placement. tDCS was delivered via an 8cm2 oblong saline soaked sponge electrode over the previously determined scalp location. SLT (90 minutes) involved reading aloud sentences on a computer screen. The first 13 minutes of SLT was concurrent with the 13 minutes of tDCS. Temperature, blood pressure and self-reported side effects were measured before and after tDCS and at the end of each treatment session. The primary behavioral outcome was the Aphasia Quotient (AQ) of the Western Aphasia Battery (WAB-R). Post-treatment scans for each task were compared to pretreatment scans and the number of activated voxels in a circumscribed 5 mm perilesional area was calculated. Results: No adverse events were reported. Both anodal and cathodal groups demonstrated clinically significant behavioral improvements for the WAB AQ (>5 point gain) from pretreatment to post-treatment, whereas the sham group did not meet the criteria for clinically significant gains. Cathodal tDCS to the left hemisphere, expected to have an inhibitory effect, resulted in increased activation of voxels in both hemispheres, more so in the left hemisphere than in the right hemisphere, and specifically in the perilesional area. The mean (SD) increase in the number of perilesional voxels across three different fMRI tasks was 133.8 (268.5) for subjects randomized to anodal tDCS, 300.1 (865.7) for subjects randomized to cathodal tDCS, and 56.7 (148.2) for subjects randomized to sham tDCS. Chronicity and severity of aphasia may have influenced results. Three participants with the most recent onsets (6.2 – 6.3 months) showed no increase in perilesional activity for any task. In contrast, three participants with onsets of 7.3, 9.2, and 18.6 months respectively showed increased perilesional activity for all tasks. The remaining participants with onsets that ranged from 29.2 to 155.7 months demonstrated inconsistent increased perilesional activity on some tasks only. Participants with less severe aphasia (WAB AQ > 55) tended to show increased perilesional activation from pretreatment to post-treatment more frequently than those with more severe aphasia (WAB AQ < 55). Conclusions: Prolonged tDCS to the left hemisphere in combination with SLT, was safe. There were measurable neurophysiological changes from pre- to post-treatment. Cathodal stimulation to the left hemisphere may be a viable option and should not be overlooked in future research on tDCS and aphasia. Severity and chronicity of aphasia may influence neurophysiological outcomes . Acknowledgement: Supported by Grant # 5R21DC009876 from the NIDCD.

A85 Structure-behavior Correspondences for Canonical Sentence Comprehension in Broca's Aphasia

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INTRODUCTION: The purpose of the current study is to investigate the relation between behavior (the time-course of lexical activation) in listeners with Broca's aphasia (LWBA) and brain structure (lesion anatomy) in predicting individual variation. In a previous study (Ferrill et al., 2012) we found delayed lexical access in sentences with relatively simple syntax (see below) for LWBA; we suggested that this lexical access deficit could be responsible for the comprehension deficits observed for these individuals. Ex. "The boxer punched the golfer[1] after[2] the tremendously antagonistic discussion of the title fight." Here we examine the time-course of lexical access in sentences as above (in

canonical word order) and associate the contribution of regions of interest (ROI) in the brain that have been implicated in sentence comprehension, including LIFG and superior temporal gyrus. METHODS: We collected high resolution MRI scans for six LWBA from Ferrill et al (2012). All 6 had comprehension deficits, defined as chance performance of non-canonical (object-relative and passive) sentences from the SOAP Test (Love & Oster, 2002). Structural Analysis: Whole brain and lesion masks were created for each participant. Probabilistic maps of cytoarchitectonic areas (Amunts et al., 1999; Zilles & Amunts, 2010; maps publicly available in the JuBrain atlas at https://www.jubrain.fz-juelich.de/apps/cytoviewer/cytoviewer.php) were transformed on each participant's brain using non-linear registration (Hömke et al., 2009). Of interest is the proportion of lesioned tissue in three left hemisphere areas: BA44, BA45, and TE3 (on the superior temporal gyrus, an analogue of Wernicke's area; Morosan et al., 2005). This was calculated based on overlap between the probabilistic maps of these brain regions and lesion masks for each participant. Structure-Function Correspondence. We computed point-biserial correlations for each participant at each of two test points from Ferrill et al. (2012): at noun offset [1] and 400 msec downstream [2] (see example above). We computed priming effect sizes at each probe position and used these as the dependent variable in a least-squares regression analysis with the proportion of lesioned tissue in the ROIs as independent variables. RESULTS AND DISCUSSION: At noun offset, the proportion of lesioned tissue in BA45 was positively correlated with priming, whereas damage to TE3 was negatively correlated. Furthermore, the difference in proportion of lesioned tissue between BA45 and TE3 predicted the change in priming between noun offset to the downstream position; that is, LWBA who had greater relative involvement of BA45 tended to demonstrate priming at the noun and less priming downstream, whereas LWBA who had greater relative involvement of TE3 tended to show the inverse. This suggests a synergistic role for parts of Broca's area and the temporal lobe area, and furthermore is consistent with previous literature that implicates BA45 in lexical processes (Ullman, 2006). Our previous brain-behavior analyses (Walenski et al., submitted) have implicated BA44 in syntactic processes, but interestingly no significant relation was found between proportion of lesion in BA44 and priming patterns in the present study. This pattern suggests that syntactic and lexical processes differentially recruit subregions of LIFG.

A86 Graph-theoretic analysis of resting state brain networks in post-stroke aphasia

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Recent evidence suggests that resting-state abnormalities following chronic stroke likely influence recovery patterns, including in the domain of language. In this study, we systematically studies the resting state networks of 11 patients with post-stroke aphasia (PWA) with healthy older subjects drawn from an existing database of resting-state fMRI results to identify the impact of lesions leading to aphasia on network structure, and ultimately to relate network measures to post-stroke language impairment and recovery. 11 PWA with left hemisphere strokes and at least 4 months post onset participated. 3D anatomical images and a resting-state fMRI (rs-fMRI) series containing 140 images with TR =3s, and with 3.3125mm isotropic voxel size, were acquired in each patient. A group of control subjects over the age of 50 were selected from the 1000 Functional Connectomes database. The rs-fMRI series were pre-processed using standard procedures in SPM8. Reduction of non-neural noise was performed using the CompCor method (Behzadi et al., 2007), removing signals related to the leading principal components of voxels from the white matter and CSF. The residual signals were bandpass filtered between 0.01 and 0.08 Hz to isolate the low frequency fluctuations. Voxels were masked to select those likely to be gray matter (GM), and non GM voxels were discarded from further analysis. Because the brains of PWA are likely to undergo post-stroke functional reorganization, we used a data-driven method to cluster voxels that are spatially contiguous and have time series that are correlated above a threshold. The resulting clusters served as nodes in a graph theoretic analysis, with weighted edges determined based on: (i) the Pearson correlations between mean cluster time series, and (ii) partial correlations determined using an L1-regularized inverse covariance method (Friedman et al., 2008). We hypothesized that rs-fMRI network "hubs" would shift due to post-stroke plasticity. We calculated the weighted node degree (sum of all edge weights impinging on a cluster) and betweenness centrality (the fraction of the shortest paths between all cluster pairs that pass through that node) for each cluster, in both PWA and controls. Our results show an increase in the average number of shortest paths that traverse each cluster in the graph in PWA relative to controls. We additionally hypothesized that rs-fMRI networks in PWA would show decreased efficiency relative to controls. We calculated the global graph efficiency, defined as the inverse of the harmonic mean of the shortest path lengths between all nodes, for each subject. Initial results show a consistent pattern of reduced global efficiency in PWA relative to controls. Compared with controls, these results indicate inefficiencies in the post-stroke resting-state network, with greater shifts in network hubs in PWA dependent on the site and size of lesion. Such graph analytic results may ultimately prove informative in advancing individual-specific therapies for language recovery.

Poster Session B

Gesture, Prosody, Social and Emotional Processes

B1 Altered communicative adjustments following ventromedial prefrontal lesions

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The ventromedial prefrontal cortex (vmPFC) has been consistently implicated in supporting behaviors guided by a mental model of other agents. For instance, moral judgements made by patients with vmPFC lesions are more strongly influenced by the outcome of a harmful action than by its underlying intention, i.e. whether the harm was attempted or accidental. Yet, during linguistic interactions, patients with vmPFC lesions are able to consider the knowledge of an interlocutor, for instance by using shorter utterances and definite references following repeated verbal exchanges. It remains unclear whether that performance reflects spared linguistic retrieval of knowledge on social facts and procedures, or genuinely preserved communicative abilities. Here we test whether the inability of vmPFC patients to use a mental model of an interlocutor becomes evident once communicative interactions are not confounded with linguistic phenomena. Communicative abilities of patients with vmPFC lesions (N=8) were quantified in a controlled experimental setting involving the production of referential non-verbal behaviors with a communicative goal, exploiting a previously validated protocol. Namely, participants were asked to inform an addressee about the location of a token in a 3x3 grid (visible only to the communicator) by means of their movements on the grid (visible to both communicator and addressee). Participants marked the location of the token in the grid by waiting longer on that location as compared to other locations visited during their movements on the grid ("TimeOnTarget" effect). Crucially, participants were told this communicative game involved online interactions with a child and with another adult, in alternation. In fact, an adult confederate performed the role of both addressees, while remaining blind to which one of the two roles she was performing in any given trial. Accordingly, both performance and response times of the two presumed addressees were matched. These tasks features allowed us to directly tap into patients' ability to spontaneously generate communicative adjustments to their mental model of an addressee, rather than retrieving knowledge from pre-established conventions (e.g. a common language). The specificity of the vmPFC lesion effects was assessed with lesion-symptom mapping and by comparing communicative behaviors of vmPFC patients with those evoked in patients with brain lesions outside the vmPFC (N=8, "lesion-controls") and in age-matched healthy participants (N=15, "healthy-controls"). Patients with vmPFC lesions communicated as effectively as lesion- and healthy-controls, spending longer time on the field containing the target (TimeOnTarget effect). Crucially, both lesion- and healthy-controls showed a larger TimeOnTarget effect when they thought they were communicating with a child, whereas vmPFC patients did not communicatively differentiate between the two addressees, despite doing so when asked to comment on their age and abilities. Furthermore, following a communicative error, vmPFC patients did not increase the contrast between communicative and instrumental components of their actions, as spontaneously done by the lesion- and healthy-control groups. These findings suggest that vmPFC is necessary for using social knowledge to bias current communicative decisions to the presumed characteristics of an addressee, leaving the linguistic retrieval of knowledge on social facts and procedures relatively un-affected.

B2 Job interview in the fMRI scanner: pragmatic inferences in real addressees *Jana Basnakova[1,2], Kirsten Weber[5,6], Peter Hagoort[1,3], Jos van Berkum[4]; [1]Max Planck Institute for Psycholinguistics, Nijmegen, NL, [2]nstitute for Experimental Psychology, SAS, Slovakia, [3]Donders Institute for Brain, Cognition and Behaviour, Radboud University Nijmegen, NL, [4]Department of Languages, Literature and Communication, Faculty of Humanities, Utrecht University, NL, [5]Massachusetts General Hospital, Boston, USA, [6]Harvard Medical School, Boston, USA*

Although language gives us the tools to say exactly what we mean, our interactions with others are not always quick, clear, and maximally efficient (Holtgraves, 2002). In using language, we not only exchange information, but also negotiate our social selves – such as avoid losing face (e.g. Brown and Levinson, 1987). One of the ways people deal with these demands is to attenuate the impact of potentially face-threatening information by using indirect language. While there has been research on the speed of comprehension of indirect replies (Holtgraves, 1999) and their neural correlates (Bašnáková et al., 2013), one important aspect is typically missing. In real life, utterances are designed for particular addressees and relevant to their concerns, but participants in experimental studies are only overhearing information relevant to other (fictional) persons. We used fMRI to examine whether making pragmatic inferences will differ if participants believe that they are the addressees, not just over-hearers, of indirect face-saving utterances. We created a context where such "face-work" is especially prominent – a fictional job interview, where being indirect can be used as efficient strategy to e.g. mask the lack of relevant skills or experience. We used a 2x2 factorial design, with the factors directness (direct/indirect replies) and participant status (addressee/over-hearer). Within the directness factor, we manipulated whether a reply is a direct, information-providing answer to a question (baseline), or rather an attempt to avoid answering a question for which the answer would be undesirable. Both types of replies were identical at the sentence level, with the preceding question making them direct or indirect. In the addressee condition, participants believed that they were the interviewers posing scripted questions via intercom to three other participants acting as job candidates. In the over-hearer condition, participants knew they were listening to recorded dialogs of the same "job candidates" with a different interviewer. In order to achieve identical stimulus material, the replies were pre-recorded and played back to the participant in both conditions. Results show that the main effect of indirectness (indirect>direct replies) largely replicated our previous findings from a simple listening paradigm, with activations in medial prefrontal cortex, right temporo-parietal junction (TPJ), bilateral inferior frontal gyrus and right middle temporal gyrus, with some additional left-hemisphere activations in the temporal

gyrus and TPJ. However, we did not find an interaction between directness and participant status, suggesting that there was no difference in pragmatic inferencing if the participants were direct addressees of indirect replies or not. This suggests that even if listeners are using language-as-action, with the aim to do something with the information they infer from a person who directly addresses them (choosing the best candidate for the job), the basic ingredients of pragmatic inferencing - such as perspective taking - stay the same. This is in line with theories in literary science (e.g. Busselle & Bilandzic, 2008; similar Mar & Oatley, 2008) which maintain that even while "over-hearing" fiction, people are transported into the plot in a way that they feel directly engaged/ identified with what is going on.

B3 The Social N400 effect: how the presence of other listeners affects language comprehension *Shirley-Ann Rueschemeyer[1], Tom Gardner[2], Cat Stoner[1]; [1]University of York, [2]University of Bangor*

Communication relies on interlocutors keeping track of what conversational partners can and cannot understand. In conversations involving three parties or more, successful communication also depends on listeners tracking what other listeners comprehend. The effect of co-listeners on language comprehension is particularly interesting because, in contrast to partners in dialogue who take turns speaking and listening, co-listeners are engaged in the same task at the same time (i.e., to listen). Therefore paradigms involving co-listeners are optimal for looking at conversation as a joint action. Although co-listeners are united in task and time, background knowledge can lead two co-listeners to have different interpretations of the same utterance. This can give rise to situations in which a listener understands a speaker's utterance, yet simultaneously understands that another listener does not understand the same statement. In the current study we were interested in the cognitive process underlying this moment in time in which a listener understands sentence content from his/her own perspective and simultaneously perceives a misunderstanding on the part of a co-listener. In order to study this empirically, participants (Ps) were seated next to a confederate (C) in the EEG lab. In front of P and C was a single computer screen onto which sentence stimuli were presented. In addition, Ps were given headphones over which context sentences were presented. Each trial consisted of two sentences: one spoken context sentence, presented to P alone over headphones, and one written sentence, presented to both P and C on the computer screen. 126 trials were presented in total. The critical sentence in every trial was the written sentence presented to both P and C, and the critical word in every trial was the final word of the written sentence. The written sentence belonged to one of three critical experimental conditions: (1) PLAUS: sentences that were plausible for P and C (The fishmonger prepared the fish. The fish had gills.), (2) IMPLAUS: sentences that were implausible for both P and C (The boy woke up at dawn. The boy had gills.), and (3) CONTEXT: sentences that were plausible for P (i.e., because of spoken context sentence), but implausible for C (e.g., In the boy's dream, he could breathe under water. The boy had gills.) Continuous EEG was recorded and event-related potentials time-locked to the onset of the critical word (i.e., the final word in the second sentence) were calculated. Participants (N=15) show an N400-effect for the processing of IMPLAUS compared to PLAUS stimuli. More surprisingly participants also show a robust N400-Effect, a Social N400-Effect, in response to CONTEXT vs. PLAUS sentences. Critically, in a second experiment Ps (N=17) were presented with identical sentence stimuli in the absence of C and the Social N400-Effect disappeared. Our results suggest that (1) information about co-listeners affects language comprehension, and (2) the cognitive process by which we understand what others comprehend mirrors our own language comprehension processes.

B4 Social coordination in Amyotrophic lateral sclerosis *Elizabeth Gjersvik[1], Nicola Spotorno[1], Ashley Boller-Hewitt[1], Lauren Elman[2], Leo McCluskey[2], John Woo[2], Katya Raskovsky[1], Robin Clark[3], Corey McMillan[1], Murray Grossman[1]; [1]Penn Frontotemporal Degeneration Center, Department of Neurology, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA, USA, [2]Penn ALS Center, Department of Neurology, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA, USA, [3]Department of Linguistics, University of Pennsylvania, Philadelphia, PA, USA*

Amyotrophic lateral sclerosis (ALS) is a neurodegenerative condition of the motor system that has increasingly been associated with cognitive deficits, especially in the executive domain (e.g., Libon et al 2012). The aim of the present study is to test Social coordination in patients with ALS, in order to investigate the extent to which their executive limits can affect social interactions. Social coordination refers to the process of establishing a mutual representation, or "getting on the same page" with another individual and is hypothesized to depend in part on an executive frontal network. 27 patients diagnosed with ALS and 20 demographically matched healthy seniors were presented with 20 questions probing various semantic categories (e.g., tell me a boy's name). In the Survey condition, participants provided any response. In the Coordination condition, participants were instructed to respond with the same answer they think an anonymous partner would give. Previous work (e.g. McMillan et al, 2012) has shown that the present test is able to capture social coordination deficit in other neurodegenerative conditions like behavioral variant Frontotemporal degeneration. Responses in both the Survey and Coordination conditions were quantified by calculating the frequency of each response provided in the Coordination condition by the group of healthy seniors. By definition, a response that was provided more frequently increases the chances that an individual will coordinate with another individual. For example, the frequency of responses for the category "boy's name" included "John" 15 times, "Michael" 7 times, and "Preston" only once. If a response was provided in the Survey but not in the Coordination condition it was given a frequency of zero. We used the difference between

the (Z-transformed) score in the Coordination condition and the (Z-transformed) score in the Survey condition as a main dependent variable. The statistical analysis showed a significant difference between ALS patients and Healthy seniors [$t(45)=2.85$, $p < .01$], revealing that ALS patients are impaired in Social Coordination. In addition, neuropsychological assessment related patients' performance in the present test with the results of the visual-verbal task (Evans et al, in press) which measures mental flexibility [$R=.47$, $p < .05$]. Therefore, we argue that limited mental flexibility might constrain ALS patients' ability to coordinate with other people during social interactions. MRI analysis of a subgroup of 12 ALS patients revealed reduced white matter fractional anisotropy in the superior longitudinal fasciculus and the inferior fronto-occipital fasciculus, which are critical white matter projections in the frontal-parietal network. Overall, the present results show social coordination deficits in ALS that are due to limitations in mental flexibility and that are reflected in reduced connectivity in a large-scale fronto-parietal network.

B5 Navigating others' minds automatically: Evidence from the temporal-parietal junction

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Social interactions leading to effective understanding and communication require us to attribute mental states to others, an ability referred to as theory of mind. However, it is uncertain whether humans automatically reason about the knowledge and beliefs of others. Even less clear is the extent of such reasoning and whether or not it shares the same neural pattern as deliberate social reasoning. We used functional near-infrared spectroscopy (fNIRS) in twenty-eight young adults to examine the neural response of brain regions associated with social mental reasoning during an automatic (i.e. implicit) theory of mind task followed by a deliberate (i.e. explicit) theory of mind task. During the implicit task, brain activity was recorded during free viewing of videos containing social interactions involving an actress with different levels of knowledge or belief about the location of an object. In one condition, the actress held an accurate or true belief about the object's location (True Belief Condition- TB). In a second condition, the actress held a false belief, or was ignorant, about the object's location (False Belief Condition- FB). Finally in a third condition, the actress was initially ignorant of the object's location, but the box into which the object was placed was clear, allowing the actress to have direct perception of the object (Direct Perception Condition- DP). The explicit task consisted of reading single-paragraph stories and answering questions about a person's knowledge or beliefs (Belief Condition), or about the state of events (Fact Condition), to independently identify belief-selective cortical regions of interest for analysis of free-viewing data. We find that activity in the right temporal-parietal junction (rTPJ), the brain region characterized as specialized for mental state reasoning, is significantly greater when participants answered belief questions as opposed to factual questions. Additional evidence from the implicit task shows the rTPJ fluctuates automatically according to changes in knowledge of the actress in the video clip, responding most when she presumably holds a false belief about the location of a hidden object (i.e. response to FB was significantly greater than that to TB and DP). These results call into question the validity of the traditional view of theory of mind as a resource intensive, deliberate skill, instead suggesting it may be more foundational to human cognition and social interaction than previously thought. Our data demonstrate humans automatically reason about mental states, including false belief representations, as shown by activation of the rTPJ, the same region associated with deliberate reasoning, providing evidence for a single theory of mind system with the ability to operate deliberately or automatically. The findings of the present study have important theoretical and clinical implications for the characterization of theory of mind across the lifespan, for developmental assessment of social-cognitive skills, and for the contiguous development of treatment and interventions for individuals with social-communicative impairments such as autism.

B6 Neural basis of social coordination deficits in bvFTD

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Conversational partners establish shared mental representations to mediate common understanding. Game theory, rooted in principles of strategy and decision-making, refers to this as social coordination. Patients with bvFTD offer a unique window into the neural mechanisms of social coordination. Characterized by inappropriate social behavior and executive limitations, bvFTD is a rare neurodegenerative disease associated with progressive atrophy in frontal and temporal regions. To probe social coordination in bvFTD, we developed a novel task in which patients (N=12) and matched controls (N=14) were shown two-scene stories illustrating the movement of a target toy that was embedded in a shelf of competing objects sharing color, size, or pattern features. Participants had to describe the scene with sufficient detail so a conversational partner could correctly identify the moving toy. Trials varied in the amount of information available to the partner: in common ground trials, the partner had equal access to visual information; in colorblind trials, the partner was colorblind; and in privileged ground trials, there was a physical obstruction partially blocking the partner's view. The latter two conditions put increasing demand on perspective-taking ability. When conditions were compared, we saw that patients were impaired on colorblind trials, which required subjects to mentally represent their partner's knowledge, but not on privileged ground trials, in which there was a physical reminder of the partner's limited knowledge. High-resolution structural MRI related performance on colorblind trials (with common ground trials as a baseline) to orbitofrontal (OFC) and medial frontal (MFC) atrophy, suggesting a crucial role of these areas in cognitive perspective-taking. Responses were also

scored as precise, superfluous, or insufficient, depending on adjective use. This analysis showed that patients (47.97 ± 8.65%) gave more insufficient responses (e.g. when two pigs were present, "pig" instead of "red pig") relative to elderly controls (21.56 ± 11.05%, p<0.001). This was negatively correlated with forward digit span (p<0.01) and Trailmaking Test, Part B (p<0.05). The rate of insufficient responses was related to MFC and OFC atrophy, as in the colorblind analysis, as well as atrophy in dorsolateral prefrontal cortex (DLPFC). This suggests that DLPFC plays a role in resource demands associated with maintaining object features in an active cognitive state during processing. In sum, our results indicate that social coordination deficits in bvFTD are due to impaired perspective-taking and executive dysfunction, due to frontal atrophy.

Auditory Perception, Speech Perception, Audiovisual Integration

B7 Top-down modulation of cortical responses to voice and speech: developmental changes from childhood to adulthood

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Human listeners are surprisingly efficient in selecting, grouping and processing relevant acoustic elements of a sound while ignoring other elements of the same sound and the possible interference of background noise. In adults, this processing has been shown to rely on neural mechanisms that enable flexible representations of the same sound depending on the current behavioral goal [1,2]. Much less is known on how - during development - these processes change and reach their mature efficiency. Here we measured functional MRI responses while children (8-9 years, n=10), adolescents (14-15 years, n=13) and adults (~24 years, n=10) listened to the same speech sounds (vowels /a/, /i/ and /u/) spoken by different speakers (boy, girl, man) and performed a delayed-match-to-sample task on either speech sound or speaker identity. Whole-brain fMRI data (3x3x3 mm3, 3T Siemens Allegra head scanner, TR=2.5 s; TA=2.0 s, sounds presented in silent gap) were collected according to a slow event-related design. Following pre-processing, random effects GLM analysis was performed on data sampled on individual cortical surface meshes, aligned to a cortical group surface mesh using cortex-based alignment [3]. Functional contrast maps (t-statistics) were calculated to assess (interaction) effects of task and age group on sound-evoked fMRI responses. All participants performed well-above chance level (50%) on the delayed-match-to-sample speaker and vowel tasks. Accuracy of speaker identification was comparable across age groups (Group: F(2,30)=0.37; n.s.), but girl/boy voices were more difficult to recognize than the adult voice (Stimulus: F(2,60)=18.0; p=0.000; mean (SD) % correct: boy 89.9 (6.9); girl 82.9 (12.2); man 96.7 (5.3)). Accuracy of vowel identification was lower in children than in adolescents and adults (Group: F(2,30)=10,0; p=0.000; mean (SD) % correct: children 95.4 (3.6); adolescents 99.1 (1.5); adults 99.3 (1.0)), without significant stimulus differences. Across age groups, speech sounds evoked BOLD responses in a wide expanse of superior temporal cortex, in the inferior frontal cortex, the medial prefrontal cortex, and especially during the vowel task, in the posterior temporal cortex. Task modulations of sound-evoked responses showed developmental changes that were most apparent when comparing children and adults, with intermediate effects in adolescents. Most interestingly, a cluster on the right superior temporal gyrus/sulcus, with strong voice selectivity in the voice localizer [4], showed an age-related increase in speaker-task specific activity. This result suggests an incremental specialization for the active processing of voices in the right superior temporal cortex [5]. An age-related increase in vowel-task specific activity was observed in a smaller right posterior temporal cluster. Because the vowel task required matching of vowel sounds to letters, this result may relate to continued refinement of letter-speech sound associations with reading experience [6]. References [1] Bonte M et al. (2009). J Neurosci, 29(6): 1699-170 [2] Bonte M et al. (2014). J Neurosci, 34(13): 4548-4557 [3] Goebel R et al. (2006). HBM, 27: 392-401. [4] Belin P et al. (2000). Nature, 403: 309-312. [5] Bonte M et al. (2013). Neuroimage, 83: 739-750. [6] Blomert L (2011). Neuroimage 57: 695-703. Supported by the Netherlands Organization for Scientific Research (NWO) VENI-grant no.451-07-002 (MB).

B8 Eye gaze during perceptual adaptation of audiovisual speech in adverse listening conditions

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Visual speech cues can benefit comprehension in adverse listening conditions, such as in the presence of background noise (for example, Sumby & Pollack, 1954), or with accented speech (Yi, Phelps et al, 2013), and can also aid perceptual adaptation to unfamiliar, degraded speech (Kawase, Sakamoto et al, 2009; Pilling & Thomas, 2011). How this visual information is gained and used by the listener is less understood. When listening to speech in noise at increasing signal-to-noise ratios, listeners look more at a speaker's mouth than eyes (Vatikiotis-Bateson, Eigsti et al, 1998), indicating that visual attention is modified as auditory processing becomes more difficult. We hypothesised that similar patterns of eye gaze would be observed during comprehension of unfamiliar or degraded speech. Particularly, we were interested in whether patterns of eye gaze changed over time as listeners adapted to the unfamiliar speech, and whether eye gaze patterns were related to individual comprehension. We tracked participants' eye movements while watching video clips of a speaker with foreign-accented or noise-vocoded speech. Each video clip comprised an IEEE sentence that the participant repeated aloud. We observed equal baseline comprehension for both speech types, with greater adaptation over time for noise-vocoded speech. Eye tracking results revealed that overall, participants looked more at the mouth of the speaker than at the eyes for both speech types. The duration of fixations decreased over time as participants

adapted to the unfamiliar speech. However, more long fixations on the mouth were observed for noise-vocoded speech, compared with more short fixations on the mouth for accented speech. Longer fixations on the mouth predicted better comprehension of the noise-vocoded speech, but not of the accented speech. Our findings suggest that sustained visual attention on a speaker's mouth reflects effective use of visual speech cues during comprehension in adverse listening conditions, and support a role for visual attention in perceptual adaptation of audiovisual unfamiliar speech.

B9 White matter changes in the visual pathways of late-blind subjects correlate with the ability of ultra-fast speech perception

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As a consequence of their loss of vision, blind subjects may show neuronal degeneration within white matter structures of the central visual system. However, due to neuroplasticity of the visual system, they may also exhibit cross-modal reorganization patterns, leading to some recovery or revitalization of degenerated tracts (for a review see Merabet and Pascual-Leone, 2010, Nat Rev Neurosci 11:44-52). Cross-modal reorganization of the visual system in blind humans has been described in various studies by means of functional magnetic resonance imaging (fMRI), showing visual cortex activation during the subjects' engagement in non-visual tasks. For example, blind people can learn to understand spoken language at very high speaking rates of up to ca. 20 syllables/s when using text-to-speech devices as a substitute for text reading. Previous fMRI data on late-blind humans showed that their capability of ultra-fast speech comprehension covaries with task-related hemodynamic activation within the right visual system (V1) and pulvinar (Pv) and left supplementary motor area (pre-SMA), furthermore, magnetoencephalographic (MEG) data showed right-lateralized activity in the visual system phase-locked to syllable onsets. These findings gave rise to the assumption that the visual system is provided with syllabic-prosodic information through an early cross-modal pathway and, subsequently, transmits this information to the frontal speech processing network (Hertrich et al., 2013, Frontiers in Psychology 4:530). The present study was designed to show structural alterations that may underlie these cross-modal and skill-related brain mechanisms in blind subjects. To these ends, late-blind subjects from the previous functional imaging study, differing in their skill of understanding ultra-fast speech, were measured using diffusion tensor imaging (DTI). Fractional anisotropy (FA) was calculated as a quantitative measure of the directionality of water diffusion, indicating fiber tract characteristics that might be influenced by blindness and the acquired skill. In order to localize diffusion-related changes in space, "Tract-Based Spatial Statistics" (TBSS) was applied to the data set, as proposed by Smith et al. (2006, NeuroImage 31:1487-1505). Using TBSS, voxel-wise statistical analysis of the FA data was carried out by projecting all FA values of the subjects on a mean FA tract skeleton before conducting statistics across subjects. In comparison to sighted controls, FA was reduced in the blind group within parts of bilateral optic radiations and in the region of dorsal thalamus/Pv of the right hemisphere. Within the right-hemisphere optic radiation and thalamus/Pv, furthermore, blind subjects showed significant positive correlations between FA and the capacity of ultra-fast speech comprehension. No such correlations were found in the sighted control group. Thus, the present DTI results complement previous findings of skill-dependent visual cortex engagement in late-blind individuals during the perception of ultra-fast speech. At least in part, these structural alterations comprise revitalization of pathways that had been degenerated du to blindness.

B10 Within-block amplification of the mismatch negativity suggests rapid phonetic learning for non-native categories

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A puzzling phenomenon in non-native speech perception is that non-quantity listeners who lack phonological experience with vowel duration in their native language, rely excessively on durational cues when listening to non-native vowels. In behavioural and ERP measurements, non-quantity listeners exhibit large sensitivity to duration in non-native stimuli, which is comparable to that of quantity listeners who have native phonological length (Cebrian, 2006; Chládková et al., 2013). One explanation for non-quantity listeners' duration-reliance states that duration is largely salient acoustically and therefore all listeners attend to it in non-native vowels (Bohn, 1995). An opposing view argues that duration in non-quantity listeners is a blank-slate dimension, allowing for rapid creation of new categories (Escudero and Boersma, 2004; Escudero, 2005). Confirmation for either of these hypotheses has not as yet been provided. In order to directly test these contrasting hypotheses, we traced the development of duration-induced MMN throughout a single stimulus presentation session. The amplitude of the MMN to speech-sound changes generally attenuates after several minutes of presentation (McGee et al., 2001). Therefore, if duration has a universal perceptual saliency, all listeners should show the same trend: duration changes should elicit a stronger MMN at the beginning than at the end of a block. However, if non-quantity listeners have a blank-slate for duration initially and then readily form new categories, they should not show such MMN-attenuation. In contrast, their MMN to duration would be weaker at the beginning (when they are at the blank-slate stage) than at the end of the block (when they have started forming some entities on the originally blank dimension). EEG was recorded from 22 non-quantity (Spanish) and 23 quantity (Czech) listeners. They were presented with an oddball paradigm comprising duration changes in the /□/-vowel, non-native to both groups. Responses to short standards were subtracted from short deviants, and likewise for long stimuli. The data from the 30-minute session were split into halves to yield two time-specific difference waves: one for the first part and one for the second part of the session. We quantified the average MMN amplitude in a 40-ms window at a

negative peak determined between 100ms and 200ms post deviation onset. A repeated-measures ANOVA with SessionHalf and Language as the within- and between-subjects factors, respectively, revealed a significant interaction of the two factors (F[1,41]=6.112, p=.018; at FCz). In Czech listeners, MMN amplitude decreased throughout testing from -2.526μV to -1.747μV, while in Spanish listeners, it followed the opposite trend, rising from -1.790μV in the first half to -2.023μV in the second half of the session. The lack of MMN attenuation in Spanish listeners suggests that non-quantity listeners' detection of duration differences increases after very short exposure to stimuli involving durational variation. This finding supports the blank-slate hypothesis (Escudero and Boersma, 2004). The results indicate that fast phonetic learning took place: Spanish listeners readily picked up the differential distributions of the short and the long sounds in the stimulus set (e.g. long=frequent, short=rare,) which allowed them to group the short versus long stimuli into two distinct categories.

B11 Shape-sound matching abilities are limited in young monolingual and bilingual infants

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Behavioural investigations have shown that at 3-4 months of age, young infants can already match auditory and visual information from both linguistic (e.g., words, syllables, articulatory gestures) and non-linguistic sources (e.g., pure tones, geometric shapes). This matching ability is typically thought to reflect cross-sensory integration and to rely on developing connections between auditory and visual cortices. However, anatomical studies suggest that such inter-cortical connections do not begin to develop until after 6 months of age. To reconcile these reports, we have designed several studies to 1) systematically investigate 4 and 12-month-old infants' behavioural matching (or integration) abilities for different types of linguistic and non-linguistic stimuli, and 2) observe emerging resting state networks between the different cortices. Here, we report data from our first behavioural experiment within this series of studies. We investigated infants' biases in associating visual (non-linguistic: rounded vs. angular shapes) and auditory (sound combinations) information. Our starting point is that adults and toddlers consistently match certain sound combinations or syllables with angular or rounded objects (e.g., /buba/ is matched with rounded shapes, /kiki/ with angular shapes). This bias has been explained by the different articulatory gestures (e.g., rounds vs. not-rounded) necessary for producing the sounds. Moreover, recent findings suggest that bilingual adults show a stronger bias than monolinguals. To assess whether infants possess these biases, we tested 4 and 12-month-old monolingual and bilingual infants using a behavioural preferential looking paradigm. First, 24 Spanish monolingual and 28 Spanish-Basque bilingual 4-month-old infants were tested for any bias to match the sound combinations /buba/ and /kike/ with rounded and angular shapes. The results revealed no evidence that either group of infants has a consistent bias to match either sound combination with either shape. Second, we tested whether auditory stimuli that were better matched to the infants' language background (Spanish and Basque) would improve young infants' performance: we selected two pseudo-words (based on previous adult ratings) that are perceived as Spanish-like (/raceto/ vs. /bubano/). These two new pseudo-words were presented to 15 4-month-old Spanish monolingual infants following the same procedure as in the first experiment. However, similar to our previous findings, no bias was observed. Data collection from 12-month old infants is currently ongoing. Our preliminary behavioural findings suggest that the sound-shape bias that we examined requires more auditory and visual experience and/or more developed connections between auditory and visual cortices than 4-month-old infants possess. Our future studies will further investigate the neural basis of multisensory integration in 4 and 12-month-old infants.

B12 Corticostriatal contributions to feedback-dependent speech category learning

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Learning novel speech categories in adulthood is acknowledged as one of the most challenging category learning problems for humans. Using functional magnetic resonance imaging (fMRI), we investigated neural and computational mechanisms underlying feedback-dependent speech category learning in adults. Adult native speakers of English (N = 23) learned novel speech categories (Mandarin tone categories) while blood oxygenation level dependent (BOLD) responses were collected. Participants made a category response to each stimulus, which resulted in positive or negative feedback. Neural activity during stimulus presentation and feedback processing were separately estimated using an optimized rapid event-related design. Behavioral accuracies were calculated and neurobiologically-constrained quantitative decision-bound models were used to gain insights into individual differences in the computational strategies employed during different stages of category learning. When native English speakers categorized non-native speech categories with corrective feedback, significant activity was seen in multiple, domain-general category learning systems: a fast-learning reflective system, involving the dorsolateral prefrontal cortex (DLPFC) which develops and tests rules based on feedback in an explicit manner, and a slower-learning reflexive learning system involving the putamen, which operates by implicitly associating perception with responses that lead to reinforcement. Successful categorization was associated with increased DLPFC activity during early trials and increased putamen activity during later trials. Computational modeling of response strategies constrained by the neurobiology of the two category learning systems revealed greater use of reflexive strategies over learning trials, which was associated with increased activity in the putamen, but not in the DLPFC. Our results demonstrate differential

involvement of the cortico-basal ganglia circuitry in speech categorization as a function of expertise and time scale of learning. Our findings represents an important conceptual advance in the understanding the neurobiological basis of domain-general neural systems during speech learning.

B13 The development of internal representations of sound categories *Sung-Joo Lim[1,2,3], Andrew J. Lotto[4], Jonas Obleser[3], Lori L. Holt[1,2]; [1]Carnegie Mellon University, [2]Center for the Neural Basis of Cognition, [3]Max Planck Institute for Human Cognitive and Brain Sciences, [4]University of Arizona*

Listeners are sensitive to statistical regularity of input distributions defining their native speech categories. The structure of speech categories also encourages the use of decision boundaries in categorization. While listeners' sensitivity to both distribution and decision boundary information reflects internal representations of speech categories, how these different information sources interact over the course of category learning is relatively unknown. Moreover, typical measures of overall categorization accuracy are not sensitive enough to characterize the underlying representations. To investigate the development of internal representations of auditory categories, we used a mixed-logistic regression analysis to track trajectories of listeners' category-learning-related sensitivity on a trial-by-trial basis. All participants received explicit categorization training for learning a pair of novel nonspeech sound categories with trial-by-trial feedback. Critically, during a brief practice session prior to training, one group of participants consistently heard a prototypical sound exemplar of each category ("Anchor"), whereas the other group heard arbitrary sounds ("No Anchor"). The groups improved in accuracy at an equivalent rate across the training session. However, the different pre-exposure phases led listeners to adopt different categorization strategies, revealed by the regression analysis. From early in learning, "Anchor" group listeners relied on the optimal decision boundary defined by the category prototypes and exhibited sensitivity to the distributional regularities of categories relative to category prototypes. On the contrary, "No Anchor" listeners exhibited reliance on a decision boundary informed by feedback for correct categorization. Results demonstrate the richness of auditory categorization data beyond simple accuracy measures. Early encounters of category exemplars can have a notable impact on both the initial set-up of the perceptual space and the longer-term consequences of learning. With respect to the neurobiological implementation of such perceptual organization processes, predictions for the relative engagement of basal ganglia structures and auditory cortical regions can be formulated: whereas activity patterns in the auditory cortex would reflect internal representations of newly learned sound categories, the recruitment of the basal ganglia would be modulated by the degree of listeners' reliance on the feedback-contingent decision boundary.

B14 Neural processing of speech envelope modulations in normal and dyslexic readers: Source analysis of auditory steady-state responses *Astrid De Vos[1,2], Robert Luke[1], Jolijn Vanderauwera[1,2], Pol Ghesquière[2], Jan Wouters[1]; [1]KU Leuven, Experimental oto-rhino-laryngology, Leuven (Belgium), [2]KU Leuven, Parenting and special education research group, Leuven (Belgium)*

Background: Developmental dyslexia refers to a hereditary neurological disorder characterized by severe difficulties in reading and spelling despite normal intelligence, education and intense remedial effort. Depending on the used criteria, dyslexia is thought to affect between 5 and 10% of the population. Although it is widely agreed that the majority of dyslexic individuals show difficulties in one or several aspects of phonological processing, the underlying cause of these phonological problems remains debated. Recent evidence suggests that a fundamental deficit in phase locking of neural oscillations to temporal information in speech could underlie the phonological processing problems found in dyslexia. Objectives: To examine phase locking properties of neural oscillations, neurophysiological methods providing a high temporal precision (i.e. EEG) are necessary. However, EEG data analysis, and hence data interpretation, has not always been straightforward due to limited spatial resolution. Since the EEG is measured at the scalp, recordings are inherently attenuated and transformed due to volume conduction (as the electrical signal passes through cerebrospinal fluid, skull and skin). Consequently, EEG data have been characterized by large intra- and inter-subject variability. With the aim of reducing this variability, research has intensively focused on the development of computational methods to localize the neural sources underlying the EEG signal. Using these recent advances, this study aims to investigate whether cortical phase locking to temporal information in speech is impaired in dyslexia. Methods: Auditory steady-state responses (ASSR) were recorded in a group of normal-reading and dyslexic adolescents. Continuous speech-weighted noise stimuli were amplitude modulated at modulation frequencies near 4 Hz, 10 Hz, 20 Hz and 40 Hz, corresponding to the range of modulation rates present in the temporal envelope of speech. As a reference condition, also 80 Hz was also included. Stimuli were presented in three modalities: monaurally to the left ear, monaurally to the right ear and bilaterally to both ears. Responses were recorded with a high-density 64-electrode array mounted in head caps. Source analysis was performed using CLARA (Classical LORETA Analysis Recursively Applied) and generic MRI based head models. Anatomical brain images were also collected with MR scans, including T1-weighted as well as T2-weighted images, to allow for the construction of realistic individual head models. Results and conclusions: Results at sensor level already showed differences in auditory temporal processing between normal and dyslexic readers at 10 Hz modulation rates. Detailed results at neural source level will be presented at the conference. This study is the first to apply source localization methods on ASSR data in dyslexia. Source

localized EEG measures allow for a more sensitive and robust view on auditory processing in dyslexia since underlying neural processes are being observed where and when they truly take place. We hope that this approach will deliver unique insights on which neural aspects of auditory processing affect the formation of phonological representations in dyslexia.

B15 Electrophysiological differences in 6- month-old infants at risk for Autism Spectrum Disorder: Evidence from the processing of non-native language contrasts *Sharon Coffey-Corina[1,2], Denise Padden[2], Cherie Percaccio[2], Patricia Kuhl[2]; [1]UC Davis, Center for Mind and Brain, [2]University of Washington Institute for Learning and Brain Sciences*

Introduction. Autism spectrum disorder (ASD) is on the rise. Currently as many as 1 in 68 children in the U.S. are diagnosed annually. Early diagnosis of ASD is a pressing concern as early intervention has proven to be effective in treating this disorder. Our goal is to determine whether electrophysiological measures of speech processing may serve as a diagnostic biomarker of ASD. Previous research has shown that toddlers (19-30 mos.) and children (9-10 yrs.) with autism exhibit increased P2 amplitude to unknown words relative to non-affected controls. In an effort to assess infants, we examined the utility of using native and nonnative speech contrasts in 6-month-old infants at risk for ASD. Previous studies in typically developing infants have shown that ERP responses to these stimuli are related to later language skills (Kuhl et al., 2008). Our at-risk subjects were followed longitudinally and identified as ASD or asymptomatic at 24 months. This allowed us to retrospectively examine ERP responses in infants who would or would not later present with ASD. Method. We recorded event related potentials (ERPs) from 6 month old, monolingual, American infants (N=22) who had an older sibling previously diagnosed with ASD and typically developing age-matched controls (N=21) who had older siblings without ASD. An auditory oddball paradigm was used with 80% standards and 20% deviants. The contrasts were a computer synthesized alveolo-palatal affricate (/tchi/) versus fricative (/ci/) phonetic contrast that is phonemic in Mandarin Chinese but not in American English. ERPs were recorded while infants listened to stimuli presented by loudspeakers. Measurements for P2 were taken between 200-300 ms post stimulus for both amplitude and latency at central electrode sites, Fz and CZ . Results There was an overall stimulus effect ($p = .003$) with deviants producing a larger P2 than standards. Deviant P2 had a shorter latency than standards ($p = .007$). Group differences for stimulus type were significant when comparing all ASD siblings to the control group ($p < .003$). The ASD sibling group was then subdivided into children who met criteria for diagnosis of ASD at 24 months (Symptomatic, N=8) and children who did not (Asymptomatic, N=13) (one child lost to attrition). Comparisons of these subjects and controls revealed significant Group X Stimulus interaction ($p = .012$). Symptomatic infants elicited the largest P2 for deviants and had the largest difference between standards and deviants. Control children had the smallest P2's and less difference between the 2 stimuli. The Asymptomatic group showed P2 effects that fell in between. This same group of participants was also run on an additional paradigm during the same visit, using native English contrasts /pa/ and /ta/. This contrast produced no significant group differences for P2. Conclusions. Our results indicate that electrophysiological assessment of sensitivity to nonnative speech sounds may serve to distinguish prelinguistic infants' development of ASD. This finding adds to the growing evidence that the maturation of the language system may provide a reliable index of social-cognitive integrity in Autism Spectrum Disorder.

B16 TMS to bilateral posterior Superior Temporal Gyrus impairs perception of intelligible speech *Dan Kennedy-Higgins[1], Joseph T. Devlin[1], Stuart Rosen[1], Steve Nevard[1], Helen Nuttall[1], Patti Adank[1]; [1]University College London*

The dual stream model of speech processing (Hickok & Poeppel, 2007) proposes a bilateral ventral stream that processes speech signals for comprehension and a unilateral dorsal stream that translates acoustic speech signals into articulatory representations in the frontal lobes. In agreement with this model, a large body of fMRI, EEG, and animal studies primarily associates the ventral stream with effective speech comprehension, most notably the posterior superior temporal gyrus (pSTG). It is therefore surprising that only a handful of studies to date have addressed speech processing by applying TMS to ventral stream areas such as posterior Superior Temporal Gyrus (pSTG). Instead, research over the past 10 years using online/offline TMS has focussed almost exclusively on the dorsal stream by investigating the potential role of motor/production regions in speech perception. The current study aims to address this gap in the literature by testing the essential role of pSTG using TMS. We tested 14 healthy native British English speakers on their performance on the speech recognition threshold (SRT) tests without TMS and after receiving TMS to left pSTG, right pSTG and vertex (control area). The SRT represents minimum signal-to-noise level in dB at which an individual can perceive 50% of the auditory speech material. During each sentence online repetitive TMS (10Hz for 2.5 seconds) was applied to one of the three sites. On the basis of the dual stream model it was predicted that TMS to the pSTG of either hemisphere would significantly impair participants' performance compared to the two control conditions where no effect of TMS was expected (no TMS and vertex). Results showed a main effect of site with planned comparisons showing a significant drop in the overall performance after separate application of rTMS to the left and right pSTG compared to the vertex and no TMS conditions. No difference was found when comparing the results of left pSTG stimulation to those of the right pSTG or when comparing the no TMS and vertex conditions ($p>0.05$). Our results verify the causal role of bilateral pSTG in effective speech processing by demonstrating that online rTMS can disrupt auditory processing when applied to the auditory cortex of a healthy population. These results are important as they validate findings from other

neuroscientific techniques and animal studies on the neuroanatomy of auditory processing. Furthermore, these results illustrate a need to focus on the essential role of the previously neglected ventral stream in TMS research. Current research is focussing on trying to replicate the results of this study using 1Hz offline TMS, whilst also testing to establish whether the cognitive function being effected is speech specific or related to more global auditory processing.

B17 Auditory evoked potentials and chronic aphasia

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Studies have demonstrated the association between LLAEP and the cortical electrophysiological activity involved in attention, auditory discrimination, memory, auditory integration and decision-making skills. Several authors have described the importance of using LLAEP as a sensitive measure for the detection of specific changes related to central auditory processing. The literature has also shown that individuals with auditory processing disorders present significant differences in the latencies of P300 when compared to individuals without auditory processing disorders. Possible applications of P300 in the study of aphasia include providing additional data for differentiating between aphasia and other communication disorders. Furthermore, P300 may be particularly suitable for monitoring the recovery of neural mechanisms responsible for language during rehabilitation. The present study is a preliminary investigation with aphasics who participate in a speech-language therapeutic group. In this initial phase of our rehabilitation study, we examined long latency auditory evoked potentials (LLAEP), particularly P300, in 12 individuals with chronic aphasia. Participants consisted in ten males and two females. The average age of the sample was 63.3 years, ranging between 49 and 72 years old. Number of years post stroke varied between 2 and 6 years. All participants underwent prior hearing evaluation and LLAEP (P300) in the same period. We compared the findings of LLAEP between groups using a T-student and tested for correlations with the Pearson correlation coefficient (nr. of years post-stroke, age and education). Results demonstrated that when the left ear was stimulated, values were significantly higher for the latencies of N1 and P2 waves in comparison to responses to stimulation to the right ear. Additionally, data from left ear stimulation showed higher latency values in the P2 wave for participants with a longer period post stroke. Interpeak P1N1 values were also lower for these participants. When the right ear was stimulated, we observed a significant association between age and N1 latency and amplitude P1N1 wave, i.e., the higher the age, the higher the latency and the lower the amplitude. Seven subjects had absent responses to the cognitive potential (P3). Findings also showed significant association between age and P3 latency. The averages of latency and amplitude were respectively 369.7 ms and 8.6 microvolts. We found no correlation between these responses, time after stroke and education. Findings confirm that a brain injury can modify the structures that comprise the peripheral and central auditory pathway, altering auditory processing in aphasia. Summary: Our findings indicate higher values of latencies and amplitudes when stimulation was in the left ear, although there was no statistical significant difference between P1N1 amplitude and latency of P2. There was a correlation between age and N1 latency and amplitude P1N1 in stimulating the right ear. We also found a correlation between age and P3 latency. The discussion of these findings takes into consideration studies about chronic aphasia and neuroplasticity, recovery of neural mechanisms important for language and rehabilitation prognosis.

Motor Control, Speech Production, Sensorimotor Integration

B18 An Executive Approach to Speech Production: Linguistic Hierarchies in the Rostro-Caudal Axis of the (Pre-)frontal Cortex

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We propose a hierarchical-generative model of (pre-) frontal (pFC) executive functions supporting the various temporal and representational stages of language production. Its primary theoretical goal is to unify neurocognitive approaches to behavior planning and decision-making which posit a hierarchy of thought and action in pFC (Koechlin & Summerfield, 2007; Badre, 2008) with neuro- and psycho-linguistic accounts of spoken language as a multi-stage process proceeding from abstract lexical-conceptual intent to concrete articulatory-motor gestures (Indefrey & Levelt, 2004; Hickok, 2012). Consistent with these and earlier accounts developed by students of pFC functions in language and action (Fuster, 1995; Alexander et al., 1989; Greenfield, 1990; MacNeilage, 1998), the model incorporates parallel lateral-executive and medial-motivational modular networks organized along the rostro-caudal axis of pFC that are involved in planning, implementing and executing speech acts on the basis of their particular levels of representation and function on the one hand, and the degree of executive demands imposed on these levels on the other. In support of this framework, we present the results of two Activation Likelihood Estimation meta-analyses carried out on 41 imaging (fMRI and PET) studies on overt language production, pooled on the basis of the type of utterance studied on the one hand (word, sentences and discourse), and task-related control demands on the other (reading-repetition, naming and generation). Considered in light of clinical (neuropsychological and intracranial) evidence, these analyses reveal a three-layer hierarchy of task-related pFC activation: Reading and repeating tasks activate articulatory-motor gestures in motor-

premotor cortices (Brodmann's area 4/6) caudally; picture naming and sentence generation yield activation in and around Broca's area (BA9/44/45) and the insular cortex, reflecting the selection and organization of the lexical-propositional content of utterances; finally, word and discourse generation tasks, implying the activation of candidate lexical representations and logically organized discourse models, recruit rostral-prefrontal areas (BA46/47/10). We use these findings to propose a top-down pFC architecture fractionated into levels that we respectively dubbed inner speech, lexical-propositional speech and external speech. We argue that this framework constitutes the chief executive component of the cortical language network, which becomes functionally integrated with domain-general executive control as one proceeds from caudal to rostral pFC regions. In line with early and more recent proposals in cognitive neuropsychology and neurolinguistics (Luria & Homskaya, 1964; Berwick et al., 2013), we also submit that this model accounts for the functional distinction between internally specified speech as an instrument of thought and interpretation (including comprehension) and externally specified speech as communicative device.

B19 Tracking the Time Course of Competition During Word Production: Evidence for a Post-Retrieval Mechanism of Conflict Resolution *Niels Janssen[1], Juan A. Hernández-Cabrera[1,2], Maartje van der Meij[1], Horacio A. Barber[1,2]; [1]Universidad de La Laguna, Tenerife, Spain, [2]Basque Center on Cognition, Brain and Language, Spain*

Producing a word is often complicated by the fact that there are other words that share meaning with the intended word. The competition between words that arises in such a situation is a well-known phenomenon in the word production literature. The occurrence of speech errors such as, for example, saying "dog" when the intended word was "cat", have been taken by researchers as evidence for the existence of competition between words. The presence of competition between words raises important questions about how speakers are able to maintain fluent and error-free speech. Researchers have proposed two rather contrasting ideas about how competition during word production is resolved. According to one hypothesis, competition is resolved during the retrieval of words from memory (e.g., Roelofs, 1992). By contrast, others have argued that competition is resolved by a mechanism of cognitive control that operates after the retrieval of words from memory (e.g., Thompson-Schill et al., 1999). We used EEG to adjudicate between these two hypotheses. To track the time course of competition during word production, we relied on effects of competition obtained in the semantic blocking task. In this task, participants (N=31) named pictures presented in homogeneous sets where all the pictures shared meaning (e.g., dog, snake, fly), or in heterogeneous sets where pictures did not share meaning (e.g., dog, table, pen). In addition, participants did not name the pictures once, but repeatedly named the pictures in the two types of sets on four consecutive "presentation cycles" (e.g., dog, snake, fly [cycle1], snake, fly, dog [cycle2], fly, dog, snake [cycle3], etc). Previous studies have reported slower naming latencies in the homogeneous sets than in the heterogeneous sets on presentation cycles 2-4, which have been interpreted in terms of competition during word production. The analysis of EEG data typically involves by-subject averaging which increases the probability of type I error rates. To avoid this increase in type I errors, we relied on novel mixed effect analysis techniques in which both subjects and items were included as random variables in the statistical model. In line with previous studies, the behavioral results revealed facilitatory effects of semantic context on the first presentation cycle, indicating semantic priming, and inhibitory effects of semantic context on later presentation cycles, suggesting the presence of competition. The electrophysiological data revealed an effect of semantic context in an early time window (~ 200 – 400 ms), which was largest on the first presentation cycles but decreased on cycles 2-4. This effect was associated with semantic priming. Crucially, there was also an effect of semantic context in a late time window (~ 500 – 750 ms), which only appeared on cycles 2-4. The association of the competition effect in the naming latencies on cycles 2-4 with the appearance of the late electrophysiological effect supports the hypothesis that the resolution of competition takes place after the retrieval of words from memory. This study therefore provides further evidence for mechanisms of cognitive control in the production of words.

B20 Emotional Context modulates Embodied Metaphor Comprehension *Dalya Samur[1], Vicky Tzuyin Lai[2,3], Peter Hagoort[1,2], Roel Willems[1,2]; [1]Donders Institute for Brain, Cognition and Behavior, [2]Max Planck Institute for Psycholinguistics, [3]University of South Carolina*

When talking about emotions, people often use non-literal language. The present study investigates this special relation between non-literal (metaphorical) expressions and the emotional context that they are perceived in. In particular, the main interest is in whether motion verbs when used metaphorically are differentially sensitive to a preceding emotional context, in comparison to literal use of the same verbs. We exploited the fact that action and motion verbs have been found to activate parts of cortex that are usually involved in the perception or execution of motion and actual movement. Participants in an fMRI study (N=20) read stories with ambiguous target sentences (e.g., he got it), in which the action/motion verb could be metaphorical (he understood the idea) or literal (he caught the ball) depending on the preceding discourse. In addition, we varied how emotional the preceding context was. The main hypothesis was that emotional context would specifically influence sensori-motor activations to the metaphorical expressions, as compared to the effect of emotional context on the literal target sentences. We found that a visual motion area (hMT) in the right hemisphere showed an interaction between figurativity and emotional context. Replicating previous research, we found that literal motion sentences lead to stronger activation levels in visual motion areas as compared to metaphorical motion sentences. Most importantly, we found that emotional context modulated

the response to metaphorical sentences, but not to literal interpretations of the same sentences. This study shows that emotional context exclusively modulates mental simulation of metaphorical language processing, compared to literal language understanding, and as such underscores the special relationship between emotion and metaphor. Additionally, this study provides further support that activation in sensori-motor areas in response to action/motion language is context-dependent.

B21 Investigating the brain's grasp areas through the Chinese 'grasp' classifier; a case for the Mirror System Hypothesis *Marit Lobben[1], Laura Wortinger Bakke[1]; [1]Department of psychology, University of Oslo, [2]Department of psychology, University of Oslo*

Several investigations have pointed to a connection between the motor system and language representation in the brain. Among these, the Mirror System Hypothesis (MSH) (Rizzolatti & Arbib, 1998; Arbib 2005, 2013) suggests that brain mechanisms for language developed atop a mirror system for grasping movements through the successive emergence of systems for imitation, pantomime, and protosigns (cf. also Gallese&Lakoff, 2005). This theory has been hard to underpin by any compelling evidence. Hence, Arbib (2008) calls out for further research on neural mechanisms that support parallels between 'motor constructions' and language constructions. The present fMRI study does exactly that. We hypothesized that areas associated with grasping in a fronto-parietal network (Broca's, AIP/Wernicke's) co-opted in humans to support the language function. This dorsal stream, as well as inferotemporal (IT) ventral stream for object knowledge would subserve language processing, along with motor movement areas such as supplementary motor area (SMA), basal ganglia (BG). Also, if the language system evolved atop a praxis system for motor movement, one should expect to see a hierarchical structure in both. We investigated Chinese numeral classifier noun phrases consisting of hierarchically organized components; the nouns stand in a hyponymic relationship to their classifiers, extracting semantic features from noun groups and representing them abstractly (schematically) in the grammatical system as hyperonyms. Importantly, this is a semantically hierarchical system, and the present proposal therefore departs from former associations of e.g. the basal ganglia to syntactic rules. We used fMRI and a rapid event-related design with 20 native speakers, presenting randomized classifier – noun sequences. The stimuli consisted of two classifiers, □ zuò (used for non-graspable objects with a base) and □ b□ (graspable objects). The design included implicit rest and a baseline condition. The activations of classifiers were separated from that of the nouns by jittering and 25% mock trials where no noun followed. A conjunction analysis of the classifier conditions showed activation of cortical areas SMA, inferior frontal gyrus/precentral (BA9, BA6), and within Broca's area pars opercularis and pars triangularis. Parietal area associated with grasping includes AIP. Subcortically, BG input-channels, the caudate and putamen of the striatum, as well as the areas from subthalamic/red nucleus to the thalamus (left-dominated); in cerebellum vermis 1/2 and 3. In addition, ventral streams were active in both conditions, and BA39 in temporal lobe. Successive ROI analyses showed that percent signal change was significantly greater for the grasp than for the big–classifier condition in SMA, BA39/Angular gyrus; the opposite was the case for BA44/45. The SMA, BG and cerebellar activations suggest that Chinese classifiers are generated in areas that overlap with the motor system. We suggest that, just as motor processes in SMA reflect a person's higher order knowledge of motor actions, not their concrete physical implementation, the SMA plays a similar role in representing schematic semantical-grammatical, hierarchical knowledge. This function is complementary to concrete semantic processing of object knowledge, supported by dedicated areas in IT. The category abstractly representing affordance is processed in 'grasp' and motor abstraction areas, however not in Broca's area.

B22 White matter fiber tracking in left Arcuate Fascicle reveals individual differences in aptitude for phonetic speech imitation *Susanne Reiterer[1,2], Lucia Vaquero[3], Antoni Rodriguez-Fornells[3]; [1]Unit for Language Learning and Teaching Research, Philological Faculty of the University of Vienna, Austria, [2]University Clinic Tübingen, former Section of Experimental MR of the CNS, Tübingen, Germany, [3]Cognition and Brain Plasticity Group, University of Barcelona & IDIBELL, Barcelona, Spain.*

Learning foreign languages usually involves huge inter-individual differences within all language subdomains. Brain anatomy differences between individuals have featured prominently as explanatory basis for differences in language performance. Some recent studies have suggested that differences in white matter integrity, fractional anisotropy (FA), structure and morphology of "language tracts", including the classical Arcuate Fasciculus (AF), might underlie those individual differences in language performances. In this study, we closely investigated the correlations of different white matter integrity measures in respect to a special linguistic subdomain: the ability of spontaneous speech imitation (pronunciation). We investigated this ability in late language learners with varying degrees of imitation aptitude, focussing on the dissection of the Arcuate Fasciculus, hypothesizing that a higher leftward lateralization and higher white matter integrity in AF would accompany higher aptitude in accent imitation. 138 native German-speakers were behaviorally exposed to a difficult language-imitation task, consisting of ad-hoc imitation of unknown Hindi sentences spoken by a model Hindi speaker. Hindi was selected in order to test "pure" imitation ability, since no participant had previous experience with it. The recorded speech productions were subjected to native speaker judgements in India (30 raters, 15 females), providing a Hindi-imitation ability score. To investigate the relationship between WM structure and novel-language imitation abilities diffusion tensor imaging (DTI) data from 53 of the above participants were obtained from a 1.5T Siemens scanner (Erlangen, Germany). We investigated potential white-

matter markers of language imitation using deterministic tractography of DTI data (FSL and Trackvis softwares), dissecting the left (L) and the right (R) Arcuate Fasciculus (AF: long fronto-temporal segment, anterior parieto-frontal segment and posterior parieto-temporal segment). We extracted the number of streamlines, volume, fractional anisotropy (FA), mean diffusivity (MD), axial diffusivity (AD) and radial diffusivity (RD) of each segment of bilateral AF, computing also the sum of the three rami of each hemisphere to obtain the values for Complete Left and Complete Right AF. Furthermore, the lateralization index was calculated for every white-matter parameter and included in the analysis. A correlation between these parameters and the Hindi imitation score was performed. Good Hindi imitators showed significantly better white-matter integrity in the left AF (L long segment showed more FA, $p = 0.041$; less MD, $p = 0.040$, and less RD, $p = 0.012$; and L posterior segment also showed less RD, $p = 0.015$), but worse integrity and volume in right AF (R complete AF presented less number of streamlines, $p = 0.007$). Moreover, the lateralization index for number of streamlines correlated positively ($p = 0.013$), meaning that the more lateralized to the left is the AF, the better the performance for Hindi imitation. These results show a clear relationship between the lateralization of the AF and the aptitude in the imitation of an unexperienced language, corroborating and replicating previous studies. We conclude that speech (accent) imitation ability for foreign language phonetic material partly stems from a fine-grained neuro-anatomical basis in white matter fiber connectivity, as well as from a left lateralization in it.

B23 Vocal learning and the importance of noise *Anna J Simmonds[1], Richard J S Wise[1], Robert Leech[1]; [1]Imperial College London*

Rapid vocal motor learning is observed when acquiring a language in early childhood, or when learning to speak a second language in later childhood or adulthood. For an adult learner, accurate pronunciation is one of the hardest things to master; adult learners are almost always left with an accent that clearly marks them as a non-native speaker. Much of the neurobiology of human vocal motor learning has been inferred from studies on songbirds. Essential for song learning is a pathway, the homologue of mammalian cortical-basal ganglia 'loops', which includes the avian striatum. Our previous work has confirmed these inferences, demonstrating an important role for striatal function in adult human vocal learning. Recent theoretical and experimental work suggests an important role for noise, or stochastic facilitation, in motor learning, i.e. variability in the motor movement is necessary for the development of expertise. The current study used high-resolution MRI optimized for the striatum (while still including peri-sylvian brain regions activated during speech production) to investigate behavioural and neural variability in motor movements in adult human vocal learning. Monolingual native-English participants were scanned while repeating novel non-native words (Mandarin and Spanish) and native non-words. At the end of each of the 4 runs, participants rated their performance on each word, using a five-point scale. The stimuli were bi-syllabic and matched for number of phonemes. Non-native stimuli had the target phoneme (one not used in English) and stress on the first syllable and the second syllable easy to produce for native English speakers. Stochastic variability was assessed behaviorally by using physical variability in the acoustic signal including correlations of the long-term spectra of repetitions of the same utterance. Variability was also assessed neurally by measuring relative increases and decreases in BOLD activation for vocal learning, and variance of the regional BOLD signal and non-stationarity in functional connectivity. These measures enabled relating behavioral variability both within- and across-participants to neural activation and measures of neural variability. This study demonstrated that, as in the songbird, anterior striatal activity relates to behavioral variability and cortical variability. In addition, this variability was related to on-line self-perception of performance. A 2 (Language: Native and Non-native, each against the silent Rest baseline) x 2 (Run: First and Second) factorial design was used and a whole-brain ANOVA was performed. The interaction between Language and Run was observed in bilateral auditory, somatosensory and sensorimotor cortices, and in the anterior striatum. There was a sharp decline in anterior striatal activity between the first two runs during the repetition of non-native words. This rapid decline in activity by adult vocal learners may reflect a rapid 'habituation' to the pronunciation of non-native words. This is likely due to imperfect self-monitoring, resulting in a form of motor learning in which the learners settled for a less than proficient (native-like) performance. This finding may account for the persistence of a foreign accent in adult vocal learners, which is 'good enough' for communication when making do with modifications of the habitual articulatory sequences used for the first language.

B24 What you learn is what you get: Why inferior frontal cortex is involved in language understanding *Friedemann Pulvermuller[1], Max Garagnani[1,2]; [1]Freie Universität Berlin, [2]University of Plymouth*

What is the role of the inferior frontal cortex, IFC, in language perception and understanding? Neurobiological theories of language either see no role at all or phrase this role in terms of analysis-by-synthesis, mirroring or simulation (Poeppel et al., 2012; Pulvermüller & Fadiga, 2010). These statements seem to be a priori or data driven, but not always justified by known neuroscience principles. Also, their neuromechanistic translation into real neuronal circuitry is not always clear. We here present a neurobiological model of the human language cortex that incorporates crucial aspects of its cortical anatomy and function and use this model to study the emergence of language circuits related to different types of linguistic learning. Recent research has shown that action recognition activates the IFC, but only if the perceived actions can be performed by the individual (Buccino et al., 2004; Pobric & Hamilton, 2006). When spoken words are being perceived (Fadiga et al., 2002),

IFC activation depends on the way these items have been learnt: Perceptual learning, of word forms is reflected in superior temporal activation only, whereas IFC activation kicks in for word that had been subject to articulatory learning, AL, where subjects hear and pronounce the items (Pulvermüller et al., 2012). Our modelling effort aims at explain these differences based on established neuroscience knowledge. We used a model of perisylvian motor, premotor, prefrontal, primary auditory, auditory belt, and auditory-belt cortex and their connectivity to simulate the perceptual and articulatory learning of novel spoken word forms. Results show that action perception circuits develop in the case of correlated sensorimotor activation, which simulates active articulation. In contrast, passive perceptual learning of auditory word forms led to circuits produced much reduced frontal activation but temporal activation comparable to that brought about by articulatory learning. These neurocomputational modelling results closely parallel previous experimental findings. These results show that, in a brain-like device, the involvement of the inferior-frontal cortex in the recognition of word forms depends on the way these symbols have been learnt. Spoken words – and, by extension, other symbols – that have been subject to perceptual learning (e.g., when children just listen or watch others using signs) seem to develop brain representations that are primarily based in sensory and adjacent multimodal areas. However, if words and gestures are learnt in the context of the individual's own activities and actions (e.g., when babbling syllables, repeating words and imitating manual gestures), the developing brain-internal mini-networks are action perception circuits linking perceptual schemas to actions. We discuss our findings in the context of current theories of the role of IFC in speech perception and comprehension. Buccino, G. et al. 2004. J Cogn Neurosci, 16(1), 114-126. Fadiga, L. et al. 2002. European Journal of Neuroscience, 15(2), 399-402. Pobric, G., Hamilton, A.F. 2006. Curr Biol, 16(5), 524-529. Poeppel, D. et al. 2012. J Neurosci, 32(41), 14125-14131. Pulvermüller, F., Fadiga, L. 2010. Nature Reviews Neuroscience, 11(5), 351-360. Pulvermüller, F. et al. 2012. Cortex, 48(7), 471-481

Language Development, Plasticity, Multilingualism

B25 Losing control: an investigation of lexical processing in adult second language learners

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This study uses functional magnetic resonance imaging (fMRI) as a method to bridge the gap between developmental and neural models of second language (L2) acquisition. Models such as the BIA-d (Grainger Midgley & Holcomb, 2010) propose that cognitive control occurs later in L2 acquisition to allow L2 words direct access to the non-linguistic conceptual store. In contrast, neural models of L2 acquisition, such as Green's (2003) convergence hypothesis, suggest that L2 learners will initially utilize areas associated with cognitive control more, with activation in these areas decreasing as learners gain more proficiency in the L2. The current study attempted to test these contrasting predictions by examining the neural correlates of lexical processing in second language learners over the course of an academic year. Furthermore, we were interested in whether individual differences in cognitive control ability would be related to the degree of activation elicited by the L2. Our analysis of the BOLD activity in several regions of interest (ROIs) at Time 1 (T1) and Time 2 (T2) compared activation in response to unambiguous first and second language words, as well as interlingual homographs, such as pie (foot in Spanish). In both sessions we found more activity in control areas such as the middle frontal gyrus (MFG) and anterior cingulate cortex (ACC) in response to homographs than unambiguous Spanish words, and similarly for unambiguous Spanish words compared with English. Over time, these relationships changed such that there was overall less activity in control areas at T2, especially for the processing of unambiguous Spanish words compared to unambiguous English, but also for homographs in comparison with unambiguous Spanish words. We interpret these effects as indicating increased L2 processing efficiency in response to continued L2 instruction or increased L2 proficiency, as would be predicted by the convergence hypothesis (Green, 2003). We additionally conducted a functional connectivity analysis using extended unified structural equation modeling (Gates, Molenaar, Hillary & Slobounov, 2011), and identified a trend from conflict-first processing to meaning-first processing. Specifically we observed increased connectivity of the IFG and MTG, two regions traditionally involved in semantic processing and control at T2. These increases in the strength and scope of the connectivity contrasted with a decrease in medial and middle frontal gyrus connectivity, areas traditionally associated with executive control. Support for this interpretation also comes from our individual difference analyses, which found that participants with larger Flanker effects—and presumably worse inhibitory control—showed more activity in the cognitive control network, including the medial and middle frontal gyri, at the second session than at the first session. This pattern of results suggests that learners with worse inhibitory control were still relying on this network at T2 while learners with better inhibitory control were able to use these areas more efficiently. This shift from conflict to meaning focused processing is incompatible with the assumptions of the BIA-d (Grainger, Midgley & Holcomb, 2010) but instead provides evidence for the convergence hypothesis (Green, 2003).

B26 The role of natural cues in language selection: MEG evidence from English-Arabic bilinguals during number naming

Estibaliz Blanco Elorrieta[1], Liina Pylkkänen[1,2]; [1]NYUAD Institute, New York University, Abu Dhabi, [2]New York University

Introduction. Selection of appropriate representations is a pervasive component of language production. In the bilingual brain, the usual selection demands are compounded by the need to select an appropriate target language. While much research has addressed the effects

of language switching using artificial cues to language choice such as color (Meuter & Allport, 1999; Costa and Santesteban, 2004), the role of more naturalistic cues in language choice has not been characterized. Are the brain mechanisms of language choice modulated by the nature of the cue? We contrasted two cues that are both natural but which potentially contrast in their automaticity as cues, namely script vs. cultural context, the former of which constituting the more automatic cue, by hypothesis. The effects of these cues were examined in prefrontal and cingulate cortices, previously implicated for language selection and switching (Abulatebi & Green, 2006). To robustly activate language selection mechanisms, we had participants perform not only a 'match' task, in which the language that matched the cue was to be chosen, but also a mismatch task, with the opposite instruction. With MEG measurements we assessed whether a cultural cue would correlate with more robust "language selection activity" in early processing, implying more controlled language choice, and whether the mismatch effects between the script and cultural cues would differ. Methods. 20 Arabic-English bilinguals named numbers from 1 to 4 in the two languages in a randomized sequence. Language choice was indicated by orthography or cultural context. In the former, a number was drawn on the blackboard and its script (either Roman or Arabic) indicated the language of response. In the latter, the cue was a depiction of a clearly Arabic or Western man standing next to a series of dots drawn on the blackboard. Overall, the script and culture displays were matched for visual complexity. The match task was accompanied by a mismatch task, in which participants did the opposite (e.g., named in English when presented with Arabic script). MEG data were recorded during the planning for production, prior to motion artifacts. Results. A main effect of Cue was found early at 150:300ms, with Culture eliciting greater cingulate activity than Script both in match and mismatch conditions. A uniform mismatch effect was found later (300:450ms) for both cue types in the Left Inferior Prefrontal Cortex (LIPC). Conclusion. These findings suggest that activity associated with language selection is indeed affected by the intrinsic properties of the cue. When language was cued by script, cingulate activity was reduced during language selection, suggesting a more automatic choice, as compared to the non-orthographic culture cue. In contrast, the similar LIPC increase for mismatch conditions irrespective of cue suggests that the control mechanisms for overriding natural cue-language associations are not sensitive to cue type. Crucially, the increase for culturally cued language was observed in activity distinct from that exhibiting a mismatch effect, suggesting that natural but less automatically cued language choice does not engage the same mechanisms as clearly unnaturally cued language choice, as exemplified by the mismatch trials.

B27 Thickness Asymmetry in Language-Relevant Cortex: Effects of Bilingualism

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Functional language lateralization has been proposed to be more bilateral in bilingual, as opposed to monolingual, individuals, and a variety of evidence supports this view for at least some bilinguals (Hull & Vaid, 2007). It is unclear whether cortical structural asymmetries may also differ between these populations. One brief report (Mechelli et al., 2004) found increases in grey matter density in left and right inferior parietal cortex of bilinguals that was moderated by age of acquisition. Klein et al. (2014) found increased cortical thickness in left IFG and reduced thickness in right IFG in bilinguals who acquired the second language after age 3, as compared to monolinguals. Unfortunately, thickness values were not reported for either hemisphere, nor were asymmetry indices calculated. Hence, prior findings are inconclusive about whether cortical structure is more bilateral for bilinguals. The current study directly compared left/right asymmetry in cortical thickness for monolingual and bilingual persons in perisylvian regions that are implicated in language, as well as in regions implicated in bilingual cognitive control. If structural correlates of bilingualism are more bilateral, we should observe reduced or absent asymmetry for these regions in bilinguals, relative to monolinguals. Method. Two MRI scans were obtained for 78 right-handed young adults (39 monolingual English, 39 bilingual Spanish-English, matched for age and gender). Mean L2 age of acquisition was 6.8 yrs (range birth-17 yrs). Cortical reconstruction and volumetric segmentation was performed with the FreeSurfer pipeline. Cortical thickness averages were extracted for 14 parcellations a priori chosen to include regions implicated in language and speech and/or bilingual language control (pars opercularis and triangularis, anterior and posterior insula, planum temporale, Heschl's gyrus, lateral STG and posterior ramus, STS, MTG, inferior frontal sulcus, anterior cingulate, AG, SMG; see Garbin et al., 2010; Hernandez, 2009). Cortical thickness asymmetries were calculated for these regions of interest, and for 54 parcellations that spanned most of the remaining cortex. Results. Cortical thickness asymmetry across the 14 ROIs was marginally smaller for bilingual, as compared to monolingual persons, $t(21) = 1.9$, $p = .06$, and asymmetries for these groups were uncorrelated, $r = .024$, ns. On average, cortex was thicker in the right, than in the left, hemisphere in these ROIs for monolinguals (-.027), but not for bilinguals (-.009). In contrast, for the remaining parcellations, there was no difference between monolingual and bilingual thickness asymmetries, $t < 1$, and asymmetries were strongly correlated across groups, $r = .53$, $p < .0001$. These findings provide some support for the view that cortical thickness is less asymmetrical in the bilingual brain, but only in regions that have been implicated in language or bilingual cognitive control. Cortical thickness varies dynamically over the entire life-span, and variations in

cortical thickness can indicate increased myelination at the gray/white matter boundary, or gray matter pruning (Aleman-Gomez et al., 2013). Our findings imply that second language experience may differentially modulate these changes across hemispheres, perhaps due to increased myelination and/or loss of gray matter in RH language homologues.

B28 Functional and Anatomical Changes as a Function of Second Language Learning *Jennifer Legault[1], Shin-Yi Fang[1], Shinmin Wang[2], Yu-Ju Lan[2], Ping Li[1]; [1]Pennsylvania State University, [2]National Taiwan Normal University*

Learning of various cognitive tasks has been associated with changes in both neural activity and gray matter volume (see Lövdén et al., 2013 for a review). Our study used a longitudinal design with a multimodal neuroimaging approach to examine how learning of a second language (L2) may lead to corresponding changes in the brain. First, we examined whether amount of L2 learning, as assessed by behavioral performance on L2 learning tasks, was associated with differences in neural activation. Next, we used a whole-brain voxel based morphometry (VBM) analysis to parse out regions that showed increased gray matter (GM) volume as a function of L2 learning. In this study, we investigate how L2 learning can lead to functional and anatomical changes in the brain in different leaning contexts such as traditional paired association learning and virtual environment. The traditional paired association learning consisted of either word-word association or picture-word association tasks. The virtual environment condition used Second Life (www.secondlife.com), an online virtual environment platform, to assist learning with richer contextual information. Three groups of participants learned Chinese words in the three learning conditions. All the participants received a battery of computerized tests to assess their cognitive and language performance. Participants underwent training sessions over the course of two weeks consisting of 60-90 aurally-presented Chinese words and were tested on their recall accuracy immediately after each training session. These stimuli were comprised of three different categories: kitchen, supermarket, and zoo. After learning all items in the three categories, participants performed a forced choice recognition task. Their performance was measured as accuracy and reaction time. In addition to these behavioral measurements, MRI data were collected before and after the training, which included both functional responses patterns and structural brain data. All participants were able to reach at least 80% accuracy by the end of the two week training. We found a significant positive correlation between working memory performance and accuracy increase between the first and second learning sessions. The functional MRI results showed greater neural activation in the caudate nucleus, putamen, and middle temporal gyrus at the post- versus pre-training MRI session in response to learned Chinese words. Further, more successful learners displayed more neural regions being activated as compared to the less successful learners. Results from our whole brain VBM analyses indicated GM volume increased between pre- and post-training sessions in the left inferior parietal lobule and caudate nucleus, right superior temporal gyrus, and bilateral anterior cingulate gyrus. This finding is consistent with previous literature demonstrating GM volume increase in these areas is associated with L2 learning (Abutalebi et al., 2012; Mechelli et al., 2004; Grogan et al., 2009). However, our VBM results may represent the fastest structural changes in response to L2 learning that have been reported as of yet in the language learning literature. In sum, our study has shown that both functional activity and anatomical changes in the brain vary as a function of L2 learning experience, reflecting structure-function-behavior relationships.

B29 Domain-general cognitive control vs language-specific inhibitory control in multilingual language switching *Wouter De Baene[1,2], Wouter Duyck[1], Marcel Brass[1], Manuel Carreiras[2,3]; [1]Ghent University, Belgium, [2]Basque Center on Cognition, Brain and Language (BCBL), Donostia-San Sebastian, Spain, [3]IKERBASQUE. Basque foundation for Science, Bilbao, Spain*

The extensive language-switching practice of early, highly proficient bilinguals is assumed to result in an efficient language control mechanism that engages (partly) the same neural network underlying general (non-verbal) cognitive control. On the other hand, one very influential theoretical account of such language control in bilinguals suggested that competition between languages is resolved by active inhibition. Recently, it has been claimed that the most convincing and purest demonstration of inhibitory processes in a switching paradigm is the observation of lag-2 repetition costs or backward inhibition. This is the observation that switching back to language A following its recent inhibition (ABA-sequences) is more difficult than switching to language A without its recent inhibition (CBA-sequences), due to the residual active inhibition of language A. In this fMRI study, we examined the neural overlap between language switching and task switching,. We also assessed specific inhibitory switch-related cognitive control processes in proficient bilinguals. Because backward inhibition can only be assessed in paradigms involving switching between three (or more) languages or tasks, we selected participants that were trilingual (Spanish, Basque and English). Thirty-six trilinguals participated in a language-switching session and in a task-switching session. Within these two sessions, language and task, respectively, were manipulated: the language to use (Spanish, Basque or English) and the task to perform (motion, colour or gender detection) could repeat or switch across trials. The neural correlates of switch-related processes were examined by contrasting activity on switch trials vs. activity on repeat trials. For the neural correlates of language and task inhibition, we contrasted the activity for recently inhibited languages or tasks (ABA-sequences) with activity for languages or tasks that were not recently inhibited (CBA-sequences). Furthermore, by comparing activity between language- and task-switching sessions, the specificity of the neural mechanisms of language inhibition and language control to more general inhibition and cognitive control was examined. By

comparing switch-specific activity in language switching and task switching, we found neural overlap in a fronto-parietal network. Additionally, disjunction analyses indicated some areas that were active only for language switching or for task switching. Additional voxel-by-voxel pattern analyses, however, suggested that the engagement of these areas was only quantitatively but not qualitatively different between language switching and task switching. When comparing inhibition-related activity in language switching and task switching, no neural overlap was found. Furthermore, disjunction analyses in combination with voxel-by-voxel pattern analyses suggested that the engagement of (amongst others) bilateral superior orbitofrontal cortex, including left caudate, was specific for language switching. In sum, these results suggest that language switching in multilinguals involves domain-general cognitive control areas as well as language-specific inhibitory control-related areas.

B30 Distributed neural representations of logical relations in school-age children *Romain Mathieu[1], James R. Booth[2], Jérôme Prado[1,2]; [1]Laboratoire Langage, Cerveau et Cognition (L2C2), CNRS/Université Lyon 1, Lyon, FRANCE, [2]Northwestern University, Evanston, IL , USA*

Children's understanding of logical relations involving linear-orders (e.g., Dan is taller than Lisa) and set-inclusions (e.g., All Tulips are Flowers) is critical for the acquisition of many important notions in school. For example, these relations may support the concepts of ordinality, measurements, categorization, and mathematical proof. Previous behavioral and neuroimaging studies in adults suggest processing differences between these relations. Specifically, linear orderings have been preferentially associated with spatial encoding and set-inclusions have been preferentially associated with verbal encoding. In the present study, we sought to investigate whether this sensitivity to the type of logical relation appears during the period of elementary school in development. We used functional magnetic resonance imaging (fMRI) to characterize the neural processing of linear-ordering and set-inclusion relations in 25 typically developing children from 9 to 14. Each participant performed a verbal reasoning task in the scanner. Participants evaluated reasoning problems involving either linear-ordering or set-inclusion relations. Additionally, we identified brain regions involved in maintaining verbal and spatial information in working-memory using a verbal maintenance localizer that consisted in a rhyming comparison task, and a spatial maintenance localizer that consisted in a numerosity comparison task. Across all subjects, brain activity was modulated by the type of logical relations present in deductive arguments. Consistent with previous studies in adults, we found a crossover interaction between relation (linear-ordering, set-inclusion) and brain mechanisms (spatial, verbal), across all subjects. Linear-ordering relations were associated with greater activity than set-inclusion relations in a region of the right Superior Parietal Lobule (SPL) involved in the maintenance of spatial information, whereas set-inclusion relations were associated with greater activity than linear-ordering relations in a region of the left Inferior Frontal Gyrus (IFG) involved in the maintenance of verbal information. Because this interaction was not related to age, it is likely formed before the period of elementary education and indicates an early-developing sensitivity to the type of logical relation in children. However, the period of elementary education might play an important role in shaping the neural processing of logical relations, as indicated by developmental changes in regions of the rostrolateral prefrontal cortex (RLPFC) and medial superior frontal gyrus (mSFG) that were also dependent upon the type of relation. In sum, our results demonstrate a dissociation among the neural representations of linear-ordering and set-inclusion relations in spatial and verbal brain regions of school-age children. Because this dissociation was not modulated by age, it is likely formed before the beginning of elementary school and suggests that different types of logical relations may be preferentially encoded in different formats early on during development. However, developmental changes of activity that are dependent upon the type of relation were observed in additional frontal regions. Thus, the period of elementary education might play an important role in shaping the neural systems supporting deductive reasoning.

B31 Preserved language comprehension with age and its relationship to cognitive control *Karen L Campbell[1], Cam-CAN[2], Lorraine K Tyler[1]; [1]University of Cambridge, [2]Cambridge Centre for Ageing and Neuroscience (Cam-CAN), University of Cambridge and MRC Cognition and Brain Sciences Unit*

Introduction: A wide body of work suggests that aging leads to a decline in performance across several cognitive tasks, particularly those which tap cognitive control such as working memory and fluid intelligence. While some studies have also reported deficits in language comprehension, these have tended to use tasks which place additional demands on working memory or control mechanisms. When language comprehension is assessed in an online fashion, thus minimizing working memory demands, performance shows very little change with age (e.g., Tyler et al., 2010). Given the steep decline in controlled processing with age, these findings suggest that language comprehension is a relatively automatic process – one which should be minimally related to individual differences in cognitive control. The present study aimed to test this prediction using a large, population-derived sample (aged 18-88) from the Cambridge Centre for Ageing and Neuroscience (www.cam-can.com) project. We asked whether the semantic and syntactic aspects of language comprehension are differentially affected by age and whether these abilities relate to individual differences in cognitive control (as measured by fluid intelligence). Methods: Participants (N = 604, 18-88 years old, M = 54.80, SD = 18.45) were given a battery of tests, including standardized measures of fluid and crystallized intelligence. They also performed a language comprehension task in which they listened to sentences containing either a syntactically (e.g., 'bullying teenagers') or semantically (e.g., 'dirty fouls') ambiguous

phrase, followed by a disambiguating continuation verb. The continuation verb could either be in line with the dominant (e.g., 'dirty fouls disqualify') or subordinate (e.g., 'dirty fowls soil') interpretation of the ambiguous phrase, and participants' task was to decide whether the continuation was acceptable or not. Results: We show that 1) language comprehension was not affected by age, in that older adults were just as slowed by, and rejected just as many, subordinate (or unexpected) continuations as younger adults, and this was true for both semantic and syntactic items; 2) fluid intelligence did not relate to the resolution of syntactic ambiguity, but it was positively related to the resolution of semantic ambiguity throughout the lifespan. Crystallized intelligence, on the other hand, was positively related to performance in both conditions, regardless of age. Conclusion: Taken together, these findings suggest that while syntactic processing is a relatively automatic process, unrelated to individual differences in cognitive control, the ability to overturn incorrect semantic interpretations may critically depend on fluid abilities. Moreover, despite general declines in controlled processing with age, predictive ability appears to be preserved, in that older adults respond to unexpected stimuli in the same way as younger adults. These findings challenge the view, put forth in the memory and attention literature, that aging negatively affects one's ability to predict upcoming events (Zanto et al., 2011; Bollinger et al., 2011).

B32 It's good to see you again: Bilinguals rely on visual interlocutor identity for activating appropriate language modes *Clara Martin[1,2], Monika Molnar[1], Manuel Carreiras[1,2,3]; [1]Basque Center on Cognition, Brain, and Language (BCBL), Donostia, Spain, [2]IKERBASQUE. Basque Foundation for Science, Bilbao, Spain, [3]University of the Basque Country, UPV/EHU, Spain*

Bilingual language activation is modulated by explicit linguistic cues (e.g., sentence context or lexical items), and bilinguals can also be trained to rely on non-linguistic cues, such as flags or colors, for language activation. Moreover, it has been recently demonstrated using an audio-visual lexical decision task that interlocutor identity (e.g., Spanish monolingual, Basque monolingual, or bilingual identity) interacts with language selection during comprehension. However, the locus of this interlocutor effect is unclear. The current study was designed to assess what stage of comprehension is affected by the context of interlocutor identity. We did so by using the technique of event-related potentials (ERPs) and by exploring bilinguals' brain activation between the onset of the visual presentation of the interlocutor and the onset of speech the interlocutor produced. We had two predictions. (1) Interlocutor identity only interacts with language activation during speech processing itself. In this case, no effect of interlocutor identity before speech onset should be present in the ERPs. Alternatively, (2) bilingual listeners pre-activate the expected language when presented with an interlocutor they know. In this case, an ERP effect should be present even before the interlocutor starts to produce speech. Twenty-three early proficient Spanish-Basque bilinguals took part in the ERP experiment. They were first familiarized, through video segments, with two Spanish, two Basque and two bilingual interlocutors. Then, they had to perform an audio-visual lexical decision task on items uttered by the six interlocutors. Participants had to decide if the words they heard were real or not in any of the languages. There was an average of 350 ms gap between the onset of the video and the onset of the auditory signal. Our results indicate that the influence of interlocutor identity (bilingual versus monolingual interlocutor) on the bilingual's brain started around 150 ms after the onset of the video, even before the onset of speech. Thus, it has been illustrated, for the first time, that proficient bilinguals are able to pre-activate a language for further speech comprehension by relying on contextual cues (e.g., interlocutor identity) available in ecologically valid communication settings. This preparation for language mode seems to affect participants' behavior, since participants were faster to perform the lexical decision task on any type of lexical item when the interlocutor was monolingual versus bilingual. Our results have relevant implications to models of bilingual language control suggesting the possibility of selective language pre-activation even before any linguistic input based on ecologically valid cues, such as an interlocutor identity.

B33 Examining the pillars of Translanguaging *Anna Beres[1], Manon Jones[1], Guillaume Thierry[1]; [1]Bangor University, UK*

Translanguaging is a method of learning involving a simultaneous switch between languages and between comprehension and production. We have previously reported neuroscientific evidence for facilitated access to existing semantic representations for items used in learning mediated by translanguaging as compared to control items presented in a monolingual learning context (SNL, 2013). We tested participants using a picture-picture priming paradigm after a learning phase involving either English or a code-switch between English and Welsh simultaneous to a switch between reading and speaking. Beyond the expected effect of semantic relatedness on mean N400 amplitude, well known to index semantic processing effort (Kutas and Hillyard, 1980), we found a striking main effect of translanguaging on the same N400, suggesting that relevant semantic representations had become selectively more accessible in long term memory. Moreover, this effect could still be measured 2 to 4 weeks later without participant training or advance warning of a retest. Here, we set out to test the two components of translanguaging separately in order to determine the contribution to the overall effect of code-switching on the one hand and comprehension-to-production on the other. In experiment 1 and 2, we presented fluent Welsh-English bilinguals with a stream of words featuring successive dyads either related or unrelated in meaning and either in the same or a different language. Whilst we found no modulation of the N400 by semantic relatedness between words when the task was to detect animals within the word stream, the expected relatedness effect appeared when a second group of participants were asked to make overt relatedness judgements. Remarkably, in both experiments 1 and 2, we found a main effect of

code-switching; such that language change significantly increased N400 mean amplitude as compared to language constancy. In experiment 3, we presented participants with word-word or word-picture pairs. Based on the colour of the prime words, participants either made a relatedness judgment (on the target word or picture) or they named the picture /read the word target and then made the relatedness judgment. We found the expected effect of semantic relatedness in the N350 and N400 ranges for picture and words, respectively, but we observed no difference between comprehension and comprehension-to-production conditions, suggesting that the latter condition had no measurable immediate impact on semantic integration. Overall, results from experiments 1 and 2 suggest that code-switching deepens semantic access whereas a switch from comprehension-to-production has little impact on semantic integration if any. Translanguaging therefore appears as a complex process that cannot be reduced to a simple combination of code-switching and comprehension-to-production switching. However, it must be kept in mind that measures taken in experiments 1-3 were online whereas effects of translanguaging as measured previously targeted medium to long-term consolidated effects. Future studies will need to explore consolidated effect of code-switching and comprehension-to-production switching separately.

B34 Learning Novel Words through Enactment: A Combined Behavioral and fMRI Study

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Laboratory and classroom research has shown that enactment, i.e., performing gestures while learning words or phrases, enhances memorability in a native (L1) or foreign (L2) language. Whereas studies conducted in L1 provide evidence for the efficacy of gestures on verbal memory only if self-performed while learning the words, such evidence is still missing in L2. In pursuit of such evidence, we had fifteen participants learn 45 words in Vimmi, an artificial corpus that conforms with Italian phonotactics. As an instructor, we employed a virtual agent with anthropomorphic appearance instead of a human trainer, as has recently been done in enactment studies in L2. The virtual agent trained participants according to three conditions. In the baseline condition, "audiovisual", participants read silently the written word in Vimmi, listened to an audio file and saw a static picture of the trainer. In the condition "only watch", in addition to the baseline, participants watched a video where the virtual agent performed an iconic gesture semantically related to the word. In the condition "enactment", participants read and listened, and watched the trainer. Immediately thereafter, they repeated the word aloud and performed the gesture themselves. The training lasted four days. From day 02 to day 05, learning progress was documented by free recall and cued recall tests. Considering data from other experiments, we expected memory performance to increase from the baseline condition to the only watch and to the enactment condition. However, this was not the case. Repeated measures ANOVAs did not yield significant differences among training conditions. In the week following the behavioral training, we acquired fMRI data. During scanning, participants performed a word recognition task. They were presented with learned and new words in Vimmi. Participants were instructed to indicate new words by pressing a response key with their left hand. Here we expected different cortical networks to reflect the different encoding conditions; however, the fMRI-contrasts among conditions did not differ significantly. Only the contrast learned words < new words revealed significant activity in the left inferior frontal gyrus, one of the core regions in the language network, and in the left precuneus, a brain area mediating episodic memory and mental imagery. This result is in line with other studies. More specifically, the precuneus has been previously found to be involved in enactment. We reason that the described results do not fully meet our expectations because of the low number of participants (15). Furthermore, participants reported feeling uncomfortable with the agent as their instructor. Presently we are training and scanning additional subjects to gain more statistical power. Also, more work is necessary in order to elucidate how the agent as an instructor might have compromised memory results.

B35 Asymmetry within and around the planum temporale is sexually dimorphic and influenced by genes involved in steroid biology

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The genetic determinants of cerebral asymmetries are unknown. Sex differences in asymmetry of the planum temporale, that overlaps Wernicke's classical language area, have been inconsistently reported. Meta-analysis of previous studies has suggested that publication bias established this sex difference in the literature. We screened with voxel-based-morphometry over the cerebral cortex for sexual dimorphisms of asymmetry in 2337 healthy subjects, and found the planum temporale to show the strongest sex-linked asymmetry of all regions, which was supported by two further datasets, and also by analysis with the Freesurfer package that performs automated parcellation of cerebral cortical regions. We performed a genome-wide association scan meta-analysis of planum temporale asymmetry in a pooled sample of 3095 subjects, followed by a candidate-driven approach which measured a significant enrichment of ssociation in genes of the ´steroid hormone receptor activity' pathway. We also found suggestive association on chromosome

2q32.2 (rs785248, p=2.1*10-7). Variants in the genes and pathways identified may affect the role of the planum temporale in language cognition.

B36 Language outcome after perinatal arterial territory stroke *Torsten Baldeweg[1], Gemma B Northam[1], Wui K Chong[2], Sophie Adler[1], Frances M Cowan[3]; [1]University College London, [2]Great Ormond Street Hospital London, [3]Imperial College London*

Introduction: Children with perinatally-acquired focal hemispheric lesions develop normal everyday language, even when lesions are large and encroach on left hemisphere language areas. This may be due to the capacity of the developing brain to compensate by functional reorganization. However, as language abilities have not been fully characterised in this group (i.e. with formal testing) it is unclear whether subtle deficits persist. We predicted that language scores would be: (i) reduced in children with left hemisphere injury; (ii) associated with injury to perisylvian tissue (including the arcuate fasciculus); and (iii) that this relationship would be modified by reorganization of language functions to the contralateral hemisphere. Methods: Two groups were studied: (1) term-born children with perinatal ischaemic or haemorrhagic stroke (n=30, mean age 13.1yrs, 18 males): all were followed longitudinally and had neonatal neuroimaging (many were included in Ricci et al. 2008) and (2) control children, group-matched for parental education, age and sex (n=44). Neuropsychological evaluation of speech, language and intelligence (IQ) was performed together with detailed neuroimaging, including fMRI (to determine language dominance), diffusion-weighted imaging (DWI) and volumetric T1-weighted imaging. Side of lesion was: Left =22, Right=7, Bilateral (L>R)=1. Results: Children with a history of perinatal stroke had IQ scores within the average range (mean 99±14) but 13 points lower than controls. Language performance (CELF-3UK scores) was reduced after correcting for non-verbal IQ in children with left-sided injury only. Reorganization of language functions to Broca's homologue in the right hemisphere was observed in 44% of children with left-sided lesions. Unexpectedly, neither language scores nor atypical language lateralization was related to the integrity of the left arcuate fasciculus. Rather, inter-hemispheric reorganization was associated with lesions predominantly affecting the extreme capsule/uncinate fasciculus in the left hemisphere. Importantly, there was no difference in language abilities in children with typical (left hemisphere) language dominance versus those with atypical (right) representation. Conclusions: Children with hemispheric lesions acquired in the perinatal period have language and IQ scores in the average range, but performance is nevertheless significantly lower than controls. Importantly, language ability is not related to lesion location, even when left hemisphere language areas are involved; this is possibly due to compensatory inter-hemispheric reorganization in the developing brain. Reference: Ricci D, Mercuri E, Barnett A, Rathbone R, Cota F, Haataja L, Rutherford M, Dubowitz L, Cowan F. Cognitive outcome at early school age in term-born children with perinatally acquired middle cerebral artery territory infarction. Stroke. 2008 Feb;39(2):403-10.

B37 Behavioral advantage in confrontation naming performance in brain tumor patients with left-frontal tumors *Ethan Jost[1,2], Morten Christiansen[1], Nicole Brennan[2], Andrei Holodny[2]; [1]Department of Psychology, Cornell University; Ithaca, NY, [2]Department of Radiology, Memorial Sloan Kettering Cancer Center; New York, NY*

Uncovering how the brain enables human language has long stood at the intersection of psychology, neurology and biology (Dronkers et al., 2007). Dating back to Broca's findings regarding brain damage and aphasia, much of the focus has been placed on language processes in the left-hemisphere. Recent case studies have shed light on the possibility that the brain's language network can re-organize as a result of tumor invasion, recruiting Broca's homologue in the right-hemisphere after damage to Broca's area proper in the typically dominant left-hemisphere (Holodny et al., 2002). The present study sought both to identify whether the unexpected right-frontal fMRI activation seen in such case studies exists as a group-level trend in patients with left-frontal tumors and also examine the possible compensatory nature of this activation. Thus, we conducted a retrospective analysis of 159 brain tumor patients who had undergone pre-surgical fMRI language mapping. Patients with left-frontal tumors were hypothesized to be more likely to show right- or co-dominant fMRI language activation compared to patients who had tumors elsewhere in the brain (H1). Patients with left-frontal tumors who were identified as right- or co-dominant for language were expected to possess more intact language function as measured by the Boston Naming Test (H2). All patients underwent pre-surgical fMRI for purposes of identifying language-related regions of cortex to be avoided during surgical resection. A trained neuropsychologist administered the Boston Naming Test prior to the scan and at least one block-design language paradigm during fMRI. Each patient's language laterality was determined by the neuroradiologist. Left-handed or ambidextrous patients and those with technically suboptimal scans were excluded. To test H1, patients were split into two groups: 1) tumors in the left-frontal lobe (n = 81), and 2) tumors elsewhere in the brain (n = 78). A two-tailed z-test comparing the distribution of hemispheric dominance of the left-frontal group and the overall distribution was significant, with more right- or co-dominant patients in the left frontal group than would be expected ($z = 2.16$, $p = .0308$). To test H2, patients with left-frontal tumors were split into: 1) left language dominant (n = 21) and 2) right- or co- language dominant (n = 8). A two-tailed independent samples t-test using each group's Boston Naming scores found that the mean was significantly higher ($t(23)=-2.3$, $p = .031$) for the right- or co-dominant group (M = 56.38; SD = 2.72) than for the left-dominant group (M = 48.76; SD = 14.49), suggesting that the atypical dominance was not merely an artifact of the ratio-dependent nature of the fMRI laterality index. These results suggest that the functional language network

may exhibit a greater degree of plasticity than previously known. Importantly, they also suggest that the right-hemisphere may be able to compensate for damage to putative language cortex.

Lexical Semantics

B38 The sounds of meaning: Investigating the functional interaction between action sounds and semantics

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Traditional cognitive theories conceive concepts and meanings as abstract mental entities processed and represented in a dedicated system functionally separate from other cognitive systems including perceptual or motor modules. In contrast to this classical view, recent approaches in the tradition of theories of semantic and conceptual "grounding" emphasize that perceptual and motor knowledge is necessary to build concepts and to learn and understand the meaning of signs (Barsalou, 2008; Pulvermüller, Moseley, Egorova, Shebani, & Boulenger, 2014). Also the recognition of sounds has been found to involve motor regions (Rizzolatti & Sinigaglia, 2010), but the status of such motor activation for the recognition of sound "meaning" is under discussion (Hickok, 2013). If motor circuits carry a role in both action sound recognition and in the understanding of action words, they should mediate semantic priming effects between the two. Such priming should reflect the anatomy of the motor system, because motor representations located side by side likely influence each other functionally, whereas distant ones don't. Therefore, a strong prediction of the action-semantic perspective is that semantic priming between action sounds and words follows the somatotopy of the motor system. Footstep sounds should therefore prime the word "kick" (but not "kiss"), whereas whistle sounds should prime the word "kiss" (but not "kick"). Such a cross over effect would be unexpected if motor semantics was epiphenomenal or optional. Using multi-channel, event-related potentials (ERPs) we sought to investigate priming effects between sounds and spoken words related to face or leg actions in a paradigm. To direct subjects' attention away from the sounds, a distraction-oddball design was used and the mismatch negativity (MMN) to rare "deviant" mouth- and leg-related action words (kiss and kick) was recorded in the context of frequent "standard" mouth- or leg related-action sounds (whistle, footstep) or non-action meaningful sound (water drop). Action-related words produced significantly larger MMNs when they were presented in the action body-part discordant context (i.e. "kiss" in footstep context; "kick" in whistle context) than in the body-part congruent contexts (whistle - "kiss"; footstep – "kick"), a pattern consistent with semantic priming. Furthermore, we observed anticipatory negative-going potential starting about 150 ms prior to action related standard sounds onset. This readiness potential-like potential likewise reflected body-part relationship between action sounds and words. Our results show that the body-part-relationship of action sounds and action words lead to neurophysiologically-manifest priming effects that reflect the somatotopy of the motor system. This finding supports action semantics and falsifies motor system epiphenomenonology in semantic processing. Barsalou, L. W. (2008). Grounded cognition. Annu Rev Psychol, 59, 617-645. Hickok, G. (2013). Do mirror neurons subserve action understanding? Neurosci Lett, 540, 56-58. doi: 10.1016/j.neulet.2012.11.001 Pulvermüller, F., Moseley, R., Egorova, N., Shebani, Z., & Boulenger, V. (2014). Motor cognition - motor semantics: Action-perception theory of cognitive and communicative cortical function. Neuropsychologia, 55, 71-84. doi: 10.1016/j.neuropsychologia.2013.12.002 Rizzolatti, G., & Sinigaglia, C. (2010). The functional role of the parieto-frontal mirror circuit: interpretations and misinterpretations. Nat Rev Neurosci, 11(4), 264-274.

B39 A meta-analysis of neuroimaing studies on Chinese and Japanese semantic processing

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Introduction: Chinese characters and Japanese kanji both contain rich semantic clues in their semantic radicals. However, these clues may be utilized differentially in the comprehension of the respective languages, as morphology is emphasized in Chinese character processing and Japanese is learnt phonologically. Therefore, how these between-language differences would contribute to their differential neural substrates of semantic processing is worth exploring. Previous studies have mainly examined the semantic-related neural mechanisms of Chinese and Japanese independently, but limited studies have direct comparisons between them. Methods: To investigate this language effect, the current study conducted a meta-analysis using the activation likelihood estimation (ALE) method to seek the converging semantic-related activation of prior Chinese studies as well as Japanese studies. The task contrasts were categorized into "visual word", "visual sentence", "auditory word", and "auditory sentence". Between-language contrasts were then conducted combining both modalities (visual & auditory) and both levels (words & sentences) altogether, as well as pertaining to a specific modality or a specific level. Between-modality and between-level contrasts were also conducted within each language group, so as to examine whether the modality and level effects are differentiated between Chinese and Japanese. Results: Chinese semantic processing activated several brain areas in addition to that seen in Japanese studies. These included the bilateral middle frontal gyrus (MFG) and the bilateral fusiform gyrus (FFG). No area was found to be specifically recruited for Japanese semantic processing. Both modality and level effects were found to be largely similar between Chinese and Japanese, however minor differences were noted. For the modality effect, only auditory-specific areas were found: the left middle temporal gyrus (MTG) for Chinese and the left superior temporal gyrus (STG) for Japanese. In the level effect comparisons, a sentence-specific area was observed in the right middle frontal gyrus (MFG) for Chinese and the left inferior frontal gyrus (IFG) for Japanese. Conclusion: The MFG, the FFG, and the MTG typically involved in Chinese semantic processing are

usually engaged in lexical integration, visual-spatial analysis, and semantic representation, respectively. In contrast, the STG (Wernicke's area) and the IFG (Broca's area) involved in Japanese semantic processing are the classical language areas for phonological reception and phonological rehearsal, respectively. This differentiation between languages indicates that orthographic processing is essential for Chinese comprehension whereas phonological processing is more relevant for Japanese comprehension. It might be further inferred that the semantic information supplied in both Chinese and Japanese orthography may be more beneficial to Chinese than Japanese comprehension. The current research findings further deepen our understanding of how linguistic characteristics shape our brains in processing semantics.

B40 The automaticity of language-perception interactions *Jolien C. Francken[1], Erik L. Meijs[1], Peter Kok[1], Simon van Gaal[1,2], Peter Hagoort[1,3], Floris P. de Lange[1]; [1]Donders Institute for Brain, Cognition and Behavior, Radboud University Nijmegen, Nijmegen, Netherlands, [2]Faculty of Psychology, University of Amsterdam, Amsterdam, The Netherlands, [3]Max Planck Institute for Psycholinguistics, Nijmegen, Netherlands*

Previous studies have shown that linguistic material (e.g. words) can modulate visual perception, by biasing and/or enhancing perceptual performance. However, it is less clear what are the requirements for these interactions to occur: does the relationship between the linguistic and visual stimuli have to be apparent, i.e., do words need to be attended to modulate perception? Or is the interaction automatic, i.e., would the interaction still occur when words are unconsciously perceived? Here we addressed this issue by manipulating attention towards/away from linguistic material, and presenting the linguistic material either consciously or unconsciously. In two separate experiments, subjects performed either a visual motion detection task or discrimination task. On each trial, the visual motion stimulus was presented in either the left (LVF) or in the right visual field (RVF), preceded by a centrally presented motion word (e.g., 'rise'). The motion word could be congruent, incongruent or neutral with regard to the direction of the visual motion stimulus that was subsequently presented. In one experiment, participants ignored the words, while in another experiment, they had to perform a semantic categorization task on a subset of trials to ensure attention of the linguistic stimuli. We also manipulated awareness of the words by means of backward masking. Behavioral results showed that even when words were unattended, participants were faster and more accurate when the direction implied by the motion word was congruent with the direction of the visual motion stimulus. Interestingly, the speed benefit was present only for motion stimuli that were presented in the RVF. When words were attended, the effects were significantly larger and present in both visual fields. Consciousness of the words greatly amplified the influence of language words on motion discrimination, but unconscious language still interacted with motion perception, inducing a response bias in both visual fields. Neural data showed larger neural activity when the motion word and stimulus were congruent in the left middle temporal gyrus, an area that is involved in semantic processing of verbal material. The location and extent of activation were similar for attended and unattended conditions. These effects were only observed when the motion word was consciously perceived. Together, our results suggest that attention increases the 'broadcasting' of linguistic information, resulting in larger and bilateral effects of language on perception. Yet, even in the absence of attention or consciousness language modulates visual motion perception, indicating that language-perception interactions take place automatically. Moreover, this interaction takes place in 'language areas', rather than 'visual areas', elucidating the nature of linguistic-perceptual interactions.

B41 Tracking the emergence of word-meaning in the brain: an fMRI study *Raphael Fargier[1], Pia Aravena[2], Louise Raguet[2], Anne Cheylus[2], Yves Paulignan[2], Carolina Ciumas[2], Tatjana Nazir[2]; [1]FAPSE, University of Geneva, Geneva, Switzerland, [2]L2C2 CNRS-UMR5304, Institute of Cognitive Science, Bron, France*

While lexical concepts are assumed to be distributed in neural networks encompassing sensory and motor regions of the brain, recent observations suggest that there is not a strict one-to-one mapping between semantic processing of words and the actual processing of the experiences they denote. Here, we developed a learning experiment with functional Magnetic Resonance Imaging (fMRI) to determine the neural networks underlying the processing of novel words associated with either visual or motor experiences. Specific issues concerned whether modal structures are involved invariably during processing of novel words and their referents and/or whether (associative) convergence zones develop with learning to help the integration of linguistic and modal information onto coherent representations. For this, participants were requested to associate novel pseudo-words with either the execution of object-directed hand movements (action pseudo-words) or the observation of novel 2D objects (visual pseudo-words) on Day1. Both trained (two lists of verbal stimuli; videos of trained hand movements and pictures of objects) and untrained material (one list of verbal stimuli; videos of hand movements and novel object pictures) were tested in an fMRI session (on Day2). Preliminary results indicate a correspondence between action video and novel action pseudo-word processing in somatosensory association cortex while visual association areas and precuneus tend to be activated in object processing and novel visual pseudo-word. Our study contribute to the growing body of research suggesting that beyond modal areas, association and modality-invariant regions participate to the elaboration of word meaning in the brain.

B42 Early differences in semantic processing during visual naming *F.-Xavier Alario[1,2], Dashiel Munding[1,2], Anne-Sophie Dubarry[1,2,3], Sophie Chen[1,3], Jean-Michel Badier[1,3], Marieke Longcamp[1,2]; [1]Aix-Marseille Université, [2]CNRS (Centre National de la Recherche Scientifique), [3]INSERM (Institut National de la Santé et de la Recherche Médicale)*

Visual naming involves a wide range of cognitive processes that are fundamental for speech, the cortical dynamics of which have yet to be fully described. We contribute to this description using an picture naming task in MEG, in which we manipulated the semantic demands across conditions. In different blocks, participants overtly named: colours from random scrambled patches, line drawings of items from a single semantic category (vehicles), or line drawings of items from four categories. Colour naming demands the least semantic processing, while items from a single category target a smaller semantic "target-space" than items from multiple categories. MEG data were collected on a 4D Neuroimaging system from seventeen subjects, of which two were excluded due to atypical levels of artifactual noise. The continuous signals were band-pass filtered between 0.5 and 35Hz and ERF amplitudes were averaged by subject and condition. Sources were reconstructed on the cortical surface of the MNI template using a Minimum Norm estimates. We performed time-resolved statistics on the source data using pair-wise planned comparisons (Student's t; $p < 0.001$ uncorrected). Significant differences began in occipital cortex 54ms post stimulus, and spreading forward to anterior (R = 117, L = 318) and middle (L = 153ms, R = 122ms) bilateral temporal cortices, left temporo-parietal junction/inferior parietal lobule (232ms), left superior temporal cortex (330ms), bilateral IFG (L = 427ms, R = 232ms), among other significant differences in activity. These regions are associated with visual object recognition, semantics, lexical retrieval, phonology and representational integration. The contrasts reveal early differences in the diffusion of information through a wide network. Notably, effects present in temporal cortices as early as 117 ~ 153ms post stimulus indicate early semantic processing. Reported differences are all present several hundred milliseconds before response onset, before movement-artifact related contamination of the recordings.

B43 Penguins can't fly: how concept typicality affects category verification and verbal memory recognition

Mara Alves[1], José Frederico Marques[1], Ana Raposo[1]; [1]University of Lisbon

The categorical structure of semantic knowledge provides us a system to organize the world, by establishing similarities and differences among concepts. For a given category (e.g. bird), some exemplars share many features and are therefore typical members of that category (e.g. sparrow), while others are more atypical as they present more distinctive features (e.g. penguin). While the impact of concept typicality on semantic processing has been extensively studied, it is less clear how this variable affects verbal memory retrieval of those concepts. It is well established that processing the meaning of words often aids episodic memory. However, it remains unknown how the categorical structure of concepts may support recognition memory for those concepts. We conducted a behavioral study to explore how two semantic variables – concept typicality and congruency – influence verbal episodic retrieval in healthy young adults. During encoding, 32 participants performed a category verification task, in which a category and an exemplar were presented and participants had to decide if the exemplar belonged to the category. We manipulated concept typicality such that the exemplar was either a typical (e.g. bird-SPARROW) or an atypical member of the category (e.g. bird-PENGUIN). Category congruency was also manipulated, with the exemplar being presented either with the correct category or with a different category (e.g. bird-SUBMARINE). Subsequently, participants performed an item recognition task, in which they saw exemplars presented before and new ones, and had to decide if the item was old or new, along with a Remember/Know judgment for old decisions. As expected, category verification was faster and more accurate for typical than atypical concepts. This concept typicality effect occurred only when the exemplar belonged to the category (i.e. congruent condition). Interestingly, we found the inverse pattern during item recognition, with better item memory and more Remember responses for atypical than typical exemplars, independently of category congruency. There was also a main effect of category congruency such that items encoded with their own category were better recognized and elicited more Remember responses than items encoded with different categories. Together, these results suggest that categorical structure improves verbal episodic recognition in two ways. First, the superior memory for atypical exemplars suggests that processing the unique features of those items (e.g. a penguin is a bird that can't fly) results in richer memory traces, as these items carry more distinctive semantic characteristics that are diagnostic in item recognition. Second, processing information that is congruent with the hierarchical structure of semantic memory also promotes episodic retrieval. We propose that the processing of distinctive categorical information is highly diagnostic during item recognition. A focus on semantic distinctiveness is a promising approach to characterize the interplay between semantic and episodic processing in verbal memory.

B44 Fronto-temporal network promotes verbal memory retrieval via semantic elaboration

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The lexical-semantic properties of words have a significant effect on the ability to later retrieve those words. For example, processing the meaning of words, relative to processing their perceptual features, facilitates recognition. Likewise, concepts with more unique lexical-semantic features (e.g. low-frequency words) are generally better remembered than concepts with less unique features (e.g. high frequency words). Neuroimaging studies often implicate the left lateral prefrontal cortex in verbal memory retrieval. It has been argued that this activation reflects controlled semantic processing that facilitates later recognition. Yet, it remains unclear what aspects of semantic processing predict verbal memory performance and how it relates with prefrontal activation patterns. We addressed these questions in an fMRI paradigm using a verbal episodic recognition task, in which we manipulated the semantic

distinctiveness of conceptual features. During encoding, participants performed a category verification task, in which they had to decide whether or not an exemplar belonged to a given category. Critically, exemplars were either typical members of a category such that they shared many features with other members and were therefore semantically non-distinct (e.g. mammal-LION) or were atypical members of the category, bearing more unique and distinctive features (e.g. mammal-SEAL). Subsequently, participants were presented with the same exemplars among new ones, which were also typical or atypical, and had to decide whether or not the item had been presented before. Behaviorally, the recognition of atypical exemplars was more accurate than recognition of typical items. At a neural level, old items that were atypical of the category (relative to new atypical items) showed increased activation in left lateral prefrontal cortex, associated with controlled semantic elaboration, as well as bilateral middle temporal cortex, a region consistently linked to accessing semantic information. Additionally, there was significant activation in occipital-parietal regions, including left inferior parietal lobe, left inferior occipital and bilateral angular gyrus, which may be associated with the integration of features. In contrast, old concepts that were typical members of the category (relative to new typical items) only showed occipital-parietal and anterior medial frontal activation, which might be related to source monitoring. Together, these findings reveal that processing atypical concepts improved recognition. This facilitation was accompanied by the recruitment of a left fronto-temporal network. We suggest that participants use the distinctive semantic features of atypical concepts as a cue that the concept had been presented before. Moreover, we propose that the fronto-temporal activation is critical during verbal recognition tasks because it enables retrieval of semantic attributes that are indicative of the previously presented concepts.

B45 Healthy Aging Modulates Idiom Processing: An Eye Movement Study of Idioms Presented in a Canonical vs. Non-Canonical Form

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Understanding the figurative meanings of idioms (kick the bucket = to die) can be challenging because of the need to modulate ongoing activation of figurative and literal meanings. Healthy aging has been associated with impairments in cognitive control (Braver & West, 2011), and several studies have demonstrated age-related changes in figurative meaning comprehension (Nippold et al., 1997; Ueckermann et al., 2008; Westbury & Titone, 2011). However, it is currently unclear if older adults show impairments in natural figurative language processing (for example during silent reading) and how age-related effects vary depending on the strength of figurative and literal meaning competition (for example, when idioms are presented in a non-canonical form). To address these questions, we recruited 21 older (mean age = 65.48 years) and 41 younger adults (mean age = 23.7 years), who read verb-determiner-noun idioms while their eye-movements were recorded. Idioms and matched literal phrases were embedded in sentences where a figurative or literal context followed the idiom (respectively, Mary kicked the [black] bucket after suddenly becoming seriously ill on the weekend; Mary kicked the [black] bucket when it was blocked from her view by the chair). An adjective preceded the phrase-final noun for half of the sentences. We computed LMER models for early (gaze durations and go-past times for phrase-final nouns) and late measures of reading (likelihood of regressing out of the context region). Across models we tested for the effects of sentence type, canonical form, and age group. The results for older adults showed longer gaze durations for phrase-final nouns, irrespective of whether they were idiomatic or literal, or occurred in a canonical or non-canonical form. However, older adults read idioms presented in a non-canonical form more slowly than younger adults in terms of go-past time on the noun, which suggests that breaking up the idiomatic form through adjective insertion led to heightened processing costs for older adults. Moreover, older adults showed a greater likelihood to regress out of the post-phrasal disambiguating region than young adults when canonical idioms were presented with literally biased sentence continuations. This suggests that older adults had interpreted the idioms figuratively on the first-pass, but had difficulty when they encountered a literally biased disambiguating region. These findings speak to several theoretical issues concerning idiom processing (e.g., Libben & Titone, 2008). First, the disruptive effects of non-canonical presentation in older readers suggest that they are more likely to retrieve the figurative meaning as a whole rather than compute them through compositional analysis (which would involve greater cognitive load through co-activation of meanings). Second, the processing cost that older adults encounter while reading literal sentence continuations, indicates that older readers are more likely to commit to an idiomatic interpretation rather than keeping multiple phrasal interpretations alive. Thus, it appears that older adults directly retrieve idiomatic forms and meanings from memory as a general comprehension strategy, perhaps due to their relatively greater experience encountering idiomatic forms, or to a loss of flexibility in maintaining multiple phrasal interpretations in working memory.

B46 Italian blues reveal links between language, brain, and behavior

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Linguistic relativity puts that our native language has the power to influence or re-structure our cognitive and perceptual processes. Recent studies have addressed this issue in the domain of color, revealing, in different studies, a relationship between lexical categorization and perception or brain responses (Thierry, Athanasopoulos, Wiggett, Dering, & Kuipers, 2009; Winawer et al., 2007). As it is crucial to link language-related perception processes in brain and mind, we here apply both neurophysiological and behavioral measures of color

discrimination in speakers whose languages slice up the color space in different ways. While German speakers have a single color term for blue (blau) and green (grün), Italian speakers lexically distinguish lighter (azzuro) from darker (blu) blues, but possess only one term for green (verde) in all shades of lightness. We found that, in Italian subjects, the visual Mismatch Negativity (vMMN), an index of automatic change detection that is present even without direct attention to the critical stimuli, was greater when observing color stimuli in the blue range crossing the critical lightness boundary between azzuro and blu – compared with color changes of similar lightness differences in the green range. In contrast, the vMMN in German speakers did not differ between lightness changes in blue and green. This difference in vMMN patterns paralleling language-specific linguistic distinctions was seen at parietooccipital electrodes at an early latency 120 – 260 ms. A behavioral color discrimination task with the Italian subjects showed faster reaction times in blue conditions as compared with green conditions. Crucially, a correlation was found for Italian speakers between the strength of the early vMMN response to blues and the reaction times on blue pairs in the color discrimination task, which was not present for greens. This result shows that, in Italians, the neurophysiological response (vMMN) reflects the ease of perceptual discrimination across a linguistically-defined boundary, whereas no such cognitive-physiological relationship exists for perceptual discriminations unrelated to language. The close relationship between behavioral and neurophysiological responses to linguistically-marked sensory changes along with the enhanced brain responses to such changes provide strong support that language drives perceptual processes in mind and brain, as once suggested by von Humboldt and Whorf. We use our data to evaluate current action perception theory of language and cognition and the general function of semantic embodiment (Pulvermüller, Garagnani, & Wennekers, 2014; Pulvermüller, Moseley, Egorova, Shebani, & Boulenger, 2014). Supported by the DFG and the Freie Universität Berlin. Pulvermüller, F. et al. 2014. Biol Cybern, in press. Pulvermüller, F. et al. 2014). Neuropsychologia, 55, 71-84. Thierry, G. et al. 2009). Proc Natl Acad Sci U S A, 106(11), 4567-4570. Winawer, J. et al. 2007. Proc Natl Acad Sci U S A, 104(19), 7780-7785.

B47 The role of LIFG in metaphor comprehension *Sarah Solomon[1], Sharon L Thompson-Schill[1]; [1]University of Pennsylvania*

Casual conversations, news articles, and literary works are all dripping with figurative language, but the way in which the underlying neural processing differs between figurative and literal language remains unresolved. While previous research has consistently shown the left inferior frontal gyrus (LIFG) to be more active for comprehension of figurative language than literal language, the reason for this engagement has not been directly examined. Perhaps the most popular explanation for LIFG recruitment in metaphor processing relates to selection demands – more specifically, the need to select between the abstract and literal meanings of a word. However, it is not clear how this explanation would apply to novel metaphors, in which the metaphorical meaning of the term is generated during the comprehension process itself. Instead of selecting between pre-existing meanings of a word, we hypothesize that LIFG is implicated in novel metaphor comprehension insofar as it must pick out the assortment of conceptual properties relevant to the metaphor. In other words, LIFG activity during metaphor comprehension should be driven by characteristics of conceptual properties. We created a paired list of 48 metaphorical ("The train is a worm."), and literal ("The creature is a worm.") sentences. The novel metaphors were selected such that the object concept (worm) was included in the McRae Norms, and that the metaphor-relevant property (slithers) was included in that object's entry. We also selected a property that was not relevant to the metaphor (slimy), and gathered property-related variables from the database. One group of participants took part in a behavioral study in which they had to verify either the metaphor-relevant or -irrelevant property of the concept after reading either the metaphorical or literal version of each pair. A separate group of participants took part in an fMRI study, where they read the same sentences while performing a cover task that required them to read and comprehend each metaphor's meaning. Participants also completed a color-word Stroop task. We looked within the most Stroop-responsive voxels in LIFG to examine the role of this region in metaphor comprehension. We find that, consistent with previous research, comprehension of metaphorical sentences relative to literal sentences recruits LIFG. We also find that the level of LIFG activity during reading of individual metaphors is predicted by characteristics of the metaphor-relevant and –irrelevant properties. Additionally, we find that levels of LIFG activity during metaphor processing predict performance on the property-verification task, even though these measures were collected from a separate group of participants. These results suggest that LIFG is recruited for metaphor comprehension at least in part due to the need to retrieve or select those specific properties that are relevant to metaphorical meaning. Using a task in which participants simply processed novel metaphors, and were never instructed to focus on object properties, we were able to examine the dynamic selection and filtering of conceptual knowledge during metaphor comprehension, and explore the role that LIFG plays in this process.

B48 Spatio-temporal dynamics of the lexical selection network in speech production: Insights from electrocorticography *Stephanie K. Ries[1], Rummit K. Dhillon[1], David King-Stephens[2], Kenneth D. Laxer[2], Peter B. Weber[2,3], Rachel A. Kuperman[4], Kurtis I. Auguste[3,4], Josef Parvizi[5], Nina F. Dronkers[6,7], Robert T. Knight[1]; [1]University of California, Berkeley, CA, USA., [2]California Pacific Medical Center, San Francisco, CA, USA., [3]University of California San Francisco, CA, USA., [4]Children's Hospital and Research Center, Oakland, CA, USA, [5]Stanford School of Medicine, CA, USA., [6]Veterans Affairs Health Care System, Martinez, CA, USA, [7]University of California, Davis, USA.*

Lexical selection accesses and fits an appropriate word to ongoing speech and is a core process for language production. Despite the central importance of lexical selection to language, its neural basis is poorly understood. Different regions of the prefrontal cortex (PFC) and of the left temporal cortex (LTC) have been associated with lexical selection but their precise role and the way they interact to enable lexical selection remains underspecified. This lack of knowledge stems in part from the fact that brain imaging techniques used to study healthy speakers do not provide temporal information on the brain regions involved in lexical selection. We had the unique opportunity to record electrocorticography (ECoG) in 4 neurosurgical patients to examine where and when subregions of the PFC and the LTC were engaged in lexical selection. Three of these patients had lateral frontal electrode coverage, 2 had medial frontal coverage, and 3 had left temporal coverage. Patients performed picture naming wherein semantic context was manipulated to affect the difficulty of lexical selection: pictures of objects were presented within semantically-homogeneous (difficult) or heterogeneous blocks (easy). Specifically, this paradigm elicits a semantic interference effect which is thought to reflect increased competition between semantically-related alternatives at the level of lexical selection. As predicted, across subjects performance was worse in homogeneous vs. heterogeneous blocks. High-gamma (HG) activity was sensitive to the semantic interference effect at several cortical sites. Early effects onset between 300 and 400 ms post-stimulus in posterior inferior temporal sites and also at a medial frontal activity (in the anterior cingulate cortex, ACC). These effects preceded left PFC effects that were observed at posterior middle frontal sites. HG activity in inferior temporal, medial frontal and lateral frontal regions spanned the entire time-window between stimulus presentation and vocal onset. Finally, semantically driven response-locked effects were maximal around vocal-onset at mid-superior and middle left temporal sites. Our results reveal a network of brain regions involved in lexical selection during picture naming as probed by the semantic interference effect. The timing and sensitivity to semantic interference of the HG activity are in agreement with the idea these regions play different roles in the selection and production of single words. We suggest that posterior inferior temporal cortex is engaged during initial lexical access as soon as semantic concepts are available. Medial frontal cortex may be involved in guiding left posterior middle frontal activity in providing top-down control to help solve the competition between semantically-related alternatives. Finally, superior and middle temporal HG activity time-locked to vocal-onset may reflect a speech monitoring mechanism sensitive to the difficulty of lexical selection.

Discourse, Combinatorial Semantics

B49 When a causal assumption is not satisfied by reality: Differential brain responses to concessive and causal relations during sentence comprehension

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Concessive relation is a kind of relation which expresses an implication that the relation between the two propositions is unexpected in terms of a natural of events assumed by the language users. The processes underlying the processing of concessive and causal relations are different, because, in comparison to processing causally related construction, processing the concessive construction involves an additional computing process, that is, negation of a potential causal attribution between two events. For example, a concessive construction like "Grandma moved from southern to northern China although she likes the south, where winter is warm" implies a causal assumption that is based on one's real world knowledge (i.e., one normally likes to live in a warm place) but is disapproved by the asserted fact (i.e., she moved away). Using the event-related potential (ERP) technique, this study investigated how a concessive construction is processed and to what extent its processing differs from the processing of a causal construction with an explicit marker because, in which a causal assumption is stated and approved by the fact. Concessive and causal conjunctive clauses always followed main clauses describing facts, forming the structure "NP (Human) moved from place A to place B, because or although + pronoun (he/she) + verb (likes) + there + [noun + critical word …]subordinate clause". The anaphoric word nali (there) in Chinese unambiguously referred to place B for causal construction and to place A for concessive construction. The critical word (e.g., warm) in the subordinate clause was either congruent or incongruent with the discourse context in a way that the implied (for concessive construction) or stated (for causal construction) causal relation was satisfied or not by the real world knowledge. The anaphoric word elicited a larger P600 for the concessive than for the causal construction. The critical word revealed a congruency effect: relative to the congruent word, the incongruent word eliciting a larger N400 followed by a larger P600 in the causal construction but eliciting a comparable N400 followed by a later negativity in the concessive construction. A direct comparison revealed a larger P600 for the congruent concessive sentence than for the congruent causal sentence. These findings demonstrated that although the semantic difficulty elicited by the inconsistency between the assumed causal relation and the real world knowledge is equivalent for both types of sentences, the re-establishment of the conjunctive relations and the underlying brain responses are differentially affected by the type of conjunctions. This is consistent with the claim that causal and concessive conjunctions build the discourse coherence in a different way. While causal conjunction has concept meaning,

concessive conjunction typically codes procedural information since it only signals how the message relates to the prior discourse (Blakemore, 2005; Iten, 1998).

B50 Marking the counterfactual: ERP evidence for pragmatic processing of German subjunctives

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Counterfactual conditionals (e.g. "If the dice had been loaded, then the game would have been unfair") provide two pieces of information: their literal meaning expresses a suppositional dependency between the antecedent and the consequent (loaded dice and unfair game) while their backgrounded meaning implicitly refers to the opposite factual state of affairs (not loaded dice, fair game). Several event-related potential (ERP) studies have targeted the processing of counterfactual consequents, yet counterfactual antecedents have remained unstudied so far. We present an ERP study which employed German past tense conditionals to compare subjunctive mood (which marks counterfactuality) with indicative mood (which marks hypothetical statements) at the critical point of mood disambiguation via auxiliary introduction in conditionals' antecedents. In German this contrast is maximally parallel, as subjunctive mood introduction in past tense is accomplished by a minor variation of the auxiliary (waren vs. wären), while the rest of the sentence remains identical in counterfactual and hypothetical conditionals ("Wenn die Würfel gezinkt waren/wären, dann war/wäre das Spiel unfair"; literal translation „If the dice loaded were/had been, then was/would have been the game unfair."). Another advantage of German syntax is that the mood-disambiguating auxiliary takes the antecedent-final position where propositional content is already conveyed. We collected EEG data of 16 subjects which read 52 counterfactual and 52 hypothetical conditionals that varied in semantic acceptability (2 × 2 design). Experimental sentences were presented with 104 declarative filler sentences in a randomized order. A semantic acceptability rating and probe detection task followed each sentence. At the critical first occurrence of the mood-disambiguating auxiliary in the antecedent we observed an early (200-400 ms) centro-parietal positivity followed by a transient (450-600 ms) negative deflection in left frontal regions for subjunctive compared to indicative auxiliaries. Importantly, no comparable differences between indicative and subjunctive were observed at the second occurrence of the respective auxiliaries in the consequent, ruling out a merely perceptual effect of umlaut (a vs. ä). Additional analyses showed that linguistic mood did not interact with the N400/P600 truth-effect elicited by the unacceptable vs. acceptable sentence-final content words. We interpret the positivity for subjunctive relative to indicative auxiliaries as an instance of the prediction-related P300. Cloze values and off-line naturalness-ratings support the conjecture: the subjunctive continuation was anticipated with a greater likelihood and rated to sound more natural than the indicative continuation. We furthermore interpret the frontal negativity effect of counterfactuals in respect to working memory requirements for rule application and increased referential processing demands for the representation of counterfactuals' dual meaning. We propose that the increased processing demand for subjunctive mood as indexed by the observed negativity effect reflects the process of counterfactuality marking, in terms of implication detection which is relevant for a representation of the counterfactuals' dual meaning. Our result suggests that the counterfactual's dual meaning is processed without any delay at the earliest point where counterfactuality is marked by subjunctive mood in the antecedent of a conditional.

B51 Different brain dynamics for the late anterior and posterior positivities in semantic processing

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Although traditionally the late positivity such as P600 has been assumed to be syntax-specific (e.g., Hagoort et al., 1993; Osterhout & Holcomb, 1992), recent studies have shown that a pure semantic violation can also evoke a late positivity (e.g., Kuperberg, 2007). Furthermore, two distinct components with different scalp topographies are commonly reported for semantic processing during sentence reading. The one with a more anterior scalp distribution is associated with congruent but unexpected sentences, while the more posterior distributed one is associated with incongruent sentences. In the present study, using the Event-Related Optical Signal (EROS) technique that has the advantage of both high temporal (less than 100ms) and spatial resolution (5-10mm), we explored the different neural dynamics of these two distinct components by time-locking to the late positivity window. Sixteen participants read sentences word-by-word and made a semantic judgment at the end of each sentence. Three types of sentences were constructed: High constraint-congruent, high constraint-violated, as well as low constraint-congruent sentences. The EROS responses were recorded simultaneously with ERPs time-locked to the final target word of each sentence. The ERP results replicated previous findings, showing that, as compared with the target word in the high constraint-congruent condition, the target in the low constraint-congruent condition elicited a larger late anterior positivity component, while that in the high constraint-violated condition evoked a larger late posterior positivity component. Importantly, the EROS results revealed the activation of LIFG in the time window of the late anterior positivity and the activation of left posterior middle temporal gyrus (LpMTG) and left anterior temporal lobe (LATL) in the time window of the late posterior positivity. These results suggest that the late anterior and posterior positivity components may reflect different cognitive processes: the former in LIFG is for cognitive control, whereas the latter in LpMTG and LATL is for lexical retrieval and reactivation to form a new possible coherent semantic representation.

B52 Relational vs. attributive interpretation of noun-noun compounds differentially engages angular gyrus

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The angular gyrus (AG) has been found to respond to a number of different tasks involving combinatorial processing over and above lexical processing. For instance, meaningful noun compounds like "lake house" have been found to elicit greater activity in the angular gyrus (AG) than when their constituents are reversed ("house lake") and less compositional (Graves et al., 2010). In other studies, AG has been implicated in tracking verb argument structure and thematic relations between concepts (Binder et al., 2009; Schwartz et al., 2011, Thompson et al., 2007). This sort of relation-based combination can be contrasted with feature-/attribute-based combination, as in adjective-noun composition, which has been found to elicit activity relative to non-compositional stimuli in other regions, such as the left anterior temporal lobe (LATL) (Baron et al., 2012; Bemis & Pylkkänen, 2011). In this study, we further investigate the case of noun-noun compounds, and ask whether AG activity is also modulated by the type of combinatorial operation applied to a noun-noun compound. We explicitly compare attributive-biased noun-noun compounds, e.g. "cactus carpet" (where the dominant interpretation applies an attribute of "cactus" as a modifier to "carpet," as in "a prickly carpet," rather than imposing a relational meaning, as in "a carpet on which a cactus stands"), with relation-biased compounds (e.g. "cracker tray"; i.e. "a tray for holding crackers", not "a cracker-like tray"). We hypothesized that AG would show greater activation for relation-biased compounds than attribute-biased compounds. In an fMRI study, adult English speakers were presented with noun-noun compounds (e.g. "cactus carpet") and asked to indicate by button press (1) when they had decided on a coherent meaning for the compound and (2) whether a subsequent "probe" matched the meaning they had in mind (e.g. "a prickly green carpet?") The probe was included only to engage subjects and was not analyzed. We compared 64 attributive-biased (94.5% bias, 17 subjects) and 64 relation-biased (89.6% bias) compounds matched on unigram frequency, compound length, compound familiarity, and reaction time for the decision task described in (1) above. We then analyzed volumes collected after the subject indicated they reached a coherent meaning and prior to when the probe question appeared. Looking in those voxels for which there was a significant difference in activity between task and ITI baseline (fixation cross), we found voxel clusters in right AG and anterior cingulate which showed greater activity in response to relation-biased compounds than attributive-biased compounds ($p<0.05$). This differential activity in AG based on the type of combination applied in a noun-noun compound is consistent with mounting evidence that the role of AG in combinatorial semantics is specific to relation-based information, whereby explicit or implicit relation predicates instantiate the combinatorial operation. This contrasts with previous characterizations of semantic combination, especially in LATL, as combination over commensurate features or attributes.

B53 ERP INDICES OF WORD FREQUENCY AND PREDICTABILITY IN LEFT AND RIGHT HEMISPHERES

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We present an ERP investigation of the contribution of left and right hemispheres in predictive language processing, and its time-course. Dambacher et al., (2009) find early top-down effects of predictability, suggesting that context integration occurs rapidly – in the same timeframe as bottom-up lexical factors such as word frequency or length. In contrast, studies examining hemispheric differences have focused on later time windows (e.g. the N400: Wlotko and Federmeier, 2007; 2013), with evidence suggesting the left hemisphere (LH) emphasizes top-down predictive processing whereas the right (RH) is more bottom-up and integrative. In this work we extend Dambacher et al.'s (2009) study using the divided visual field paradigm to investigate both the possible interplay of frequency and predictability in the early lexical access timeframe (<100 ms after stimulus onset) as well as their later influences on the N400 in the two brain hemispheres. Frequency of target words (high/low), predictability of target sentences (high/low) and visual field of presentation of the target words (LVF/RVF) were manipulated examining modulations in early (before 100ms) and later (250-450 ms) ERPs. 19 right-handed native speakers of German saw 144 tandems of context (high/low predictability) + target (same for both high/low frequency words) sentences twice (with target words presented once to the LVF and once to the RVF) in each of two blocks: High Pred: The man on the picture fiddled around with models of Columbus' fleet. Low Pred: The man on the picture wore a golden crown and sat on a stately throne. Target: In his right hand he held a ship (high frequency) of considerable length. Early effects (0-100ms after stimulus onset): We found a significant frontal positivity for low frequency compared to high frequency words, across both hemispheres. Moreover, a significant interaction between frequency and predictability revealed that this early frequency modulation was present only in the high predictability condition. In contrast with Dambacher et al. (2009) who report an early predictability effect, in our study frequency modulated predictability in the first 100ms – indicating that top-down and bottom-up factors interact rapidly after stimulus onset with no hemispheric advantage (Pulvermüller et al., 2009). Later effects (250-450ms): In addition to two-way interactions between predictability and VF and predictability and frequency, a three-way interaction (frequency X predictability X VF) was consistent with the view that modulation of predictability by frequency was mostly present in the LVF(RH): There only high frequency target words exhibited a centro-parietal negativity (N400) in low compared to high predictability contexts. In conclusion, our study highlights the interplay between bottom-up (frequency) and top-down (predictability) factors in early time windows, with both hemispheres similarly involved in the initial lexical access of words (<100ms). With respect to the N400, our findings are consistent

with Wlotko and Federmeier et al. (2007; 2013) as the negativity connected to predictability occurs in both hemispheres. In addition, however, our results show that the RH is also sensitive to frequency in this later time region, providing a possible window into the nature of top-down/bottom-up cooperation across hemispheres.

B54 Before and after, and processing presuppositions in discourse *Ming Xiang[1], Emily Hanink[1], Genna Vegh[1]; [1]University of Chicago*

The connectives "before" and "after" order eventualities in the temporal domain. Münte, Schiltz and Kutas (1998, Nature) showed that, compared to after-initial clauses, before-initial clauses elicited a larger prolonged left frontal negativity (e.g. Before/After the scientist submitted the paper, the journal…). Together with results from other behavioral studies, comprehension cost on "before" has standardly been taken to show the influence from our conceptual knowledge about how events are temporally sequenced in the real world: more computations take place for before-initial clauses because they present events out of chronological order, whereas after-initial clauses do not. In the current study, we show that the original results arise not (just) because of this clash in temporal sequence, instead, it is an example par excellence of our rapid sensitivity to presuppositions in discourse. Temporal before and after-clauses generally presuppose the veridicality/factuality of the eventuality they denote. For instance, the default interpretation of the sentence "Before/After John won the Oscar, he bought a big house." is that John indeed won an Oscar. However, although after-clauses are exclusively veridical, before-clauses allow non-veridical events, and receive an interpretation that the denoted events are likely to have had happened, as shown by "Before/*After the bomb exploded, it was defused by the police. ", where changing "before" to "after" leads to contradiction (Heinämäki,1974; Condoravdi, 2010). Comprehenders therefore couldn't be certain whether the veridicality presupposition for before-clauses is satisfied until they read the main clause. The process of maintaining such uncertainty may be the source of the prolonged negativity observed for "before", which is associated with extra working memory (WM) burden. We conducted an ERP experiment to test this hypothesis, using two sets of stimuli. The first set contains "Ad-hoc events", which are arbitrary events, as exemplified by the "Oscar" example above (as well as the original stimuli in Münte et al., 1998). In the "Real-World events" set, the temporal clauses always contain a true, widely-known, historical/cultural event, as in "Before/After Star Wars came out, George became interested in astronomy". Since the "Real World" events eliminate any uncertainty associated with the veridicality of the before-clauses, we predict the absence of the negativity differences between before- and after-clauses, in contrast to the "Ad-hoc" events. Experimental stimuli included 80 Ad-hoc and 80 Real-World before/after sentences, and an additional 80 filler sentences with when-clauses. ERPs were obtained over a prolonged 6200ms time window (with an additional 200ms pre-stimulus baseline) from the onset of the connective before/after, with the first 3150ms being the temporal clause, and the next 3050ms the main clause. Results (n=30) showed that over the 1000-6200ms time window there is an Event x Connective x Clause x Hemisphere interaction ($p<.05$) in the anterior region, reflecting a larger prolonged negativity on before than after-clauses for Ad-hoc events ($p<.01$), but no difference was found for the Real-world events. In conclusion, our results suggest processing cost of maintaining discourse presuppositions, which are part of the inherent semantics of temporal connectives like before and after.

B55 Human Intracranial Electrophysiology Reveals Common Semantic Processing for Comprehension of Written Sentences and Visual Scenes *Peter Ford Dominey[1,2,3], Sullivan Hidot[1,2], Anne-Lise Jouen[1,2], Marcela Perrone-Bertolotti[4], Carol Madden-Lombardi[1,2,3], Jocelyne Ventre-Dominey[1,2], Jean-Phillipe Lachaux[5]; [1]INSERM Stem Cell and Brain Research Institute, Bron, France, [2]University of Lyon, France, [3]CNRS France, [4]Univ. Grenoble Alpes, LPNC, UMR 5105, Grenoble, France, [5]Center for Neuroscience, UCBL, Lyon*

Introduction: We previously identified a fronto-temporo-parietal network involved in representation of meaning during sentence and scene comprehension. Here we investigate real-time neurophysiology of this system using intracranial EEG (iEEG). To localize the epileptic focus for subsequent surgical removal, intracortical electrodes were stereotactically implanted in four patients. We tested the hypothesis that in some electrodes in the fronto-temporo-parietal network, comprehension of a second stimulus would vary depending on its coherence with the first stimulus, and that this variance would be the same for sentence and scene processing, that is, it would reflect the operation of the common meaning system. Methods: We tested 4 subjects in a protocol where they saw a visual scene (or read a sentence) depicting a human event, then saw a second scene (or sentence) that was either a semantically coherent follow-up, or not, of the first. Stimuli were presented for 2 seconds, separated by a delay of 1-1.5 seconds between first and second stimuli. Trials were blocked by modality (scene or sentence), two blocks per modality for a total of 4 blocks. Each had 30 coherent, and 30 incoherent trials. 2/3 of the trials were followed by probe questions for vigilance. For each subject we acquired neural activity with ~100 recording sites distributed over ~15 electrodes implanted primarily in the left temporal cortex. iEEG data were processed to extract the normalized broadband gamma [50 - 150 Hz] energy level (GBR – gamma band response). Responses were analyzed in 50 ms windows from stimulus onset to 500ms, and in 200 ms windows from stimulus onset to 2000 ms. Analysis and Results: We performed 2x2x2 ANOVA with factors Modality (image or sentence), Condition (coherent or incoherent) and Stimulus (first or second), on GBR values over 50ms time windows, and a 4 way ANOVA that included a 4th factor, Time (5 x 200ms intervals). Post-hoc comparisons used Kruskal–Wallis nonparametric tests. The following criteria identified electrodes of interest: For both the sentences and scenes, no significant INCOH-COH (I-C) difference for the

first stimulus (p>0.05), and a significant I-C difference for second stimulus (p<0.05). For each subject, at least 10% of electrodes displayed the target effects (S1:12/98, S2:13/104, S3:16/111, S4:12/115) for a total of 53/428 (12%). Three classes of responses were observed: A: the sign of I-C is different for sentences vs. images (57%) and B-C: the sign is the same (B: I>C for 30%, and C: C>I for 13%). Responses were distributed in the semantic network including temporal pole, medial temporal lobe, inferior and middle temporal gyri, fusiform gyrus, and peri-rhinal cortex. Discussion: Cortical sites that reliably distinguish Coherent vs. Incoherent stimuli sequences, similarly for Sentences and Pictures, were observed in four subjects in the left fronto-temporo-parietal semantic network. This is consistent with the hypothesis that for sentences and images, comprehension engages a common semantic network that has previously been revealed in fMRI, and scalp EEG. This research contributes to the further characterization of the human semantic system.

B56 ERP responses for polarity sensitivity and definiteness restriction violations: Access/retrieval and integration/composition in logical semantic processing

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[BACKGROUND] In an ERP sentence-reading/judgment study we examined orthogonal logical-semantic violations involving "every"/"any" in (1)/(2). Observe: "every" is deviant (*) in the "pivot" (PVT) position of existential constructions (2a/b), but not in the subject position (SUB) in (1a/b). In contrast, "any" is deviant in (1b/2b) but not in (1a)/(2a). "Any" is a Negative Polarity Item (NPI): to be licit it must co-occur with a licensor such as negation ("None" in (a)-cases). Both kinds of deviance are thought to turn on logical-semantic/-pragmatic processing, and they may elicit a common ERP-profile that has also been reported in connection with the processing of contradictions (see Drury & Steinhauer 2009). Until now no study has examined these cases together. (1a) None of us thought that ANYONE/EVERYONE was in the room; (1b) All of us thought that *ANYONE/EVERYONE was in the room; (2a) None of us thought there was ANYONE/*EVERYONE in the room; (2b) All of us thought there was *ANYONE/*EVERYONE in the room. "Any" can also exhibit a distinct "free choice"/(FC) interpretation, as in "Anyone could be in the room". But note FC-any is sensitive to the presence of the modal "could" (compare: *Anyone was in the room). Thus, in (1b), "anyone" should be deviant as an NPI--but possible as FC--until the subsequent auxiliary ("was") is reached. In (2b), the auxiliary ("was") comes first, ruling-out the FC-reading before "any" is encountered. We hypothesized that this should yield distinct ERP-profiles for the +/−LIC contrast in (1a/b) for "any" compared to (2a/b). We also hypothesized that the violation response for "any" in (2b) should be similar to that for "every" in (2a/b), and that violations in (2a/b) for "every" (relative to (1a/b) should be independent of the +/−LIC contrast. [METHODS] Sentence presentation was standard RSVP (500 ms per word), with sentence-final acceptability judgments. ERPs time-locked to target words were examined for 1200 ms epochs (100 ms baseline). Mean amplitude of N400s (300-500 ms) and P600s (600-800 ms) were examined via repeated measures ANOVAs. [RESULTS] "Every" in the existentials yielded P600 effects ((2a/b)>(1a/b)), independent of a +/−LIC main effect--a sustained deflection extending through both time-windows, with −LIC more negative going ((1b)/(2b)>(1a)/(2a)). Though there were no +/−LIC x PVT/SUB interactions involving "every" (as expected), these interactions did obtain for "any", reflecting opposite polarity patterns in SUB versus PVT: an N400 effect in SUB ((1b)>(1a)); and a P600 effect in PVT ((2b)>(2a)). Finally, the P600 effect for unlicensed "any" in (2b) exhibited a strikingly similar amplitude/timing as the P600 violation effects for "every". [CONCLUSIONS] The presence/absence of NPI-licensors elicits ERP effects on downstream items that are independent of NPIs. Further, though the contextual properties that govern the well-formedness of "every" (SUB/PVT) versus "any" (LIC/NLIC) are independent of one another, both types of violation ("every" in PVT and unlicensed-NPIs) appear to tap overlapping if not identical processing mechanisms, which we have previously discussed as indexing composition/integration mechanisms (reflected by P600 deflections). Finally, N400 effects for "any" in SUB-position (1b)>(1a) may represent the processes underlying access/retrieval of FC-any versus NPI-any.

B57 Modulating conceptual combination using focal non-invasive brain stimulation

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Human thought and language rely on the brain's ability to dynamically construct an unlimited number of complex concepts from a limited set of simpler constituents. For example, individual concepts like "plaid" and "jacket" can be combined into the more complex representation "plaid jacket." This process is fundamental to human intelligence, but little is known about its neuroanatomic basis. Here we find that transcranial direct-current stimulation of the left angular gyrus modulates the processing of combinatorial semantic information. The angular gyrus is a multimodal cortical association area that has been hypothesized to function as an integrative hub in semantic memory. We previously found in fMRI and patient experiments that the angular gyrus is critical for processing lexical-semantic combinations (e.g., integrating "plaid" and "jacket" into a coherent understanding of "plaid jacket"). In this study, participants viewed a pair of words on the screen and indicated by button press whether or not the word pair combined into a meaningful concept (e.g., meaningful combinations like "rusty fence" versus non-meaningful combinations like "steel salad"). The meaningfulness of word pair combinations was determined in a separate norming study, and the word pairs were balanced on a number of psycholinguistic variables. We tested whether we could modulate the integration of semantic information by applying a focal version of transcranial direct-current stimulation (tDCS) to an fMRI-guided region of interest in the left angular

gyrus. This technique has been shown to modulate neural excitability by altering resting membrane potential. While traditional applications of tDCS affect broad regions of cortex with poor spatial resolution, high-definition tDCS allows us to apply relatively focal current stimulation by using a ringed array of compact scalp electrodes centered on our cortical region of interest. We tested the prediction that focal current stimulation of the left angular gyrus would enhance the processing of meaningful relative to non-meaningful lexical combinations in healthy adults. We modeled transcranial current flow to determine an electrode configuration that optimally stimulated the left angular gyrus. The stimulation point was guided by previously reported coordinates for the group activation peak in an fMRI study that showed heightened BOLD activity for meaningful compared to non-meaningful word pair combinations. Each participant received a real stimulation condition and an active sham condition on separate days. The stimulation conditions were counterbalanced across participants and equally spaced out in time. We found that performance on meaningful relative to non-meaningful word pairs was specifically modulated by the application of anodal tDCS over the left angular gyrus. These findings are consistent with the hypothesis that the angular gyrus supports a critical mechanism for integrating coherent lexical combinations, and it appears that this mechanism can be altered by focal tDCS.

B58 Density of prototypical features is associated with better category learning in Alzheimer's disease and healthy older adults. *Jeffrey Phillips[1], Nam Eun Min[1], Phyllis Koenig, Corey McMillan[1], Murray Grossman[1]; [1]University of Pennsylvania*

Semantic categories vary in how narrowly they are defined. In acquiring a new category, individuals' encoding of the category depends on the learning task and the features of specific exemplars encountered during learning. We trained healthy older adults (n=41) and individuals with a diagnosis of Alzheimer's disease (AD) or mild cognitive impairment (MCI; combined n=43) to categorize exemplars of a fictitious animal, the "crutter". Stimuli were images depicting variants of a crutter which could take one of two values on each of 10 anatomical features. We hypothesized that individuals trained on exemplars with a high proportion of the prototype's features (8/9 out of 10) would display better category learning than those trained on exemplars with fewer of the prototype's features (6/7 out of 10). We additionally hypothesized that category learning would depend on whether participants were told that training items belonged to a common semantic category (explicit condition) or simply instructed to think about the appearance of training items (implicit condition). We predicted elderly controls would learn equally well in implicit and explicit conditions, while the AD/MCI group would learn better in the implicit condition. These hypotheses resulted in between-subjects factors of training feature density (6/7 vs. 8/9), instruction type (explicit vs. implicit), and diagnosis (AD/MCI vs. elderly control). Test items varied in the number of a prototype's features from 0 (antitype) to 10 (prototype). Category membership was non-deterministic, and participants were not given feedback about the accuracy of their responses. Learning was assessed relative to an ideal model in which the likelihood of endorsing a test item as a crutter was directly proportional to the number of features shared with the prototypical image. Thus, this model considered the conjunction of all stimulus features on every trial. Prototype and antitype images were only shown during the test phase and were not labeled distinctly from other items. AD/MCI participants demonstrated more difficulty with category learning than elderly controls. However, AD/MCI participants also learned to categorize items in proportion to the number of prototypical features. Both groups benefited from the higher density of prototypical features in the 8/9 condition, although elderly controls appeared to benefit more in this condition than the AD/MCI group. Contrary to hypothesis, AD/MCI participants performed equivalently in the explicit and implicit instruction conditions. Among elderly controls, a modest effect of instruction type was observed, with slightly better category discrimination in implicit than explicit conditions. Overall, results demonstrate that learning of a category prototype is improved when training materials exhibit high overlap of critical features. Additionally, results in the AD group suggest that individuals with degeneration of the hippocampus and medial temporal lobes may be capable of category learning, even when stimuli vary on a large number of features.

B59 Fearing and loving: verb category matters in processing implicit causality *Einat Shetreet[1,2], Joshua K. Hartshorne[3], Gina R. Kuperberg[1,2]; [1]Tufts University, [2]Massachusetts General Hospital, [3]Massachusetts Institute of Technology*

The sentence "Will frightened Diane because…" is more likely to be completed with the pronoun "he", referring to the subject (Will), than the pronoun "she", referring to the object (Diane). In contrast, the sentence "Will loved Diane because…" is more likely to be completed with the pronoun "she", referring to the object, than the pronoun "he" referring to the subject. This implicit causality bias has been linked to the semantic class of verbs: object-experiencer verbs, like frighten, are associated with a subject causality bias, while subject-experiencer verbs, like love, are associated with an object causality bias (e.g., Hartshorne & Snedeker, 2013). The implicit causality bias can impact online word-by-word comprehension, with prolonged costs evoked by pronouns that are inconsistent (versus consistent) with the bias in both behavioral (e.g., Koornneef & van Berkum, 2006) and event-related potential (ERP) studies (e.g., van Berkum et al., 2007). In the current study, we explicitly examined whether the semantic verb class influences the neurocognitive costs incurred when the implicit causality bias is disconfirmed by the input. Unlike previous ERP studies that have not classified verb classes in this fashion, we only used subject- and object-experiencer verbs. The verbs were defined according to taxonomy from VerbNet (which is an extension of a systematic function of verb class by Levin (1993)). Furthermore, these verbs had been tested

for pronoun resolution bias in a large-scale behavioral study (Hartshorne & Snedeker, 2013). We measured ERPs as seventeen right-handed participants read two-clause sentences, presented word-by-word (400ms, ISI: 200ms). In 50% of sentences, the first clause contained an object-experiencer verb and in 50%, it contained a subject-experiencer verb. Verb class was fully crossed with bias consistency (pronouns were either consistent or inconsistent with the bias). ERPs were time-locked to the pronoun in the second sentence. After object-experiencer, but not subject-experiencer verbs, we observed a prolonged negativity effect between 300-800ms on pronouns that were inconsistent (versus consistent) with the implicit causality bias. These findings suggest that semantic verb class, influence the set-up of an implicit causality bias during word-by-word processing. Specifically, we suggest that comprehenders used object-experiencer verbs to generate relatively higher probability expectations for encountering a bias-consistent pronoun than a bias-inconsistent pronoun. Encountering the bias-inconsistent pronoun led to increased costs of selecting the less probable actual event structure over the more probable (predicted) event structure as the incoming pronoun was integrated. We further suggest that these 'selection costs', reflected by a prolonged negativity effect, can be distinguished from 'revision or reanalysis costs' observed on bias-inconsistent pronouns, reflected by a late positivity/P600 effect, previously observed by Van Berkum et al. (2007). Finally, we suggest that comprehenders were more likely to set up online causal expectations with object-experiencer than with subject experiencer verbs because the causal structure of object experiencer verbs is encoded within the lexical structure itself (Pesetsky, 1995), whereas, for subject experiencer verbs, it needs to be inferred.

B60 Lateralization of Joke Meanings in Normal Adults: A Hemifield Investigation

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How ambiguous text is processed is a central issue in psycholinguistics and has become of increasing interest in neurocognitive research. Jokes are a prime example of purposive ambiguity. Previous studies suggest that the two hemispheres make different contributions to resolving lexical ambiguity (Beeman & Chiarello, 1998): the left-hemisphere (LH) seems specialized for rapid selection of dominant meanings; the right-hemisphere (RH) appears to more slowly access and maintain a wider array of meanings. Further, RH damaged patients show a range of pragmatic deficits including deficits in making inferences needed to understand jokes that require semantic reanalysis or "frame-shifting" (Coulson & Kutas, 2001). ERP studies suggest that the frame-shifting, and/or re-establishment of coherence when processing jokes occurs between 500 and 900 ms after the punchline (Coulson & Lovett, 2004). Vaid, Hull, Heredia, Gerkens and Martinez (2003) found that the initial meaning of a joke is primed early during a joke text, but the joke meaning becomes primed immediately after the punchline; after 1 second, the initial meaning is no longer primed and the joke meaning becomes the sole active meaning. Extending a previous hemifield study of joke comprehension (Hull, Vaid, Chen & Martinez, 2005) the present research examined the relative contribution of each hemisphere to joke comprehension using a divided field primed lexical decision paradigm in which joke texts were visually presented centrally and target words that were either related or unrelated to the joke meaning were presented lateralized and shown either immediately after the punchline or after different time delays. It was hypothesized that priming of the joke meaning should be greater in the LVF/RH and should increase from the immediate to the delayed time point as frame-shifting occurs and coherence is re-established. Participants were English-speaking college students. Stimuli were 64 one-liner jokes adapted from Coulson and Kutas (2001) and Vaid et al. (2003). Half were followed by word targets, half by nonwords. Joke texts were shown centrally word by word for 400 ms per word. Following the last word (punchline), a lateralized target was shown after either 400 ms (Exp. 1) or after 1500 ms (Exp. 2) and a speeded lexical decision was required. Initial meanings showed greater RH priming consistent with the multiple meaning maintenance role for the RH; this effect diminished when the target was presented after a delay. Joke meanings were somewhat suppressed in the LH immediately after the punchline, but activation significantly increased after the delay. Joke meanings were somewhat facilitated in the RH immediately after the punchline and more so after the delay. We suggest that these activation increases may reflect integration of the joke meaning and the re-establishment of coherence. The two hemispheres thus appear to make different contributions during humor comprehension. Lack of priming for either initial or joke meanings immediately after punchline may be the basis of the "double-take" moment in humor. Increased activation for joke meanings over time in both hemispheres may reflect the re-establishment of coherence. We plan to extend this study to obtain fMRI data on this task.

B61 Prediction influences brain areas early in the neural language network

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The notion of prediction is increasingly investigated in cognitive neuroscience. It has become more and more apparent that the brain should be seen as an anticipating organ, actively predicting what will happen next, instead of being a passive input-chewing device. Also during language comprehension there is evidence for (lexical) prediction. In the present study investigated the neural areas involved in prediction of upcoming words during discourse comprehension. As indicator of predictability of a word, we used word surprisal, a mathematical construct from information theory and computational linguistics. A statistical language model was trained on

a large corpus of written Dutch, and was subsequently presented with three short stories taken from Dutch literature. The model determined word surprisal (how surprising is the occurrence of the present word), based on the statistical patterns in the training corpus. Twenty-four healthy participants listened to the same three stories (approximately 8 minutes per story) while their brain activation was measured with fMRI. The same speech fragments, but reversed were presented as a control condition. The brain activation per word was correlated with surprisal value of that word, and these correlations were compared between real and reversed speech fragments. The following brain areas were more sensitive to predictability of a word during real as compared to reversed speech: Left inferior temporal sulcus ('visual word form area'), bilateral superior temporal sulcus, right amygdala, bilateral anterior temporal poles, and right inferior frontal sulcus. Most interesting in our results is the modulation by prediction of areas early in the neural processing stream, most notably the left inferior temporal sulcus and the right amygdala. We conclude that prediction during language comprehension can occur at all levels of processing, including at the level of word form. Besides pointing to the importance of prediction during language comprehension, another novelty of the present study lies in the successful combination of computational linguistics and cognitive neuroscience. We used computational linguistics to get to a computationally informed characterization of prediction. Moreover, our study illustrates the feasibility of studying continuous spoken discourse with fMRI, which opens interesting possibilities for studying more natural language stimuli than is usually done in the neurobiology of language.

B62 Neurolinguistic processing of figurative expressions: the role of emotion

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In recent years, neuroscientific research on language has shown that the emotional content of verbal material affects language processing at different levels, i.e., written word recognition (cf. Citron, 2012), text comprehension (Ferstl, Rinck, & von Cramon, 2005) but also syntactic ambiguity resolution (Díaz-Lago, Outeiral, García-Orza & Piñeiro, 2014). Nevertheless, this research has mainly focused on literal language processing, ignoring the role of figurative language in conveying emotion (Fainsilber & Ortony, 1987) and the pervasiveness of figurative language in everyday communication (Jackendoff, 1995). In this paper, I will present new experimental evidence from our lab that brings the role of emotion in figurative language to the fore. In a first fMRI study, we investigated processing of conventional taste metaphors such as "she looked at him sweetly" and compared them to almost identical literal counterparts "she looked at him nicely". Our aim was to test whether abstract metaphorical concepts are grounded in sensorimotor representations (cf. Lakoff & Johnson, 1980; Pulvermueller, 1999) and therefore whether gustatory areas are activated during comprehension of taste metaphors. The results confirmed our prediction but also showed enhanced activation of emotion-related brain regions, i.e., left anterior hippocampus, left amygdala, and orbitofrontal cortex for metaphors compared to their literal counterparts. Considering that our stimuli were tightly matched for a range of variables, including affective ones, we suggest that metaphorical formulations may be more emotionally engaging during natural reading than literal ones. Our results are in line with a recent meta-analysis of 23 studies from Bohrn, Altmann and Jacobs (2012) that reported left amygdala activation in response to figurative vs. literal language, and extend them, since no tight control over psycholinguistic variables is possible in meta-analyses. In a second fMRI study on idiomatic expressions, e.g., grasp the idea, spill the beans, that were divided in positive, negative and neutral affective categories and compared to different literal sentences, we found enhanced activation of the inferior frontal gyrus (typically involved in idiom processing) as well as the left amygdala. More interestingly, emotional idioms and in particular positive ones elicited enhanced activation in several regions including the pre- and postcentral gyri, but no differences between emotional and neutral literal sentences was reported. This seems to suggest that the emotional content of idiomatic expressions becomes more salient than the same content in literal sentences. I will discuss these novel findings in relation to previous behavioural research on emotion and figurative language as well as on the pragmatic functions of idiomatic expressions (e.g., complaints, affiliation; Drew & Holt, 1988; 1998) and will provide suggestions for future research. To our knowledge, the neuroscientific literature on figurative language has not yet addressed its possible role in emotionally engaging the reader/listener; This strand of research will provide new insights into understanding figurative language processing as well as interesting implications for research on communication and persuasion.

Syntax, Morphology

B63 Characterizing the neural computations of sentence comprehension: an activation likelihood estimate (ALE) meta-analysis

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The neural computations underlying sentence comprehension are hotly debated. For example, there is much disagreement regarding the nature of the contributions of the frontal lobe, and particularly Broca's area, to sentence comprehension. Four prominent hypotheses of how Broca's area is contributing to sentence comprehension are via (i) syntactic-specific computations (i.e. syntactic movement), (ii) articulatory rehearsal, (iii) semantic processing and (iv) cognitive control processes. Numerous functional neuroimaging studies have investigated the brain networks recruited for sentence comprehension in relation to these domain-general processes, many of which having conflicting results. These differences are in part due to most studies examining only one or two of these domain-general

processes in relation to sentence comprehension, and not examining the relationship amongst the domain-general processes themselves. To further complicate interpretation, presentation modality (auditory or visual) is often not taken into account (for example, comparing auditory sentence comprehension & a visual cognitive control task). The present meta-analysis study begins to address these issues by combining results from across multiple studies using activation likelihood estimates (ALE). ALE maps were generated from peak fMRI coordinates from healthy adult control subjects, reported in peer-reviewed journal articles containing one or more of the following paradigms, broadly defined: (i) syntactic manipulations, (ii) articulatory rehearsal, (iii) verbal semantic tasks, or (iv) a cognitive control task, such as the Stroop task. An exhaustive search of pubmed.gov identified, to date, 47 studies totaling 764 total subjects that meet these criteria. Activation likelihood estimates were computed for the syntactic, articulatory rehearsal, semantic and cognitive control conditions, respectively. Significant voxel clusters ($p < .01$, FDR corrected, minimum cluster volume = 200 mm3) in the inferior frontal lobe were identified for each of the four conditions. The four conditions each yielded distinct ALE maps, spanning the following regions: syntactic: pars opercularis (PO) and pars triangularis (PTr), semantic: PO, PTr, middle frontal gyrus (MFG), and both cognitive control and working memory: PO, PTr, MFG, precentral gyrus. Overlap of all four conditions' ALE maps was found in the pars opercularis. Pairwise contrasts of the ALEs were then computed to identify regions with significantly different ALEs for the syntactic condition compared to each of the other three conditions. A cluster in the pars opercularis was found to be significant for the syntactic but not any of the domain-general conditions. However, once presentation modality was accounted for, these "syntax-specific" effects were erased: there were no significant differences between the ALE maps for the syntactic conditions with auditory presentation (i.e. listening) and articulatory rehearsal or the semantic condition. These initial results indicate that, across a variety of experimental designs, group-level fMRI findings in inferior frontal regions related to auditory sentence processing can be accounted for by domain-general processes. In addition, listening versus reading sentences recruit distinct inferior frontal regions, and differentially engage domain-general processes.

B64 Semantic and syntactic interference resolution during Chinese sentence comprehension: Evidence from event-related potentials (ERPs)

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During sentence comprehension, interference effects occur when readers retrieve earlier sentence information to integrate with later information and intervening material matches target information on semantic or syntactic properties (Van Dyke, 2007). We used ERP methodology to investigate the time course of semantic and syntactic interference effects. The study was carried out in Chinese, which has been argued to be more semantically based (Zhang, Yu, & Boland, 2010) compared to English, which is claimed to be more syntactically based. Prior behavioral studies in English have shown that syntactic interference effects typically precede or even block semantic interference effects (Van Dyke & McElree, 2011), but a different pattern might be obtained in Chinese. Method. Forty native Chinese speakers read sentences while the EEG was recorded from 63 electrodes. Interference when retrieving the subject of the main verb was manipulated in a 2 (high-low semantic) x 2 (high-low syntactic) design. The English translations of example sentences are shown below with the semantic manipulation in brackets. The semantic manipulation varied the plausibility of the distracting noun as the subject of the verb and the syntactic manipulation varied whether the distracting noun was a subject or object. Low-Syntactic. The president saw that the scholar who rejected the [conference/visitor] yesterday waited... High-Syntactic. The president saw that the scholar who the [conference/visitor] rejected yesterday waited... Results. The ERP results at the main verb showed sensitivity to both syntactic and semantic interference. For both the semantic and syntactic interference manipulations, an LAN effect (300 – 500 ms) was obtained. Syntactic interference was also evident in a P600 effect (650 – 800 ms) with a maximum in the midline. Semantic interference also was evident in a late negativity (600 – 800 ms) with anterior maximum. We suggest that the LAN effect reflects WM operations in the high interference conditions (King & Kutas, 1995), while the late effects most likely reflect syntactic and semantic revision. Conclusions. The results showed immediate effects of both semantic and syntactic interference in the ERP results for these sentences, all of which were acceptable sentences. Semantic interference effects were obtained as early as syntactic interference effects. Thus, it is possible that semantic interference is playing a role earlier in Chinese than English, where semantic effects have been found to lag behind syntactic effects. However, a comparable ERP study in English would need to be carried out to directly address this issue, as it is possible that the ERP results would pick up early semantic effects not evident in behavioral measures. References. King, J. W., & Kutas, M. (1995). Who did what and when? Using word-and clause-level ERPs to monitor working memory usage in reading. J Cog Neuroscience, 7(3), 376-395. Van Dyke, J. (2007). Interference effects from grammatically unavailable constituents during sentence processing. JEP: LMC, 33(2), 407-430. Van Dyke, J., & McElree, B. (2011). Cue-dependent interference in comprehension. JML, 65(3), 247-263. Zhang, Y., Yu, J., & Boland, J. E. (2010). Semantics does not need a processing license from syntax in reading Chinese. JEP: LMC, 36(3), 765.

B65 Dissociation of comprehension and transformation processes for solving algebraic equations: An fMRI study

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To solve algebraic equations, two distinct processes are involved: a comprehension process for the structure of a given equation, and a transformation process for transposing variables and operators to obtain a solution. Both of these processes are separately described by hierarchical tree structures. In our previous functional magnetic resonance imaging (fMRI) study with various sentence structures, we demonstrated that activations in the opercular and triangular parts of the left inferior frontal gyrus (L. F3op/F3t) were modulated by "the Degree of Merger (DoM)," a measure for the complexity of tree structures (PLOS ONE 8, e56230). On the other hand, the orbital part of the left inferior frontal gyrus (L. F3O) has been suggested to subserve sentence comprehension (Science 310, 815-819). Based on the similarity between mathematics and language, we hypothesized that these regions have differential roles in solving algebraic equations. We estimated the DoM separately for comprehension and transformation processes, as well as the total DoM for both processes, and performed a parametric fitting for observed activations. In each trial, a task-indicating cue was visually presented for 1 s, followed by an algebraic equation such as "(a – b ÷ c) × d = e." Using the same set of stimuli, we tested three tasks. In the Algebra task, participants solved the given equation for a specified symbol (e.g., "a"), and remembered the order of operators in an obtained solution. In the Start task, participants were asked to search an operator, where computation should be started first within the given equation. That operator was converted to its inverse operator (e.g., from "÷" to "×"), and all operators were remembered in the same order. In the Reverse task, a basic control for short-term memory and operator inversion, the participants were asked to convert all operators to their inverse operators, and to memorize them in the reverse order. For each task, we tested Short (with two operators) and Long (with three operators) conditions. We recruited university students, who were all right-handed. We used 3.0 T MRI system (Signa HDxt, GE Healthcare), and analyzed the fMRI data with SPM8 software. The images of the Algebra – Reverse and Start – Reverse contrasts were generated in a first-level analysis, and used for intersubject comparisons in a second-level analysis. In both Algebra – Reverse and Start – Reverse, significant activation was observed in the bilateral frontal and parietal regions (corrected $P < 0.05$). In the direct contrast of Algebra – Start, activation was further localized in the L. F3op/F3t and L. F3O. Moreover, activations in the L. F3op/F3t were parametrically modulated by the total DoM, while those in the L. F3O were modulated by the DoM for a comprehension process alone. These novel results indicate neural dissociation of comprehension and transformation processes for solving algebraic equations.

B66 Constituent structure representations revealed with intracranial data

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An important tenet in many linguistic theories is that words presented sequentially in a sentence are combined together to form increasingly larger and more complex constituents in a hierarchical fashion. How the brain encodes such a nested structure during language comprehension however, remains largely unknown. In previous work (Pallier et al., 2011), functional magnetic resonance imaging (fMRI) data revealed a subset of areas within the left hemisphere language network that showed increasing activity as the size of linguistic constituents presented increased. Given the slow nature of the hemodynamic response function, however, the neurophysiological responses underlying this systematic increase remain unclear. Here we analyze the processing of linguistic constituent structures in the brain using intracranial recordings. We present data recorded from patients with intractable epilepsy who have had intracranial electrodes surgically implanted to monitor epileptic activity, and who volunteered to perform a linguistic task. Using Rapid Serial Visual Presentation, patients were presented with sentences of 3 to 10 words in length. To enforce sentence comprehension and memorization, after a 2-second delay, they were asked to decide whether a second sentence matched the first one in meaning. We analyzed the time dependent spectral power in the high gamma range (70 to 150 Hz). This frequency range in intracranial data is considered to be a reliable marker of the overall local firing rate near the recording site (Ray and Maunsell, 2011). Preliminary results reveal that high gamma activity at the end of each sentence increases with increasing sentence length for recording sites in the inferior frontal gyrus, the temporal pole, and the anterior and posterior regions of the superior temporal gyrus in the left hemisphere of 4 patients (37/43 recording sites, $p<0.001$, binomial test). Moreover, this increase per word was larger than the same measure applied to a control task in which the patients read lists of random words and were asked to answer whether a later probe word was in the list of words or not (32/43 recording sites, $p<0.01$, binomial test). These results highlight an agreement between intracranial high gamma power and fMRI data, and begin to demonstrate the intracranial signatures of constituent structures.

B67 Putting the load on different cognitive domains: Music, Language and Control

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Introduction: In light of the debate on modularity of cognitive domains, we used fMRI to investigate neural activation levels associated with high-load processing in different domains. For language, we measured

activation associated with garden-path, noncanonical and ungrammatical sentences. Language contrasts were compared to neural correlates of processing in the music domain, where we compared harmonic sequences to 'deceptive' sequences (including a low-probability chord) and 'ungrammatical' sequences (including an anomalous chord). To the extent that cognitive load in language and music relies on shared neural substrates for qualitatively similar processes, the garden-path contrast should show overlap with the deceptive musical contrast, while sentence-ungrammaticality should reveal overlap with musical anomaly. Participants also performed a Stroop task, tapping into general cognitive control. We were particularly interested in the role of left-hemisphere inferior frontal gyrus, associated with syntactic processing as well as general cognitive control. Methods: 20 Speakers of English (12 females; mean age 22.5) were scanned at 3T, performing event-related experiments. The language experiment consisted of an auditory picture verification task. Five sentence types were presented (40 per condition): garden-path, late-closure, object-cleft, subject-cleft and ungrammatical. For music, participants were presented with 8-chord piano sequences (35 trials each): harmonious, deceptive and anomalous. They had to respond by button press to a tuba sound inserted in 15 trials. In the Stroop task, participants responded by button press to the color of a visually presented color word, with a choice of red, green, yellow and blue. Stimuli could be congruent or incongruent with the presentation color (40 trials each). For the language and Stroop tasks, erroneous responses were modeled separately. In the music task, response stimuli (tuba) were modeled separately. Language and music contrasts were tested in one-way repeated-measures ANOVAs, while Stroop contrasts were examined with a paired t-test. In addition to whole-brain analyses and planned network analyses, we performed ROI analyses in bilateral IFG. Results: Whole-brain and network analyses are ongoing, and will be available at the time of presentation, but we focus here on the ROI analyses. In LH-IFG, the syntactic contrast OC>SC is associated with activation that is bordered both anteriorly and posteriorly by differential activation for Stroop contrast incongruent>congruent, with minimal overlap, primarily in dorsal-posterior LH-IFG. A subset of the voxels in the center of the OC>SC activation cluster is also associated with the language contrast garden-path>late-closure, without overlap with the Stroop contrast. In RH-IFG, there is activation for grammatical>ungrammatical sentences, minimally overlapping with incongruent>congruent, but not with harmonious>anomalous music activation. Conclusions: The observed partial overlap as well as separation between activation patterns associated with complex syntactic processing and cognitive control replicate previous findings. The more subtle manipulation of temporary syntactic ambiguity has much more in common with noncanonical syntactic processing than with general cognitive control. Our musical manipulations do not appear to tap into the same processing systems. In all, these data are consistent with a model in which there does indeed exist a certain level of neural autonomy for syntactic processing, while it also partly relies on general cognitive control.

B68 Similarity-based interference during comprehension of noun phrases: Evidence from ERPs

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Current accounts of sentence comprehension invoke the notion of retrieval interference as a primary determinant of difficulty during processing [1-2]. Specifically, similarity between constituents (e.g., NP feature-overlap) has been argued to interfere when people resolve subject-verb or anaphoric dependencies [3-7]. We ask whether similarity-based interference effects arise as a function of multiple NPs in the discourse that overlap in gender and/or number. We take a novel approach by examining interference effects at the second NP rather than downstream after "maintaining" multiple NPs [6-8], using ERPs to establish quantitative and qualitative processing consequences. We used the empty category PRO to introduce two NPs, only the second NP could be PRO controller (e.g., "While [PRO] talking to the waitresses, the man/men/woman/women inspected the menu"). If feature overlap affects processing of the second NP, most interference should occur under gender- and number-matching NPs. Because this interference crosses the subject-object distinction, we predicted that interference would elicit a P600 effect, the effect most reliably associated with syntactic processing difficulties [9]. Methods: During EEG recording, 24 participants read 160 grammatical sentences (40 per condition) in a 2(gender: match, mismatch) x 2(number: match, mismatch) factorial design where the first clause introduced the object-NP and had PRO as subject, and the matrix clause introduced the controller of PRO. Subject and object NPs could overlap in gender and/or number. We fully counterbalanced 160 male/female singular/plural gender-definitional nouns as object NPs, and as critical NP always 'woman/man/girl/boy' (or plural form). Sentences were mixed with 156 fillers and presented word by word (300 ms duration, 200 ms blank), followed by intermittent comprehension questions (85% response accuracy). Results: Across all electrodes, a significant gender by number interaction was observed (500-800 ms window [9]; $F(1,23)=6.02$, $p<.05$), due to a robust P600 effect of number-mismatch in the gender-match conditions ($M=-1.18$, $F(1,23)=8.04$, $p=.01$), that did not occur in the gender-mismatch conditions ($M=-.17$, $F(1,23)=.18$, ns). No distributional effects were observed. Conclusions: The P600 effect for double-match NPs suggests that interference was driven by similarity contingent upon matching gender and number. Our results testify to the strength of gender-cues during incremental processing, consistent with memory-based accounts of discourse comprehension [2-7]. The results suggest that when features maximally overlap, the subject NP may be momentarily considered as an anaphor for the more distinctive (i.e., first-mentioned and semantically richer) object NP. Alternatively, the P600 may reflect increased discourse complexity stemming from similar

NPs [10]. Our results imply a central role for interference during comprehension, even of simple grammatical sentences. References: [1] Lewis, Vasishth, Van Dyke, 2006; [2] McElree, Foraker, & Dyer, 2003; [3] Gerrig & O'Brien, 2005; [4] Gordon, Hendrick, & Johnson, 2004; [5] McKoon & Ratcliff, 1998; [6] Van Dyke & McElree, 2006; [7] Gordon, Hendrick, Johnson, & Lee, 2006; [8] Wager & Phillips, 2013; [9] Osterhout & Holcomb, 1992; [10] Kaan & Swaab, 2003

B69 Retrieval interference during comprehension of grammatical subject-verb agreement: Evidence from ERPs

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Research on subject-verb agreement during comprehension suggests a 'grammaticality asymmetry' in similarity-based retrieval interference. Whereas processing costs incurred by ungrammatical subject-verb agreement are reduced in the presence of a grammatically illicit attractor noun that matches the verb in number, attractor nouns have not been found to affect the processing of grammatical sentences [1]. However, most existing studies have only included singular verbs in the grammatical conditions, and the lack of retrieval interference in such cases could be a result of the fact that singular is an unmarked feature [2]. In the current study, we tested for similarity-based interference for both singular and plural verbs in fully grammatical sentences. If plural is a marked feature, we expect to find evidence of retrieval interference for plural verbs but not singular verbs when multiple items in memory match the number of the verb. We predicted that retrieval interference would elicit a P600 effect [3-4], the effect commonly associated with syntactic processing difficulties. Methods: Participants read 120 grammatical sentences (30 per condition) belonging to a 2(subject noun: plural, singular) x 2(attractor noun: plural, singular) factorial design in which the critical verb (have/had/were/was) always agreed in number with the subject noun. PS: "The keys to the cabinet were getting very rusty", PP: "The keys to the cabinets were getting very rusty", SS: "The key to the cabinet was getting very rusty", SP: "The key to the cabinets was getting very rusty". Sentences were mixed with 280 fillers and presented word by word (300 ms duration, 200 ms blank). Intermittent yes/no comprehension questions were answered with 92% accuracy. EEG data was recorded from sixty-four channels and segmented into epochs from 200 ms before to 1000 ms verb onset. Data was baselined to 0-200 ms post-stimulus to eliminate spurious effects from pre-critical word differences (see also [3-4]). Results: Using average amplitude per condition across 16 centrally distributed EEG electrodes, repeated measures ANOVAs in the 500-700 ms time window showed an effect of attractor that was reliably different for plural and singular verbs ($F(1,35)=4.8$, $p<.05$), with a robust P600 effect elicited by plural verbs (PP minus PS voltage difference, $M=.64$, $F(1,35) = 5.7$, $p < .05$) but none for singular verbs (SS minus SP, $M= -.22$, $F(1,35)=.44$, ns). Conclusions: The observed P600 effect for grammatically correct, plural verbs in context of a plural attractor noun suggests that retrieval interference arises as a by-product of grammatical processing, and constitutes evidence against a grammaticality asymmetry in interference effects. References: [1] Wagers, M. W., Lau, E. F., & Phillips, C. (2009). Journal of Memory and Language [2] Bock, K., & Eberhard, K. M. (1993). Language and Cognitive Processes [3] Kaan, E. (2002). Journal of Psycholinguistic Research [4] Tanner, D., Nicol, J., Herschensohn, J., & Osterhout, L. (2012). Proceedings of the 36th Annual Boston University Conference on Language Development (pp. 594-606).

B70 Implicit Structured Sequence Learning: An EEG Study of the Structural Mere-Exposure Effect

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Artificial grammar learning (AGL) is commonly used to probe implicit sequence learning. The link between AGL and natural language processing has been empirically demonstrated in a number of recent studies, suggesting an overlap in processing mechanisms (see [1] for a review). In implicit AGL paradigms, the structural mere-exposure effect provides a sensitive indirect measure of grammatical knowledge [2]. The structural mere-exposure effect is based on an underlying rule-system and is characterized by the tendency to prefer new stimuli that conform to the rules, independent of surface structure. Preference classification, in combination with a structural mere-exposure design, can therefore be used to investigate structural (syntax) processing in unsupervised AGL paradigms [3]. Here we characterize the neurobiological mechanisms underlying the structural mere-exposure effect in implicit AGL by taking advantage of the temporal resolution of EEG in a preference classification paradigm. On the first day, before the first acquisition session, we acquired EEG data during preference classification in order to establish a naive baseline and control for potential pre-existing classification biases by asking the participants to indicate whether they liked or disliked grammatical CV-syllable sequences presented auditorily. Participants were then exposed to grammatical sequences, once a day, during a short-term memory cover-task. On the last day, participants were again asked to indicate whether they liked or disliked new sequences based on their immediate intuitive impression while EEG data was recorded. Finally, the participants were given the standard grammaticality instruction and classified novel sequences as grammatical or not, after being informed about the existence of a complex set of rules generating the acquisition material. The behavioral results indicated a clear structure-based learning process consistent with previous implicit learning results [3]. The ERP results related to this included a typical P600 in the two final classification tests, independent of local subsequence familiarity. We also found an early negative component (100 - 300ms), although more broadly distributed compared to the typical language related LAN. Both

types of ERPs (magnitude) correlated with classification performance. In particular, the early negativity correlated more strongly with preference and the late positivity more strongly with grammaticality classification. We conclude that preference classification, in combination with a structural mere-exposure design, can be used to investigate structural (syntax) processing in unsupervised AGL paradigms with EEG in proper learning designs. The main finding suggests that the P600 is not generated by local subsequence familiarity but is related to structure (syntax) processing. Our results contribute to strengthen the hypothesis that implicit AGL captures aspects of structural processing shared with natural language processing. References [1] Petersson, K.M., & Hagoort, P. (2012). The neurobiology of syntax: Beyond string-sets. Philosophical Transactions of the Royal Society B 367: 1971-1883. [2] Zizak, D. M., & Reber, A. S. (2004). Implicit preferences: The role(s) of familiarity in the structural mere exposure effect. Consciousness and Cognition, 13(2), 336–362. doi:10.1016/j.concog.2003.12.003. [3] Folia, V., & Petersson, K.M. (2014). Implicit Structured Sequence Learning: An FMRI Study of the Structural Mere-Exposure Effect. Frontiers in Psychology 5:41. doi: 10.3389/fpsyg.2014.00041.

B71 The electrophysiology of long-term vs short-term predictions: The strength of prediction is cumulative

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Previous work in ERP research on the predictability of linguistic input has primarily focused on local predictions such as the next lexical element in highly-constrained contexts (Van Petten & Luka, 2012). High predictability in the lexical domain has been linked to reduced N400 amplitude (Federmeier, 2007). Here we present ERP-data from German that show that prediction is a cumulative process, accumulating over both structural and lexical cues. German word order allows for a great deal of variation, yet sets certain rigid restrictions on the placement of finite verbs in second position, with infinitives located either in the right periphery or topicalized in the sentence-initial position (prefield). Expanding on previous work on processing strategies in the German prefield (Roehm & Haider, 2009), we conducted an ERP experiment (n=24) with object-initial verb-second sentences allowing for varying degrees of predictability before the finite modal verb. The complexity and length of the German prefield varied across four conditions: short direct object (1a), long direct object (1b), direct object and unambiguous infinitive (2a), and direct object and ambiguous infinitive (2b). Various filler types were included to prevent intra-experimental processing strategies. 1a/b. (NP /+PP) Den Rundbrief [vom Chef] sollte sie bald bearbeiten 'the newsletter-ACC [from the boss] should she soon work.on ' 2a/b. (NP+Vinf-amb/unamb) Den Rundbrief bearbeiten/abbestellen sollte sie bald 'the newsletter-ACC work.on/cancel should she soon' An initial object elicits a strong prediction for a finite verb, but a topicalized infinitive is also possible (as in 2); an additional infinitive further strengthens the prediction for an adjacent finite verb, becoming almost mandatory. This difference in prediction type and strength was evident at the finite verb ("sollte"). Here, the short-NP condition elicited an N400-like negativity, while the ambiguous infinitive (2a) elicited a slightly later frontal positivity, resembling those reported for congruent but low-cloze completions (Van Petten & Luka, 2012). The long-NP and unambiguous-infinitive conditions elicited potentials between these two extremes. At the subsequent, identical-across-all-conditions subject pronoun, the three-level gradation in the ERP response reduced to a two-level distinction between the object-only (1) versus infinitive (2) conditions. Perhaps even more interestingly, mixed effects models reveal that in single subjects mean amplitude at the verb is actually a stronger predictor than experimental condition for the amplitude at the pronoun. While the condition broadly indicates the types of predictions being made, the mean EEG provides a continuous measurement of an index of prediction and thus allows for a better model fit. This reflects the accumulated strength of structural predictions (same across all conditions) and semantic predictions (differing across conditions): the syntactic subject is highly predictable, but the semantic content changes more drastically for the infinitival conditions, where the basic transitive relation is now complete. We thus argue that N400 amplitude at the pronoun reflects the accumulated strength across the preceding sentence context. Prediction facilitates processing not only locally but has a cumulative effect throughout the sentence. No prediction stands alone, but instead emerges from a dynamic process of refinement and ever increasing specificity.

B72 Inter-subject correlations of cortical activity during natural language processing in language-selective regions but not multiple-demand regions

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Background: At least two large-scale functional systems contribute to language comprehension: the "language system", consisting of frontal and temporal regions that are quite language-selective; and the domain-general "multiple demand" (MD) system, consisting of frontal and parietal regions that respond to increasing cognitive demands across a wide range of tasks. Although these systems dissociate in their patterns of BOLD fluctuations at rest and during story comprehension, the nature of their respective contributions to linguistic processing remains debated. One possible difference between these systems may be the degree of individual differences in their tracking of linguistic information. This characteristic can be measured via correlations in the activity of a system across subjects processing the same linguistic input. High inter-subject correlations (ISCs) suggest that a system closely tracks variations in the input, with relatively minor individual differences in the cognitive processes involved. We therefore measured ISCs in the fMRI BOLD signal time-courses of the language and

MD systems during story comprehension. Methods: Sixteen language and eighteen MD regions of interest were localized functionally in each of ten subjects using a language comprehension task and a working memory task, respectively. This method is advantageous to both group-level and anatomical localizations, which are complicated by the proximity of language and MD regions (e.g., in Broca's area) and by high inter-subject variability in functional-anatomical mappings. Following localization, subjects listened to 4-5 stories, each several minutes long. To discount neural responses reflecting low-level processing of the stories, the average BOLD signal time-course in each region was regressed against (1) auditory signals from anatomically defined regions in Heschl's gyrus; and (2) estimated hemodynamic responses to word onsets. ISCs were then computed on the residual signal in each region. As an empirical upper bound for these correlations we computed ISCs for the auditory signals in Heschl's gyrus. Results: The strongest ISCs were observed in left-hemispheric language regions (mean r = 0.29, SD = 0.04), where the variance replicable across subjects was 46.3% of the empirical upper bound (mean r = 0.43, SD = 0.15). ISCs in the right-hemisphere homologous regions were less strong (mean r = 0.19, SD = 0.06). ISCs in the MD system were the weakest, in both the left (mean r = 0.09, SD = 0.06) and right (mean r = 0.11, SD = 0.05) hemispheres. In this system, the variance replicable across subjects was 5.6% of the empirical upper bound. Only MD regions in the right insula and precentral gyrus showed ISCs that were not different from those of the left-hemisphere language system. Conclusions: These results demonstrate that the left-hemisphere language system tracks abstract aspects of the linguistic input more closely than most of the bilateral MD system, revealing an important difference between the respective contributions of these systems to language processing. Although regions of the MD system are sometimes recruited during language processing, this recruitment is much more idiosyncratic across individuals, perhaps reflecting individual differences in working memory, cognitive control and/or differences in which aspects of the linguistic signal cause comprehension difficulty.

B73 Predictability of a gap inside a syntactic island is reflected by an N400 effect in high span readers

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N400 amplitude has been associated with the predictability of lexical features (see [1] for review). Here we demonstrate that this response can also be elicited by a word that indicates the presence of a syntactic gap, i.e. a non-lexical structural position. In high span readers the N400 response to the same lexical item was larger when it indicated a gap inside a syntactic island [2;see below]. There was, however, no modulation of the post-gap LAN response, interpreted as filler-gap association [3,4], regardless of span. __MATERIALS_1:__ (1a)Who had openly assumed [that the captain befriended the sailor before… (1b)Who had openly inquired [whether the captain befriended the sailor before… (1c)Who had the sailor assumed [that the captain befriended __ openly before… (1d)*Who had the sailor inquired [whether the captain befriended __ openly before… ……the final mutiny hearing]? __MATERIALS_2:__Who is the main clause subject of (1a,b) but the subordinate clause object of (1c,d). Successfully interpreting (1c,d) requires associating the "gap" (indicated by the underscore) with the displaced object 'who' (or "filler"). Acceptability studies suggest that filler-gap dependencies into interrogative subordinate clauses (1d) are less acceptable than into declarative clauses (1c) [5,6]. Sentence constituents that block long-distance filler-gap dependencies are known as "island" structures (specifically "whether-islands" (1d)). ** Here we present ERP evidence indicating that high-span readers predict gaps to be less likely in whether-islands, yet all readers associate fillers with gaps in both islands and control sentences.** __METHODS:__EEG was recorded from 29 electrodes as 32 monolingual English speakers read 40 trials each of (1a-d) (+80 fillers) in RSVP format with 500ms SOA. Noun phrases (e.g. 'the sailor,' presented as one word) were matched in frequency with adverbs to control for sentence position; norming acceptability was unaffected by presence/absence of adverbs. ANOVAs and paired comparisons were run on mean area amplitude in standard language ERP latency windows: 300-600ms(N400,LAN). Reading-span was measured prior to recording. __RESULTS:___I_'openly' (the position that confirms the presence of a gap) [N.B. no lexical difference: openly-openly] N400:(1d) >(1c) ($p<0.001$); ONLY IN (1d). Effect was significant in high-span ($p=0.008$) but not low-span ($p=0.4$). _II_'before' (post-gap) LAN:(1c) >(1a)($p=0.01$), (1d) >(1b)($p=0.014$). Results indicate filler-gap association IN BOTH grammatical (1c) and 'ungrammatical' island (1d). __CONCLUSION:__High-span readers encountered the island boundary ('whether') and lowered their predictions that a gap would be present in the syntactic island. The N400 effect was larger when a gap was encountered, indicating surprisal. Low-span readers didn't modulate their predictions in this way. Using the same design in (1), prior research has not found working memory effects in either reading times or acceptability ratings of (1d) [6], indicating that low-span readers are neither failing to notice the island boundary, nor failing to gauge (1d)'s unacceptability. Low-span readers simply don't adjust their predictions as quickly. Otherwise, the same brain response (LAN) was present in both groups in island and non-island contexts. Thus individual differences (determined by working memory capacity) in the predictability of the presence of a gap do not prevent readers from associating fillers with gaps in 'ungrammatical' whether-islands.

References:[1]Kutas&Federmeier(2011),[2]Ross(1967),[3] Kluender&Kutas(1993a,b),[4]King&Kutas(1995),[5] Sprouse,Wagers&Philips(2012),[6]Michel(2013)

Language Disorders

B74 A theory-based study of coherence in discourse production of healthy and anomic aphasic speakers of Chinese

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Discourse coherence refers to the semantic connectedness of propositions in a connected speech. Various theoretical bases, narrative elicitation tasks, and sample quantifications as well as small sample sizes in most studies resulted in a substantial disparity in findings regarding the micro-linguistic and macro-linguistic aspects of aphasic discourse (Armstrong, 2000). Specifically, while some reports claimed macro-linguistic skills in aphasia to be well-preserved despite lexical, grammatical, and phonological impairments, other studies demonstrated reduced discourse coherence due to omission of important content and higher proportion of irrelevant propositions. In this study we analyzed the discourse structure in aphasic connected speech using Rhetorical Structure Theory (RST; Mann & Thompson, 1988). RST analyzes text organization by describing the semantic relations that hold between units of a text. The present study investigated how discourse coherence in healthy speakers differed from speakers with anomic aphasia. Potential factors contributing to these differences were also examined. Fifteen Cantonese-speaking adults with anomic aphasia and their controls matched in age, education, and gender participated. Sixty language samples were obtained using the story-telling and sequential description tasks of the Cantonese AphasiaBank protocol. Each sample was segmented into elementary discourse units (EDU) and annotated according to RST. The annotations were analyzed in terms of 12 parameters measuring the depth, structural disruption, and expansion of discourse structure. Twenty naïve listeners participated in a perception experiment, where they were asked to provide subjective ratings of the coherence, completeness, correctness of order, and clarity of each speech sample. The non-brain-damaged group demonstrated significantly higher production fluency, total number of EDUs, size of relation set, and fewer errors (semantic, phonemic paraphasia, morphological errors, and neologisms) than the aphasia group. Analysis of semantic relations employed revealed that controls used a richer set of relations than subjects with aphasia, particularly those to describe settings, to express causality, and to elaborate. More reformulations, corrections, false starts, and retracing were found in aphasic discourse. The aphasic group also tended to have a higher degree of omission of essential information content and was rated by naïve listeners with significantly lower coherence and clarity than controls. An effect of genre was found where both speaker groups had a faster EDU production and greater variety of relations used in their story-telling than sequential description. Unexpectedly, speakers with aphasia produced more EDU, with a greater depth of discourse structure, in the sequential description task. In conclusion, our results seemed to suggest that speakers with anomic aphasia had reduced proportion of essential information content, lower degree of elaboration, simplified discourse structure, and more structural disruptions than their healthy counterparts. We argue that the above characteristics have contributed to the reduced overall coherence in their oral discourse. The use of RST to quantify discourse coherence provided more objective measurement on macro-linguistic characteristics in aphasia and, therefore, warrants further investigation.

B75 Beyond words: Pragmatic inference in the behavioral variant of frontotemporal dementia

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Objectives: Investigate pragmatic-inference making in patients with the behavioral variant of frontotemporal dementia (bvFTD). Background: bvFTD patients exhibit deficits in executive and social domains. Previous work has shown that these contribute to language difficulties in these non-aphasic patients. Here we focus on pragmatic inference-making in discourse by studying scalar implicatures. In a scalar implicature, a speaker's use of a term like SOME (e.g., "Some elephants have a trunk") indicates that the speaker had reasons not to use a stronger term, i.e. ALL. Several studies have shown that the computation of scalar implicatures involves executive resources such as cognitive flexibility, perspective-taking and probability estimation. Consider an utterance like (1): "Some elephants have a trunk." This is correct from a narrow, logical point of view, but in daily communicative exchange we usually try to be maximally informative, rather than merely satisfying the logical requirements of a sentence. Since a trunk is a defining feature of an elephant, we expect to hear that "All elephants have a trunk." A deviation from this expectation often signals an additional inference that goes beyond the words of the sentence and incorporates the sentence's context. We expected difficulties with pragmatic inferences in scalar implicatures in bvFTD due to their limited executive resources. Methods: 17 non-aphasic bvFTD patients and 13 match healthy controls were presented with arrays containing pictures of common entities (e.g., bears and robins). A subgroup of those pictures was included in a box. In the pragmatic condition all the pictures of one kind (e.g., all the bears) were in the box, and participants were asked to evaluate the truth-value of a sentence containing SOME (e.g., "Some bears are in the box"). In the control condition, half of the objects of one kind (e.g., bears) are in the box while the other half is outside the box. Again, participants were required to evaluate the truth-value of the sentence "Some bears are in the box". We also administered a false condition where a sentence containing SOME was paired with a picture with no

target entity in the box, and stimuli where a sentence containing ALL accurately or inaccurately described the picture. Results: We conducted a D-prime analysis to weight participants' performance in the pragmatic condition with the errors in the false condition. The results revealed that bvFTD accepted SOME as a valid interpretation of a picture displaying all of the target objects significantly more often than controls [t(28)=2.29, p < .05]. Structural MRIs of 14 bvFTD showed gray-matter atrophy in bilateral frontal and anterior temporal regions relative to a group of matched controls (p<.0005 FWE-corrected). Regression analysis revealed that atrophy in right rostral prefrontal cortex (BA47/11), right dorsolateral prefrontal cortex (dlPFC), and right anterior cingulate (BA22) correlates with D-prime score. (p<.01 uncorrected). Conclusions: This study reveals that bvFTD patients tend to not compute pragmatic inferences, and accept overly logical interpretations of a sentence. The imaging results related the behavioral profile to gray matter atrophy in a network of regions critical for cognitive flexibility, perspective-taking and probability estimation.

B76 Communicative strategies and neuropsychological profiles in expressive aphasia: guidelines for rehabilitation

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This study combines the neuropsychological perspective with the pragmatic approach for investigating communicative strategies which will guide the creation of an aphasia treatment program. The main purpose of this preliminary investigation was to detect which communicative strategies, i.e. verbal and nonverbal clues, accompanied anomia and paraphasia repair in the discourse of expressive aphasics. Additionally, the study investigated the association between these strategies and neuropsychological profiles. Participants consisted in a total of ten expressive aphasics who suffered an ischemic cerebrovascular accident in the last 2 years. Patients with severe perceptual or cognitive deficits were excluded, as well as left-handed patients and patients with additional neurological diagnoses. Aphasia diagnoses were made by neurologists and confirmed by speech therapists based on the Boston Diagnostic Aphasia Examination (Goodglass & Kaplan, 1982; Radanovic & Mansur, 2002). An adaptation of the Autobiographical Memory Interview (Kopelman, Wilson & Baddeley, 1990) and the Cookie theft picture description task of Boston Diagnostic Aphasia Examination (Goodglass & Kaplan, 2000) were used to elicit two different contexts for discourse production. Analysis of the transcriptions of the videos focused on both verbal and non verbal strategies used for compensating each instance of anomia and each attempt to repair paraphasia. Discourse was analyzed by a Linguist and 15% of the corpus was independently analyzed by a Speech-Language Pathologist obtaining 86% of agreement for inter-judge reliability. In addition to the language skills evaluated with the Boston Diagnostic Aphasia Examination, other neuropsychological abilities were accessed through a cognitive screening battery adapted for expressive aphasics (NEUPSILIN-Af; Fontoura, Rodrigues, Fonseca, Parente & Salles, 2011). The participants' discourse was marked by frequent anomia and paraphasia occurrences, both noun and verb impairments being observed. Noun impairments were frequent in anomia, while verb impairments were often shown in instances of morphemic paraphasia, which was not always associated with severe agrammatism. Participants produced well-structured discourse, although topic shifts were frequently observed, possibly as a strategy for retrieving easily accessible information to avoid long pauses and maintain the discourse flow while holding the turn. A variety of communicative strategies were used when facing anomia or when trying to repair paraphasia. The most frequent verbal strategies observed consisted in metalinguistic comments such as explanations about word retrieval difficulties, help requests made to the listener, paraphrases and topic shifts. Non verbal strategies consisted in gestures used in order to express action, location and function. Naming and repetition skills matched microlinguistic deficits shown in discourse. Relatively preserved cognitive abilities, such as executive functions and working memory, were associated with the presence of communicative strategies used in discourse. The findings of the study confirm the results of previous research, which also showed preservation of discourse structure with frequent instances of lexical retrieval difficulties acompanied by verbal and non verbal repair strategies in expressive aphasics (Beeke et al., 2014; Sekine, 2013). Discourse processing models and rehabilitation approaches were discussed in order to elaborate a rehabilitation program.

B77 Examining neurological components of the metaphor interference effect in individuals with and without autism spectrum disorder

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Metaphors have more than one meaning. For example, "Some cats are princesses" has a literal meaning (i.e., the cat was born to a king and a queen) and one or more non-literal meanings (i.e., the cat will not eat unless you buy it special food). Until the early 1980s, whether metaphor processing occurred through simultaneous or serial generation of the literal and non-literal meanings was debated. Simultaneous processing would entail concurrent generation of both meanings, leading to interference, and necessitating suppression of the meaning that was not required. In contrast, serial processing would entail generating the literal meaning first, keeping or rejecting it based on the demands of the situation, then generating the metaphorical meaning if needed. By presenting literal sentences and metaphors and asking participants to "judge whether each sentence is literally true or false", researchers were able to provide evidence for simultaneous processing, due to the metaphor interference effect. Specifically, response times for metaphors were significantly slower suggesting that the 'figuratively true' meaning needed to be suppressed in order to judge the metaphor as 'literally false' (Glucksberg, Gildea, & Bookin, 1982). This

finding has implications for figurative language use in the general population and for people to whom figurative language is problematic, such as people with Autism Spectrum Disorder (ASD). Even high functioning people with ASD (i.e., those with IQs>70) who have average vocabulary and grammar skills struggle to use language appropriately when communicating with others. This struggle may result from the ubiquitous use of figurative language in daily interactions. Although we now know that people with autism can and do understand metaphors, the metaphor interference effect has yet to be demonstrated in this population. The current research project expands the knowledge on the metaphor interference effect by: (1) replicating the previous behavioural findings; (2) using neuroimaging and the basal-ganglia model of cognitive control to evaluate the neurological components of this effect; and (3) extending the behavioural and neurological findings to individuals with ASD. Methods: Six high functioning people with ASD and six control participants completed the study. Participants were matched on age, gender, language abilities, and IQ. Participants completed the sentence decision task in a 1.5T MRI scanner, indicating true or false via a button press response. Dependent variables included: accuracy, response times, and brain activation. Results: Both groups judged all test sentences with high accuracy. Response time patterns for both groups revealed the existence of the metaphor interference effect. Our findings supported evidence of the basal ganglia model of cognitive control, with a priori regions in the basal ganglia and pre-frontal cortex activated by the task. Although regions in the brain that were activated by the task were similar between groups, graphical model analysis provided evidence of differential circuitry between the groups. Conclusion: Both groups exhibited the metaphor interference effect, indicating simultaneous processing during metaphor comprehension. We reliably activated regions involved in the basal-ganglia model of cognitive control for both groups, but showed differential networks of activation between individuals with and without autism.

B78 Alzheimer's patients comprehend apt but unfamiliar metaphors

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Studies have shown that patients with Alzheimer's disease (AD) have difficulty comprehending figurative language—including metaphors, idioms, proverbs, and sarcasm (Rapp & Wild, 2011)—in tasks that require the inhibition of a literal interpretation. However, only four studies have investigated metaphor comprehension in AD, with great methodological differences among them. In the most detailed of these studies, Amanzio, Geminiani, Leotta and Cappa (2008) argued that the ability to understand a metaphor depends on the novelty of the expression, with well-known metaphors being easy because their associated meanings are retrieved from memory. In contrast, comprehension is difficult when the expression is less known because the meaning needs to be constructed rather than retrieved from memory. In the present study, we investigated the effect of aptness in the comprehension of copular metaphors (e.g., Lawyers are sharks) by AD patients. Aptness is the extent to which the vehicle (e.g., shark) captures salient aspects of the topic (e.g., lawyers), and studies with healthy participants have suggested that metaphors can be easily understood if they are apt, even when they are not familiar (e.g., Chiappe & Kennedy, 1999; Glucksberg & Haught, 2006). A group of 11 mild-to-moderate AD patients provided interpretations for metaphors that were apt and familiar (according to our norming tasks; e.g., Knowledge is power), apt and unfamiliar (e.g., The mall is a zoo), and neither apt nor familiar (e.g., Life is a bottle). We then further categorized patients based on the scores they obtained on the similarities sub-scale of the WAIS-IV. Patients who scored similar to controls were labeled high abstractors (N = 6) and patients who scores significantly worse than controls were labeled low abstractors (N = 5). Compared to healthy controls, AD patients categorized as high abstractors showed no difficulty for apt metaphors regardless their familiarity level, whereas low abstractors produced significantly worse interpretations than controls, but the quality of their interpretations was more related to a metaphor's aptness level than its level of familiarity. Therefore, we suggest that the ability to construct figurative interpretations for metaphors is not always diminished in AD patients nor is it dependent only on the novelty level of the expression. Instead, metaphor comprehension in Alzheimer's patients involves both item variables, such as aptness, as well as participant variables, such as abstraction ability. We suggest, moreover, that the ability to interpret metaphors may persevere in the course of Alzheimer's Disease progression, despite semantic memory deterioration. This ability is conditional on patients' abstraction abilities and on metaphor aptness. We propose that the neural circuits that serve semantic memory--typically affected in AD--might be different from those serving the computation of metaphorical meaning.

B79 Social deficits in ASD are linked with greater task-driven neural synchrony under naturalistic conditions

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A defining feature of autism spectrum disorders (ASD) is difficulty in social situations. However, previous functional brain imaging studies of ASD have relied on pre-recorded visual or auditory stimuli rather than naturalistic social context. These studies typically show attenuated brain responses to social stimuli relative to typically developed (TD) controls (Weisberg, 2014; Lombardo et al., 2010). Similarly, rest-state studies typically show weaker correlations between brain regions in ASDs, especially in social areas (Gotts et al., 2012; Kennedy & Courchesne, 2008). Whether the brains of ASD people show less correlation in a naturalistic social context has not been tested. We recruited 18 high-

functioning males with ASD age 14-30 and 20 typically developed age and IQ-matched controls (TDs) for an ecologically valid social task: Subjects engaged in free, spontaneous conversations with an experimenter while they were scanned with functional magnetic resonance imaging (fMRI). Both parties could see and hear each other through MR-safe headphones and microphones. Two of the conversations were about subjects' interests or hobbies (by self-report) and the final conversation was about work or school life. We used PCA to isolate and remove large BOLD fluctuations caused by speech-related movement. Cardiac pulse, respiration, head motion parameters, ventricles and localized white matter signals were also regressed from the data to markedly reduce noise while preserving task-related BOLD fluctuations. Across functional task runs, we correlated each voxel's time series with the mean of all gray-matter voxels in the brain (Gotts et al., 2012). Correlation maps were then compared by group with an independent samples t-test. This analysis also controlled for degree of motion and percent time spent speaking (Speaking Time; ST), although neither measure differed significantly between groups. During conversation, activity across voxels in ASD brains was overall more highly correlated than for TDs. In fact there were no voxels that showed greater synchrony in TDs than ASDs. Increased synchrony was particularly prominent in the right hemisphere for ASDs, while the TDs' correlation maps were predominantly left-lateralized. Our result cannot be explained by differences in speaking time between groups, as ST was well-matched between groups (ASD=47%, TD=48%). Moreover, the ASD subjects who spoke the least showed higher levels of task-driven synchrony and more severe autistic symptoms as measured by the ADOS social and communication scales. In contrast to studies showing links between decreased whole-brain correlation at rest and autism symptomatology, here we demonstrated a reversed pattern during live social interaction: the brains of people with ASDs showed increased task-driven neural synchrony compared to TDs. Moreover, greater synchrony was associated more severe autistic symptomatology. Our results suggest that ASD brains are less differentiated than TD brains, and therefore recruit a more bilateral, spatially distributed set of areas to perform real-world social tasks. References: Weisberg, J. et al. (2014). Cerebral Cortex, 24(1), 37-48. Lombardo MV, et al. (2010) Brain 133(Pt 2):611-24 Gotts, S. J., et al. (2012) Brain, 135(9), 2711-2725. Kennedy, D. P., & Courchesne, E. (2008). Neuroimage, 39(4), 1877-1885.

B80 Brain responses to foreign-language words are diminished in dyslexic children

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Dyslexia is manifested as reading impairment, which is thought to result from compromised processing of phonological units. The impairment is not restricted to reading, however: dyslexic readers often have difficulties also in foreign-language learning. Nevertheless, it is not known whether the "bottleneck" of learning for these children is the acoustic-phonetic on-line processing or subsequent memory-related processing of spoken foreign language. Therefore, in the present study we aimed to determine whether the auditory processing differs between native and foreign language and at which level the processing of spoken foreign words is compromised in dyslexia. We hypothesized that if the "bottleneck" of learning was acoustic-phonetic processing, then the on-line processing of all foreign word forms would be inefficient in dyslexia. However, if memory-related processing was impaired and on-line processing intact, then only the processing of familiar foreign words is hypothesized to be inefficient in dyslexic readers compared with controls. To this end, we recorded auditory event-related brain potentials to compare mismatch negativity (MMN) responses to foreign- and native-language words and pseudowords in Finnish 9-11-year-old dyslexic readers (N=14) and typically-reading control children (N=14). The groups were matched with respect to age and the length of foreign-language studies in school. In an oddball paradigm used to elicit MMN responses, repeated foreign-language standard word (p=.79) was [□u:] 'shoe' and the deviant stimuli were [□i:] 'she', [□a□] 'shy', and pseudoword [□□□]* (p=.07 for each deviant). With respect to word frequency, the deviant stimuli ranged from frequent [□i:] to unfamiliar [□□□]*. The native-language items, serving as control stimuli, were phonologically matched as closely as possible with the foreign-language items (pseudoword [si:]*, [s□i] 'got', and [soi] 'rings/rang' in the context of [su:] 'mouth'). The results show that although no difference between the groups was found in native-language processing (e.g., [su:] 'mouth' vs. [si:]* with no meaning), dyslexic readers' MMN responses were significantly smaller for the most frequent foreign-language word contrast ([□u:] 'shoe' vs. [□i:] 'she') compared with controls. This suggests that in dyslexia, the processing of words is more compromised in a foreign language than in the native language. Interestingly, however, we failed to show significant differences between the groups for less frequent or unfamiliar foreign-language items, suggesting that inefficient acoustic-phonetic processing of foreign-language speech sounds may not fully account for the diminished MMN for the frequent word in dyslexic readers. Rather, the observed pattern of results is more likely to be induced by weak long-term-memory word-form representations for foreign language. A possible account for this is the inefficiency of some processing stage in the encoding of word forms to memory. To overcome these difficulties, targeted intervention improving the processing of foreign word forms should be developed for individuals with dyslexia.

B81 Deficient rapid perceptual learning of novel spoken words in dyslexic children

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The size of vocabulary is often reduced in dyslexic individuals. Is this due to slower or less efficient memory trace formation for words? The neural mechanisms of novel word learning are still not comprehensively

understood. However, recent studies of neural mapping of novel words in healthy adults indicate rapid plasticity in the left temporal and inferior frontal cortices as a result of passive exposure to spoken words. This is evident in an increase of response amplitude for novel words 70-130 ms after the disambiguation point in the absence of such increase for known words. We recorded event-related potentials (ERPs) from matched groups of 9-12 years old children with and without dyslexia. ERPs were recorded during passive oddball presentation of spoken three-syllabic pseudo-words, i.e. words without a meaning in the lexicon. A frequent item was repeated 1821 times in the experiment. We compared responses for the frequent pseudo-word averaged from first and last quarters (i.e. early and late times) of the exposure in both groups. The early and late responses in each group were compared in five different time windows after the stimulus onset. In the first two time windows (230-250 and 270-310 ms) a significant left-lateralized increase in amplitude was observed for controls whereas dyslexics exhibited no change in amplitude between the early and late times of exposure. These responses were elicited 80-160 ms after the second syllable onset, when the lexicality of the word starts to become evident. In a later time window at 490-510 ms (90-110 ms after word offset) a significant response suppression by the end of the experiment was observed for dyslexics, whereas controls showed no change. Finally, a late response at 600-640ms (200-240 ms after the end of the stimulus) showed significant enhancement between the early and late times of exposure in both groups. The results suggest a different kind of functional plasticity for spoken novel words between fluent reading and dyslexic children. Our observations indicate fast mapping of novel spoken words in a short (~35 min) time in passive perceptual learning condition for children without language disorders. This kind of fast attention-independent neural mapping of words may play a significant role in strengthening the neural circuits, i. e. memory traces for words, in language learning. This fast mapping seems to be less efficient in dyslexics, for whom the effect of exposure was seen considerably later during word processing. Hence, this could possibly explain the often narrower vocabulary in dyslexic children compared to controls. To our knowledge, this is the first report of neural fast mapping of words during perceptual exposure in children, demonstrated by ERPs.

B82 tDCS to the temporo-parietal cortex produces lasting improvements in nonword reading in adults with developmental dyslexia

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People with developmental dyslexia show reduced activation of the left and sometimes increased activation of the right temporal-parietal cortex (TPC). The left TPC has often associated with phonological processing (Shaywitz et al., 1998; Shaywitz et al., 2002; Temple et al., 2001). Transcranial Direct Current Stimulation (tDCs) has had success in improving therapeutic outcome for acquired language disorders (Schlaug, Marchina, & Wan, 2011; You, Kim, Chun, Jung, & Park, 2011), and left lateralising tDCs to posterior temporal cortex has been shown to increase efficiency of non-word reading, in poorer normal adult readers (Turkletaub et al. 2012). These findings suggest that reading ability of adult developmental dyslexics could potentially be improved through the use of left lateralising tDCs to the TPC. This study therefore aimed to investigate the effects of simultaneous anodal and cathodal stimulation to left and right TPC on a reading aloud task, in both normal skilled and developmentally dyslexic adult readers. Participants performance on a reading aloud task in which they read aloud randomised matched lists of 100 words (50 regular and 50 exception) and 100 non-words before, after, and one week on from receiving tDCs. Participants received either active (simultaneous anodal to left TPC and cathodal to right TPC) or sham stimulation. Active stimulation was given at 1.5mA and lasted for 20 minutes. Sham stimulation involved an initial period of 20 seconds stimulation before the current was ramped down to nothing. Accuracy data for dyslexics and controls prior to stimulation revealed a significant interaction between reading impairment and word type ($F(2, 60)= 15.99$, $p<.001$, partial $\eta^2=0.30$), with a significant deficit in both non-word ($p<.001$) and exception word ($p<.001$) reading for dyslexics compared to controls. The reading accuracy of controls showed a three way interaction between word type, session and stimulation type ($F(3, 61)= 4.308$, $p=.006$, partial $\eta^2=0.19$). Further investigation using t-tests reveals a significant increase in accuracy for non-words after active stimulation ($p=.005$), which is maintained at one-week follow up. This pattern was not observed after sham stimulation ($p=.164$). The reading accuracy of developmental dyslexics also revealed a three way interaction between word type, session and stimulation type ($F(3, 54)= 3.62$, $p=.019$, partial $\eta^2=0.17$). Further investigation using t-tests reveals a significant increase in accuracy for non-words after active stimulation ($p=.001$), again this is not the case for sham stimulation ($p=.101$). The tDCS benefit for non-word reading was significantly larger for developmental dyslexics than control participants ($F(1, 18)= 4.41$, $p=.050$, partial $\eta^2=0.20$). This study provides the first reported of improved reading performance in developmental dyslexia due to a single session of tDCS designed to increase lateralisation of activation of temporo-parietal cortex, and these gains were maintained at one week follow-up. These results clearly suggest that tDCS may have therapeutic benefits for developmental reading and language disorders.

B83 Comparing Language Outcomes After Stroke in Bilingual and Monolingual Adults

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INTRODUCTION: Research suggests that bilingualism induces plastic changes in the brain [1]. The neural convergence account suggests these changes affect regions identical to those mediating language in monolingual speakers [2,3] though the functional demand on these regions for non-native speakers is greater [4]

and typically, language skills in non-native speakers are poorer [1]. This account predicts that patterns of post-stroke aphasia in native and non-native speakers should be similar, with key lesion-deficit associations shared across groups. We tested this prediction with 436 stroke patients drawn from the PLORAS database [5]: 389 native-speakers (L1 group) and 47 non-native speakers (L2 group). METHODS: L2 patients were resident in the UK and showed no significant difference in native and non-native language tests, except in picture description which was better in English than their native language. The patients' lesions were identified algorithmically from MRI images [6], and encoded according to lesion load in a set of 398 anatomically-defined brain regions. These lesion descriptions, and time post-stroke, were related to 22 standardized language scores [7] in 6 steps. (1) 'Good' prognostic models were identified for the L1 patients, using feature selection [8]. (2) These models were used to make predictions [8] for all 22 language scores in every patient (L1 and L2). (3) Prediction error was estimated as the difference between predictions and real scores [8]. (4) Group differences in prediction error distributions were characterised over all brain regions and (5) for each brain region singly. Steps 1-5 were repeated (6) after controlling for lesion site and size. Permutation thresholding was used to correct for multiple comparisons. RESULTS: Language scores were poorer overall for L2 than L1 patients. Our best prognostic models showed significantly higher prediction errors (i.e. a positive shift in the distribution) for L2 than L1 patients in 18/22 tasks when lesion site and size were not controlled, and 13/18 of the affected tasks when lesion site and size were controlled as closely as possible. At the single-region level, these group differences were mainly driven by enhanced sensitivity to damage in the L2 patients, in regions where the L1 patients were also sensitive to damage (211/223 cases where (a) the L2 group showed a significant lesion-deficit association and (b) there was a significant difference in that association across groups). CONCLUSION: Our findings are consistent with the neural convergence account of plastic changes in the bilingual brain [2,3], with the differences between the patient groups (L2 group scores < L1 group scores) driven mainly by enhanced sensitivity to damage in regions that are relevant to the same language skills in both groups. REFERENCES: 1. Bialystok, et al. (2009) Psychological Science in the Public Interest. 2. Green (2008). Annual Review of Applied Linguistics. 3. Consonni et al. (2013) Cortex. 4. Parker Jones et al. (2012). Cerebral Cortex. 5. Price et al. (2010). Nature Reviews Neurology. 6. Seghier et al. (2008). Neuroimage. 7. Swinburn et al. (2004).The Comprehensive Aphasia Test. Psychology Press. 8. Hope et al. (2013). Neuroimage: Clinical.

B84 Multimodal MRI converging evidence underliying the role of the left thalamus in dyslexia

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Neuroimaging research with typical and atypical readers has underscored functional and structural differences within regions supporting cortico-subcortical interactions during reading processes (Preston et al., 2010). Specifically, compared to typical readers, individuals with dyslexia exhibit left thalamic hypoactivation associated with phonological deficits in reading tasks (Diaz et al., 2012). Moreover, postmortem studies have evinced the presence of alterations in the medial and lateral geniculate nuclei of the thalamus of dyslexic individuals (Galaburda et al., 1994; Livingstone et al., 1991). This evidence highlights the critical role of this region in language (Johnson & Ojemann, 2000) and is consistent with theoretical accounts indicating that the thalamus is a central hub tuned by cortical areas to the relevant properties of visual and auditory inputs (Suga & Ma, 2003). Nevertheless, to date, no studies have specifically examined the relation between thalamic function and structure in dyslexic readers using a multimodal MRI approach. The present study was aimed at investigating evidence from functional and anatomical neuroimaging indexes to examine thalamic regional and connectivity differences in typical and dyslexic readers in relation to their performance on a task that discriminates between these groups: the Rapid-Automatized-Naming (RAN) task (Norton et al., 2012). We collected MRI data from 51 children and adults, typical and dyslexic readers matched on age, gender and IQ. Functional scans were collected while participants overtly named RAN arrays of numbers, letters, objects, colors and control conditions tailored to each participant's naming speed. BOLD parameter estimates extracted from a left thalamus functional ROI, identified across participants from activation blocks versus control conditions, revealed that typical readers engaged this region more strongly than readers with dyslexia. In contrast, no differences in functional activation between these groups were observed in right thalamus. Whole-brain functional connectivity analysis using the same left thalamic ROI as a seed showed significant coactivation of this region with visual cortex for control readers, but not for the dyslexic readers. Structural analyses of the left and right thalamus revealed no statistically significant differences in thalamic volume between typical and dyslexic readers. However, only for readers with dyslexia, left thalamic volume was positively associated with naming accuracy [$r(22) \geq 0.44$, $ps < .05$] and negatively with naming speed [$r(21) \leq -.56$, $ps < .01$] for all the RAN conditions. Of interest, these effects were not observed in right thalamus. Subsequently, we examined the relation of left thalamic volume with cortical thickness and found statistically significant group differences only in a visual cortex cluster including medial V1 and V2 regions. Moreover, the average cortical thickness in this cluster was significantly associated only with dyslexic readers performance on the color and objects dimensions of the RAN task; negatively with naming accuracy [$r(22) \leq -0.41$,

ps < .05], and positively with naming speed [r(22) ≥ 0.39, ps < .05]. These results highlight the crucial role of left thalamus in dyslexia, constituting the strongest evidence linking its function and structure, at the regional level and via its connections with the visual cortex, to this reading disorder.

B85 Abnormal white matter microstructure in children with specific language impairment

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Specific language impairment (SLI) is a developmental disorder that encompasses deficits in comprehension, expression and use of language in an otherwise normally developing child. It affects approximately 7% of children. Previous neuroimaging studies revealed grey matter abnormalities in SLI. Here, we present the findings of a diffusion tensor imaging study examining white matter microstructure in children with SLI compared to their unaffected siblings and typically developing controls. Families with at least one child with SLI and control families with typically developing children were recruited from a database of research participants. SLI subjects scored below the 10th percentile on at least two standardized tests of language and literacy ability. All participants were native English speakers, had a non-verbal IQ > 80 and no neurological or psychiatric disorders. We obtained diffusion images in 8 children with SLI aged 12-17 years (median 14 years), 6 of their unaffected siblings aged 12-22 years (median 15.5 years) and 16 controls aged 6-25 (median 12.5 years). Two sets of echo-planar images of the whole head (53 x 2.5mm axial slices; in-plane resolution 2.5 mm2) were acquired at 1.5T using a b-value of 1000 s/mm2 uniformly distributed across 60 gradient directions and 3 non-diffusion-weighted images. Analysis was performed using the FMRIB Diffusion Toolbox part of the FMRIB Software Library. Fractional anisotropy (FA) of white matter was examined using the whole-brain analysis method Tract-Based Spatial Statistics (TBSS). Statistical inference was carried out using Threshold-Free Cluster Enhancement in randomise (exhaustive permutations). FA values were compared between the groups of SLI, controls and unaffected siblings separately. Group differences were considered significant at p<0.05 (fully corrected for multiple comparisons). Differences in white matter were found in the SLI group compared to the unaffected siblings and typically developing controls. TBSS revealed significantly lower FA in SLI compared to controls in two distinct tracts, namely the genu and body of the corpus callosum. The abnormal reduction in FA in the genu extended to the minor forceps and the WM underlying the orbitofrontal cortex. Strikingly, the area of abnormally low FA centered on the body of the corpus callosum extended primarily into the left hemisphere to include parts of the left superior longitudinal fasciculus. The comparison of the SLI group with the small group of unaffected siblings revealed an extensive portion of the corpus callosum that had significantly lower FA in the SLI group. At a higher (corrected) statistical threshold (p<0.01), abnormal foci showing reduced FA in SLI relative to the group of unaffected siblings were seen in the body, genu and splenium of the corpus callosum. We propose that the reduced FA in the corpus callosum in language-impaired children reflects reduced interhemispheric connectivity. Such abnormalities may be related to atypical brain asymmetry and altered lateralized brain function. Our findings may yet provide useful insights into neural differences that underpin atypical lateralisation of language associated with SLI.

Keywords: SLI, language laterality, diffusion tensor imaging (DTI), corpus callosum, superior longitudinal fasciculus (SLF)

Poster Session C

Methods

C1 Calibrated multimodal fNIRS study of the neurophysiology of semantic word processing in healthy aging

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Language is a complex cognitive process to comprehend. This becomes more arduous when it comes to the study of aging brains. Despite some cognitive decline with normal aging, older adults show a good preservation of semantic knowledge. Thus, exploring the neural substrates underpinning word processing seems essential to understand how the brain confronts neuroanatomical declines. Functional neuroimaging has spurred a marked role in cognitive aging research. However hemodynamic based neuroimaging techniques are subject to interpretation difficulties due to the ambiguous interaction between cerebral blood flow, volume and oxygen consumption. In aging studies, the measured hemodynamic response does not merely reflect neuronal activities but also age-related modifications in the neurovascular coupling. The importance of meeting this challenge has led neuroscientists to calibrating functional data by integrating modalities measuring neurophysiological characteristics of individuals. A comprehensive insight into mechanisms of preserved cognitive domains would encourage healthy aging. Functional near-infrared spectroscopy (fNIRS) measures stimulus-evoked hemodynamic changes through few centimeters beneath the scalp. In this study we used a 32-channel continuous wave fNIRS to measure relative changes in oxy- and deoxyhemoglobin concentrations ([HbO2] and [HbR] respectively). Two groups of 23 French-speaking individuals (old= 69.6 ± 4.1, young=23.4 ± 2.7 years) were screened for their overall health and cognitive performance. Participants underwent a lexico-semantic decision task in an event-related paradigm. A total of 240 words and pseudo-words were presented with randomly intermix trials in 3 sessions of 12 minutes. Concreteness was manipulated across words to study the imageability effect. A time-domain optical system was used to measure absolute hemoglobin concentrations of each participant at rest. We acquired anatomical magnetic

resonance images for further co-registration of optical channels using a 3D stereotaxic system. Response times (RT) to the lexico-semantic task differed across conditions and were shorter for young adults except for concrete words. Both groups performed equally accurately across conditions except for those pseudo-words derived from concrete stimuli (p = .017). Group mean comparisons on absolute hemoglobin concentrations and oxygen saturation (SatO2) revealed decreased prefrontal [HbO2] and SatO2 in old adults (p=.0007 and p=.01 respectively). A factorial 2-level analysis of variance for all fNIRS channels set contrasts revealed a main effect of age. We observed an age-different bilateral dorsolateral prefrontal cortex (DLPFC), inferior frontal gyrus (IFG) and right posterior middle temporal gyrus (MTG) Δ[HbR], and right posterior MTG and DLPFC Δ[HbO2]. Including individual measures of baseline [HbO2] and [HbR] as regressors, we observed a modified frontal age-different pattern of activity by diminished right DLPFC and accentuated IFG engagement. The present study supports the reliability of single-word processing using fNIRS whilst exerting caution in the interpretation of data. We showed that when controlling for baseline physiology, the degree and extension of neural activity could vary in some language-related brain regions in old adults. A right IFG age-difference in response to pseudo-word stimuli could be in line with compensatory brain recruitment for longer RTs which reflect a demanding task. To better compare age groups it is thus essential to take into account individual physiological characteristics of the neurovascular coupling.

C2 Virtual agents as a valid replacement for human partners in sentence processing research

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There is a rapidly growing interest in studying the interactional aspects of dialogue, such as the turn-taking event, the role of the dialogue partner, and the characteristics of the social interaction. However, the two-participant experiments used to investigate these topics introduce variables that are hard, if not impossible, to control using standard methods. As such, we propose the use of Virtual Reality ("VR"), where the participant interacts with a virtual agent ("avatar"), as a good alternative to standard two-participant experiments. VR is compatible with neuroimaging techniques such as EEG and as such, if we can validate the claim that a human participant can be viably replaced with a virtual one, ecologically valid neurobiological research into interactional language can be investigated. We conducted within-subjects free-choice syntactic priming experiments. Syntactic priming refers to the phenomenon in which an individual repeats the syntactic structure of their conversational partner. Participants were instructed to alternately describe picture cards with either an avatar or human partner. The proportion of passive structures produced by the participant following a passive prime by their partner was measured and compared to the participant's baseline passive production. Participants showed comparable passive priming effects with both partners (% increase in passives: Human: 10.6%; Avatar: 11.7%) with no effect of a passive prime by partner type interaction (p=0.31). It has been proposed that speakers align syntactic choices and other linguistic behaviour to increase affiliation with a conversation partner (Giles, Coupland & Coupland, 1991) and to increase conversation success (Pickering & Garrod, 2004), attributes that are unlikely to be associated with a computer. To show that participants aligned with our avatar due to an association with human-like intellect, we conducted a second experiment where participants interacted with the avatar from experiment one ("Good avatar") and with an avatar stripped of human attributes (robotic voice, lack of eye contact, lack of facial expression; "Bad avatar"). Participants showed a 9.1% passive priming effect with the Good avatar and a 2.6% passive priming effect with the Bad avatar. However, these results were not significantly different (p=0.23). Interestingly, if analyzed separately per block order, participants who had the Good avatar first did show significant passive priming difference per partner type (Good avatar: 12.0%, Bad avatar: 0.7%, p<0.05), whereas those participants who had the Bad avatar first did not (Good avatar: 6.1%, Bad avatar: 4.1%, p=0.47). This difference in order was not seen in the human/avatar experiment, suggesting that a negative influence from the Bad avatar carries on into the Good avatar block. However, as the Bad-avatar-first block was only run with half the participants, more participants are currently being tested in order to analyze this effect with sufficient power. Overall, our experiments suggest that VR is a viable platform on which ecologically valid language interaction research can be conducted. Neuroimaging techniques such as EEG are compatible with VR, thus studies into the interactional aspects of dialogue can be viably conducted.

C3 Different recovery strategies in sentence processing can be disentangled using coregistered eye movements and brain potentials

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Studies using event-related brain potentials (ERPs) have shown that words that are inconsistent with the sentence context elicit distinctive brain responses: N400 effects for semantic (Kutas & Hillyard, 1980) and P600 effects for syntactic inconsistencies (Osterhout & Holcomb, 1992). To extract these signals from the background noise, the EEG is aggregated across all trials in a condition. This procedure presupposes that the brain response is the same at every exposure. In eyetracking studies, however, word integration difficulties lead to elevated reading times or regressive saccades (Frazier & Rayner, 1982). If these distinct behavioral responses reflect different underlying cognitive processes, the assumption of an invariant brain response may not be valid. To investigate whether syntactic and semantic violations elicit the same neural responses when readers do versus do not make a regression, we conducted a study with concurrently recorded eye movements and

EEG. We adapted the Dutch design from Hagoort (2003) to German. Each sentence contained a noun phrase comprising a determiner, an adjective, and a head noun. Syntactic violations consisted of a gender mismatch between determiner and noun ("Linda accidentally spills the[F] sweet beverage[N]."). In semantic violations, the meanings of adjective and noun were incompatible ("Linda accidentally spills the ground beverage."). To study the influence of the position of the violation within the sentence, we also included Hagoort's conditions with sentence-medial violations ("The inquisitive farm needs a renovation."). To obtain baseline results for the natural reading data, we randomly assigned a subset of the participants to an RSVP version of the experiment. Our analyses of the ERP data from natural reading (N=48) and RSVP (N=24) confirmed Hagoort's (2003) results: Syntactic violations engendered a P600 effect in sentence-medial position and an N400-P600 effect in sentence-final position. Semantic violations elicited an N400-P600 effect in sentence-medial position and an N400 effect in sentence-final position. In the natural reading data, we also found a P600 effect in sentence-final semantic violations. When we split the natural reading data into trials with and without a first-pass regression from the mismatching noun, we found qualitatively different neural responses. In trials with regression, both violation types triggered a P600 effect in sentence-medial position and an N400-P600 effect in sentence-final position. When readers did not make a regression from the noun, we found no effects in sentence-medial position and a sustained centro-parietal negativity in sentence-final position for both violation types. Our results show that the very same manipulation can elicit qualitatively different brain responses. These responses are clearly reflected in two different eye movement patterns. The P600 effect, typically indicating recovery processes, was only present in trials with regression (see also Dimigen et al., 2007) whereas sustained negativities followed sentence-final violations without regression. These negativities may reflect a covert recovery strategy. They were canceled out in the grand average by the large P600 effects from trials with a first-pass regression. Thus, coregistration of eye movements and EEG can be used to check the assumptions of traditional experimental paradigms and to reveal otherwise hidden effects.

C4 Reliable individual-level neural markers of language activity

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Although most language neuroimaging work aims to characterize the language system in an average brain, many research questions call for an understanding of how inter-individual neural variability relates to differences in behavior and genes. So far, anatomical markers (e.g., cortical thickness of anatomically defined regions) have been used more commonly than functional markers, plausibly due to the availability of large datasets. However, given that function does not align well with macroanatomy, especially in higher-order association cortices (Frost & Goebel, 2011), neural activity is likely to be more directly related to behavioral and genetic variability. And yet, there has been relatively little work investigating the robustness and reliability of functional neural markers. Here, we present a large dataset of language activations of healthy adult participants (n=150) and show that, as needed for investigations of brain-behavior and brain-genes relationships, neural markers of language activity are robust and stable within individuals while varying substantially across individuals. Participants read English sentences and lists of unconnected pronounceable nonwords in a blocked design. The Sentences>Nonwords contrast has been previously established to robustly activate the fronto-temporal language network (Fedorenko et al., 2010). Regions of interest (ROIs) were defined functionally in each individual. From each of the 8 ROIs, (3 frontal ROIs and 5 spanning the temporo-parietal cortex), we extracted 4 measures: activation volume (number of voxels for the Sentences>Nonwords contrast), effect size (for the Sentences>Nonwords and Sentences>Fixation contrasts), and a volume-based measure of lateralization. The effect size measures are roughly normally distributed and show large amounts of variation across individuals. For example, LIFG, a representative ROI, was roughly normally distributed for the Sentences>Nonwords contrast, with a mean effect of .70 with a standard deviation of .45, and with a mean Sentences>Fixation effect of 1.11 with a standard deviation of .64. Left hemisphere (LH) activation volume (which cannot be below 0) was exponentially distributed in most regions, and lateralization varied considerably, with most subjects showing stronger effects in the LH. In a subset of the participants tested across two sessions, we evaluated the reliability of the functional markers by examining the correlation across participants between sessions. For the Sentences>Nonwords effect size, all 8 LH regions showed correlations greater than .3, which were significantly different from 0 ($ps<0.05$) by non-parametric bootstrap in all regions except LAngG. For the Sentences>Fixation effect, all 8 LH regions showed correlations greater than .29, significantly greater than 0 ($ps<0.01$). Lateralization showed a significant correlation in 6 of the 8 regions. However, volume showed a significant correlation in only 2 of the 8 regions. Thus effect sizes and lateralization are most promising neural markers for future individual-differences investigations. We further show that although these measures are correlated to some degree, they do have some unique variance and thus can be used to potentially explain different aspects of linguistic behavior. The large set of functional language activations analyzed here establishes the robustness and replicability of the neural markers of language activity necessary for genes-brain-behavior investigations.

C5 Between-subject variance in resting-state fMRI connectivity predicts fMRI activation in a language task

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Activation during language comprehension shows considerable variance across subjects. There are many potential causes for this variance, such as task compliance or differences in strategies for language comprehension. Arguably, one of the most interesting biological sources of variance is inter-individual differences in the functional connectivity in the brain. In this study, we therefore investigated the predictive value of connectivity patterns during rest on activation patterns during a language task in a large cohort (N=102). This novel way of analyzing the relation between network topography and regional activation has, to our knowledge, not yet been applied in a language-related experiment. Resting-state functional magnetic resonance imaging (fMRI) data was acquired before a language task where sentences or a low-level baseline (fixation cross) were presented visually to the participants. Whole-brain parcellations were computed by applying a normalized cuts algorithm to the task-based fMRI data in order to reduce the multiple comparisons problem inherent to connectivity analyses. These functionally-derived parcels were then used as regions of interest on the resting-state data. The resulting parcels showed connectivity patterns that are comparable to patterns reported in studies that use anatomically-derived seed regions. The functional connectivity between the parcels during resting-state was calculated and correlated to the task contrast values, averaged for each parcel. Our analyses revealed 20 significant correlations ($p < 0.05$, FDR corrected) in the left hemisphere. Here we report the two regions of the language network with the highest number of significant correlations. The task activation of the angular gyrus correlated positively with the resting-state connectivity between the angular gyrus and the pars triangularis and pars orbitalis of the inferior frontal gyrus. On the other hand, task activation of the angular gyrus correlated negatively with functional connectivity between the angular gyrus and the frontal pole. Task activation of the pars triangularis correlated positively with functional connectivity between the pars triangularis and the superior frontal gyrus, the supplementary motor area and the frontal pole, and negatively with functional connectivity between the pars triangularis and the precentral gyrus. In this study, we have found evidence for shared variance between resting-state connectivity and task activation across individuals. These results indicate that network topology predicts regional activation during a language task. As the resting-state fMRI scans were acquired before the task, it is unlikely that the shared variance can be explained as a transient artifact of the task. Rather, we interpret the reported shared variance to be an intrinsic property of the functional organization of the brain that is reflected both during rest and language comprehension. Activation patterns during language comprehension show large variability across subjects, which calls for an explanation. Our results suggest that a portion of this variability can be explained by variance in the intrinsic functional organization of the brain and is not an artifact of task strategy or compliance, or other factors such as measurement noise.

Auditory Perception, Speech Perception, Audiovisual Integration

C6 Early robust auditory lexical processing revealed by ERPs

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Auditory lexical processing starts within 200 ms after onset of the critical (segment of a) stimulus. Here, we used items in which lexical status (i.e., whether the stimulus was a word or not) was determined at third syllable onset, to investigate whether this early lexical processing is tied to a specific ERP component. We presented listeners with naturally timed items and items in which the third syllable was delayed (~440 or ~800 ms). Across all conditions, we observed an effect of lexicality ~200 ms after third syllable onset, namely at the N200 (for naturally timed items) and at the P2 (for the items in which the third syllable was delayed). These results indicated that lexical predictions are robustly processed at around 200 ms. In the naturally timed condition, we additionally observed an earlier effect (< 100 ms) that disappeared in the delay conditions.

C7 How and when predictability interacts with accentuation in temporally selective attention during speech comprehension

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Speech signal provides a large amount of information and unfolds rapidly in time, which presents significant challenges to the auditory perception and comprehension systems. Temporally selective attention, therefore, would be critical for speech comprehension. The present study used the EEG technique to investigate how and when top-down predictability interacted with bottom-up acoustic signals in temporally selective attention during speech comprehension. Mandarin Chinese spoken sentences were used as stimuli. The critical words in the sentence context were highly predictable or lowly predictable. Meanwhile, the critical words were accented or de-accented. Additionally, a linguistic attention probe 'ba' was presented concurrently with the critical words or not. This linguistic probe lasted 50 ms and was added to 100 ms after the acoustic onset of the critical words. The results showed that, first, words with a linguistic attention probe elicited a larger N1 than those without a probe. This N1 effect started and peaked earlier for accented (or lowly predictable) words as compared with de-accented (or highly predictable) words, indicating more attentional resources allocated to accented (or lowly predictable) words. Importantly, the shortened N1 latency for accented words was observed only when the critical words were highly predictable; the shortened N1 latency for lowly predictable words was observed

only in the de-accented conditions. That is, top-down predictability and bottom-up accentuation showed a complementary interplay on the latency of this N1 effect, indicating that when a word in sentence context had already captured attentional resources due to its low predictability or due to the presence of pitch accent, the other factor didn't modulate attention allocation any more. Second, relative to the lowly predictable words, the highly predictable words elicited a reduced N400 and enhanced gamma-band power increases (facilitating effect of prediction on semantic processing), especially in the accented conditions; moreover, in the accented conditions, the amount of resources allocated at the early stage (more, as indexed by shortened probe-related N1 peak latency) was a significant predictor of the depth of semantic processing at the later stage (deeper, as indexed by larger gamma power enhancement), which indicated a close relation between early selective attention and later semantic integration. Finally, selective attention driven by top-down predictability and that driven by bottom-up acoustic signal had already interacted with each other around 240-250 ms post-word onset (namely, 140-150 ms post-probe onset). However, the earliest lexical-semantic effect stared only around 310-320 ms post-word onset. That is, the interaction between top-down predictability and bottom-up acoustic signal occurred before lexical-semantic processing, which is consistent with the hypothesis of TRACE and "predictive coding" models. In summary, during speech comprehension, listeners tend to allocate more attentional resources to words with prominent acoustic signals or to lowly predictable words; top-down predictability and bottom-up acoustic signal showed a complementary interplay in temporally selective attention; this complementary interaction occurred before lexical-semantic processing, which was in line with TRACE and "predictive coding" models; in addition, there is a close relation between early selective attention and later semantic integration.

C8 Neural Timecourse of Language-Attention Interactions in Spoken Word Processing

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Previous ERP studies into lexical processing indicated two diverging patterns of brain responses to meaningful words and meaningless materials [1]. Classical N400 literature demonstrated increased N400 response following meaningless pseudowords that could be interpreted as enhanced search for lexical entries in the mental lexicon. On the contrary, research using oddball paradigms showed an increased mismatch negativity (MMN) response for meaningful words over pseudowords, interpreted as reflecting automatic word memory trace activation. This dichotomy – stronger MMN responses for words vs. stronger N400 to pseudowords – could be explained by different factors. One possible reason is the stimulation regime: repetitive stimulus presentation in oddball tasks as opposed to multiple unrepeated stimuli in N400 studies. Another explanation is the level of attention on linguistic input: while typical N400 experiments involve a stimulus-related task, most lexical MMN studies have presented stimuli outside the focus of attention. Indeed, the few MMN studies which used stimulus-related tasks reported a specific increase of pseudoword responses that was linked to lexical search and activation of multiple lexical neighbours of meaningless pseudowords, when this is allowed by attentional resources. However, these experiments did not use the standard oddball task, and have not reported an N400-like effect. To address this apparent contradiction and scrutinise the neurophysiological timecourse of interactions between language and attention in the course of lexical processing, we employed a classical oddball design and recorded participants' ERP responses to spoken words and pseudowords when attending to either these linguistic materials or to a non-linguistic primary visual task. All deviant stimuli elicited pronounced MMN responses. The global RMS of the grand-average (across subjects/conditions) MMN response showed a clear peak around 130-140 ms after the word-recognition point and a slower shift in the classical N400 window. In the early window, following up on a significant interaction between attention and topography, planned comparisons revealed a strong main effect of attention localised in left-frontal sites: MMN responses were more negative-going for attended than unattended stimuli. In right-frontal electrodes, however, we found an interaction between attention and lexicality that was driven by the responses to words being relatively immune to attentional modulation, while the pseudoword responses increased with attention as suggested in previous studies [1]. In the N400 window, attention clearly enhanced responses to both words and pseudowords equally. Furthermore, a contrast between the positive-going response to attended words and that to attended pseudowords brought out a typical centro-parietal N400 effect, i.e. more negative-going pseudoword activity. In the non-attend condition, no significant N400 was observed. In sum, we demonstrate a complex pattern of language-attention interactions in the course of word comprehension. While early on word responses appeared more robust, pseudoword ERPs are subject to stronger attention-modulation. Later on, attention effects are more pervasive. We also show that an N400-like effect (pseudoword>word) can be successfully elicited in an oddball design, and is thus resilient to multiple stimulus repetition. It is, however, limited to attend conditions only and therefore likely reflects later top-down controlled processes in lexical access. [1.Shtyrov Y. Mental Lexicon 5:255-276, 2010.]

C9 Limits to cross-modal semantic and object shape priming in sentence context

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Many studies have documented semantic priming effects from both words and pictures on word targets, but the literature on object shape priming in language processing is less well developed. Priming is typically observed with isolated words as targets. Some studies

have shown that in sentence contexts, priming is not an automatic consequence of speech processing (Norris et al., Cognitive Psychology 2006). In addition, priming tasks tend to involve meta-linguistic judgments. In the present study we focused on cross-modal influences, which may occur when listening to spoken sentences while being situated in a visual environment. We tested effects of picture and written word primes on processing of target words embedded in sentences. The primes were related to the targets in meaning or object shape. We investigated whether these aspects automatically prime spoken-word processing even in sentence contexts and without a judgment task. EEG was recorded from 23 adult native speakers who listened to spoken sentences and viewed written words and pictures. Each trial began with a short beep and a central fixation cross. A neutral sentence began playing (e.g., "She wrote a term paper about the eye"). 1000 ms before target word onset ("eye"), a prime appeared on the screen. The prime was either a written word or a picture that was semantically related to the target (arm), had a similar visual shape to the target (ball), or was unrelated (javelin; n=32 items per condition, counterbalanced). After 500 ms, the prime disappeared and was replaced by the fixation cross. Participants were asked to carefully listen for comprehension while looking at the center of the screen. 64 word and picture filler primes which matched with the spoken words (e.g., a picture of a banana combined with a spoken sentence containing the word banana) were included to make the prime-target relationships less noticeable. To quantify the N400 component as an index of semantic processing, we averaged across a 300-500 ms time window and used a cluster-based permutation test to determine which electrodes showed differences. We also performed time-frequency analyses of oscillatory activity. The ERPs to target words showed a clear N400 component in each condition. Within the written-word prime conditions, the N400 was attenuated in the shape condition relative to the semantic condition. Within the picture prime conditions, N400 amplitude did not differ reliably between the different prime-target relationships. Clear differences between picture and word primes during prime as well as spoken-target-word processing confirmed the power of the experiment. The time-frequency analyses showed no effects of prime-target relationship during target word presentation, although during prime presentation alpha band power was lower for picture versus word primes. The results highlight the context-dependence of cross-modal priming. The fact that prime-target relationship mattered for written word primes but not for picture primes suggest that there are limits to cross-modal priming. The present findings provide complementary evidence to previous studies on the automaticity of priming from speech, by showing that priming of speech processing is not an automatic consequence of seeing pictures.

C10 Phonemic and Post-phonemic Processing of Intelligible Speech in the Anterior and Posterior Superior Temporal Sulcus

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Introduction. Neuroimaging studies of the cortical organization of speech recognition have consistently identified relatively speech-selective activation changes in the anterior and posterior superior temporal sulcus (STS). The relative contribution of the regions to the processing of intelligible speech is still unsettled, though. Sentence-level speech contrasted with unintelligible rotated speech is a reliable predictor of anterior BOLD increases. However, it is unclear what level of analysis -- phonemic, lexical-semantic, syntactic, etc. -- is driving the activation. Recent studies have found significant activation increases in aSTS for individual words contrasted with acoustically matched unintelligible controls, indicating that the activity is not exclusively attributable to sentence-level operations. Rather, the region appears to be supporting some process at a lower level. The current experiment assesses the response in speech-selective anterior and posterior regions to lexical-semantic and sublexical attributes of speech stimuli. Method. Twenty right-handed native English speakers participated in a 3T fMRI experiment with clustered sparse acquisition. The stimuli consisted of 5 types of speech: (1) monosyllabic nouns (Words), (2) monosyllabic pseudowords (NonWords), (3) spectrally rotated words (RotW), (4) spectrally rotated non-words (RotNW), and, (5) time-reversed words (TrWs). The stimuli were randomly presented in silence as a repeating triplet 5500ms after the onset of each 10s TR. Participants responded with a button press whenever an item in the triplet differed from its neighbors. 3 images were acquired in rapid succession (TA=1.7) for each stimulus presentation for a total of 1350 EPI volumes (90 trials per condition). Results. All conditions when compared to baseline showed significantly more activation along most of the lateral superior temporal gyri. There were 2 areas in the left hemisphere that were activated more for Words than RotW: aSTS and the posterior inferior temporal gyrus. In the right hemisphere, there was greater activitation in the pSTS. The same activation pattern was observed in the contrast (Words+NWs)-(rotW+rotNW), thus largely replicating previous work. Importantly, lexical status differently modulated the anterior and posterior regions: the contrast Words-NWs resulted in activation in the anterior region bilaterally, but these conditions did not lead to activation differences in the posterior region. Conclusions. Anterior temporal speech-selective areas appear to respond to lexical-semantic aspects of speech, whereas posterior temporal speech-selective areas are coding lower-level phonemic information.

C11 Oscillatory dynamics to time-stretched speech during lexical decision

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Neurophysiological models of spoken word recognition implicate peri-auditory activation within the first few hundred milliseconds after stimulus onset, however the mechanism by which these regions incrementally map spoken stimuli on to candidate lexical entries remains poorly understood. Recent attention to neural dynamics suggest that alpha-centered power reduction (event-related de-synchronization) beginning between 250-300ms after stimulus onset may play an important role; left unspecified is whether this activation is sensitive to the onset of lexical activation (reduced power = earlier activation) or the speed of activation (reduced power = more rapid lexical convergence). We tease apart neural dynamics reflecting these distinct stages using time-stretched speech in which we manipulate the speed that sub-lexical features incrementally unfold varies while keeping lexical identity constant. Methods: 168 mono-syllabic high frequency nouns and 83 matched pseudo-words, recorded by a female speaker, were time-stretched to 80% and to 120% of their original duration keeping pitch unchanged. 16 adult participants listened to a random sampling of 100 tokens each of 80%, 120%, or original stimuli and 100 pseudo-words while performing a lexical decision task. Median length of the original stimuli was 479msec and the median length-change was ± 94msec. Neural activity was recorded using magnetoencephalography (MEG) with 275 gradiometers (CTF, VSM). Left and right auditory cortex (AC) was identified in each participant using a multi-dipole model fit to the auditory M100 response from 120 1kHz tones. AC responses to target words were estimated using SAM beamforming and converted to time-frequency power and left-right AC coherence representations. Responses to 80% and 120% stimuli, both subject to digital manipulation, were compared using non-parametric cluster-based permutation tests over left power and left-right coherence maps between 1-50Hz and 0-1sec after stimulus onset. Results: Lexical decision data showed increased RTs for time-stretched stimuli that were linearly related to stimulus length. Importantly, accuracy was matched for 80% and 120% stimuli and was high overall (>90%). Target words elicited a sustained power decrease (de-synchronization) spanning 10-25Hz beginning 300ms after stimulus onset but no power differences were found (at standard and more liberal thresholds.) Rather, 80% stimuli elicited increased left-right AC coherence relative to 120% stimuli in the gamma-band, from 30-40Hz and spanning 200 and 350ms after stimulus onset ($p = .017$). Alpha-centered power was not sensitive to time-stretched speech, suggesting that this pattern does not reflect activation onset. Further study is needed to understand the role of left-right auditory coherence in early stages of spoken word recognition, though prominent models link gamma-synchrony with feature-level sampling and encoding. One avenue of interest is whether accurate comprehension of speeded speech require more efficient inter-hemispheric interactions at this early encoding stage.

C12 Timing of the speech-evoked auditory brainstem response is dependent on cochlear spectral processing

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It has been suggested that deficits in certain speech and language skills, such as speech perception and phonological awareness, are related to reduced neural timing precision at the brainstem, particularly in noise (Anderson et al., 2010; White-Schwoch & Kraus, 2013). A neurophysiological correlate of this timing deficit has been proposed in the speech-evoked auditory brainstem response (speech-ABR), the latency of which is considered to reflect neural timing. Consequently, the speech-ABR has been suggested as a potential 'biomarker' for indexing temporal processing deficits in the central auditory system. To date, however, no neural mechanisms have been directly linked to differences in human speech-ABR latency. On the other hand, the effect of cochlear processing on the ABR is well-documented (Dau, 2003). Of particular importance for ABR timing is cochlear response time (CRT), which increases from higher to lower cochlear frequency regions, and is preserved in ABRs evoked by more simple stimuli. Here, using normally-hearing young adults (n=26, aged 18-39) we investigated whether speech-ABR timing is similarly affected by CRT. Using electroencephalography, we recorded speech-ABRs to a synthetic [da] syllable from four frequency regions in the cochlea. The results showed that the speech-ABR integrates cochlear activity over at least four octaves, and that the response latency decreases significantly with increasing centre frequency in a manner compatible with changes in CRT. A second experiment investigated the effect of noise on speech-ABR latency. Noise increased the latency of the overall speech-ABR but had no significant effect on the timing of speech-ABRs recorded from delimited cochlear frequency regions. Amplitude, however, was significantly reduced, most substantially so in the highest frequency region. This suggests that the noise-induced latency shift of the speech-ABR results from a change in cochlear spectral weighting, rather than from a neural mechanism. Overall, the findings suggest that speech-ABR latency is sensitive to cochlear frequency processing, and thus cannot be interpreted as a pure measure of neural timing. Speech-ABRs clearly provide an important tool to investigate the potential basis of language processing and speech perception difficulties. However, the present study highlights the importance of considering the effect of cochlear influences on the formation of speech-ABRs, and cautions against interpretations based purely on central processes. Acknowledgements This work was supported by the Medical Research Council. References Anderson, S., Skoe, E., Chandrasekaran, B., & Kraus, N. (2010). Neural timing is linked to speech perception in noise. J Neurosci, 30(14), 4922-4926. Dau, T. (2003). The importance of cochlear processing for the formation of auditory brainstem and frequency following responses. J Acoust Soc Am, 113(2), 936-950. White-Schwoch, T., & Kraus, N. (2013). Physiological discrimination of stop

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C13 ERPs and time-frequency analyses reveal dissociable submechanisms in the establishment of relational dependencies between complex auditory objects

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Natural language syntax is essentially a system of relational dependencies between words or phrases. Unfortunately, relational linguistic processing cannot be entirely dissociated from other influences such as expectations about the semantics of upcoming words or their word class. This concern even applies to "Jabberwocky" sentences, which are often claimed to be devoid of semantic content (cf. Wilson et al., 2013). According to a recent neurobiological model of auditory language comprehension (Bornkessel-Schlesewsky & Schlesewsky, 2013), these relational and sequential dependencies are established between complex auditory objects in a constant cycle of bottom-up and top-down processing. In language, complex auditory objects (phonemes, syllables, words or sentences) arise from hierarchical organisation and combination sensitivity in the sense that simple frequencies in primary auditory cortex are combined to higher order objects such as complex tones or phonemes and subsequently to even more complex auditory objects in neuronal populations successively further downstream from auditory cortex (Rauschecker & Scott, 2009; DeWitt & Rauschecker, 2012). The present EEG study examined the processing of complex relational dependencies between auditory objects in the absence of semantic meaning by presenting musical tone sequences. Twenty-four participants with musical expertise attended to 4-tone sequences played by two different instruments (piano and French horn). The task required sequence categorisation based on relational dependencies between tones that were defined both by instrument and root tone frequency. Target sequences (requiring the answer "yes") comprised a French horn tone at position 3 or 4 that was higher in frequency than an immediately preceding piano tone. This manipulation mimics dependencies in natural language, e.g for subject-verb agreement ("He sleeps" versus "They sleep"), which requires the concurrent processing of two relational dimensions (noun versus verb and a match in features such as person and number). Participants heard 144 sequences in total, with a 1:3 ratio of targets to non-targets. ERPs showed two positive peaks for target tones (peak latencies at approximately 300 ms and 525 ms). The amplitude of the first peak was modulated by target position (higher amplitudes for position 4 vs. 3), while that of the second was not. An additional time-frequency analysis (Delorme & Makeig, 2004) suggests that, rather than reflecting two distinct components, the positive peaks result from prolonged frontal 4 Hz (theta) activity – a common frequency component of the P300 (Başar, 2000) – overlapping with parietal/parieto-occipital activity at approximately 1-2 Hz (delta). Whereas the delta activity is modulated by target position, the theta activity is not, thus leading us to interpret the former as a correlate of successively increasing target expectation (perhaps akin to a CNV), while the latter reflects a general mechanism of attentional orientation towards targets. These results indicate that the processing of complex relational dependencies comprises at least two dissociable submechanisms: attending to a target item or relation as well as anticipation of target quality (type). We hypothesise that the processing of linguistic dependencies draws upon similar mechanisms, thus potentially accounting for the ubiquity of P300-like effects in language, including the P600.

C14 The functional role of neural oscillations in auditory temporal processing during the first stages of reading development

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Background: Neural oscillations are defined as rhythmic neural activity present in the brain at rest. While previous research has not always acknowledged the functional role of this spontaneous oscillatory activity, neural oscillations now occupy a prominent place in neuroscientific research. Also in the context of speech processing, recent studies have emphasized the fundamental role of neural oscillations. By providing a functional network for temporal processing, neural oscillations in the auditory cortex enable precise encoding of temporal acoustic information, which is crucial for accurate speech perception. Based on these findings, it has been proposed that impaired oscillatory phase locking to auditory temporal information could constitute the underlying cause for the speech processing problems found in children and adults with severe reading disorders. Objectives: This study aims to elucidate the neural mechanisms underlying speech processing in children during the first stages of reading development, with specific emphasis on the contributions of neural oscillations. Methods: Resting-state EEG (rsEEG) and auditory steady-state responses (ASSR) were recorded in eighty-one seven-year old children at the end of first grade of primary school. During rsEEG measurements children were requested to lie relaxed and to be engaged in no specific mental activity. For ASSR measurements children were instructed to passively listen to amplitude modulated noise stimuli. Four modulation rates were chosen to examine phase locking of neural oscillations over a broad frequency range: 4 Hz (delta-theta rhythm), 20 Hz (beta rhythm), 40 Hz (low gamma rhythm) and 80 Hz (high gamma rhythm). We were specifically interested in modulations fluctuating around 4 Hz (acoustic units of ±250 ms) and 20 Hz (acoustic units of ±50 ms), because these modulation rates are believed to correspond to the rate at which important phonological segments (syllables and phonemes, respectively) occur in speech. All EEG recordings were performed using a high-density 64-electrode array mounted in head caps. For correlational purposes, a behavioral test battery was also collected, including cognitive (literacy and phonological

skills) and auditory (speech perception) tasks. Results and conclusions: First results appear to show differences in auditory temporal processing between beginning readers with and without reading difficulties, already after one year of reading instruction. Detailed results regarding neural auditory processing and reading development will be presented at the conference. We hope our results will contribute to a better understanding of the complex relation between auditory temporal processing, speech perception and reading development.

Motor Control, Speech Production, Sensorimotor Integration

C15 Apraxia of Speech and Aphasia Result from Distinctly Different Lesion Locations

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Introduction: The localization of a crucial lesion location that causes apraxia of speech (AOS) has been heavily debated (Dronkers, 1996; Richardson et al., 2012), as AOS rarely occurs in isolation, without concomitant aphasia (Graff-Radford et al., 2014). The identification of lesion locations that uniquely lead to AOS has important implications for disentangling debates over this controversial disorder, as well as insight into neuroanatomical correlates of speech planning processes. In this study, we delineated behaviors specific to AOS from those common amongst both AOS and aphasia and sought to determine sites of damage that exclusively corresponded to these disorders. It was hypothesized that motor and premotor areas would be specifically involved in behaviors specific to AOS (Graff-Radford et al., 2014; Josephs et al., 2012, 2013), with classic language areas related to aphasia severity. Method: Participants: 37 participants (16 female; mean age = 59.97, range=37-80) in the chronic phase of left hemisphere stroke (six months post-onset) were included. Participants varied in the presence or absence of aphasia type and severity. Procedure: Speech production was rated using the Apraxia of Speech Rating Scale (ASRS; Josephs et al., 2012; 2013) from a variety of speech samples. The speech characteristics included on this scale classify speech abnormalities into 4 categories: (a) features that occur in AOS, but not in dysarthria or aphasia; (b) features that can occur due to AOS and/or dysarthria; (c) features that can occur due to AOS and/or aphasia, and (d) features that can occur due to AOS/dysarthria/aphasia. All participants underwent a high-resolution T1 and T2 MRI sequences for purpose of analysis. Data Analysis: A voxel-based lesion-symptom mapping analysis with aphasia, dysarthria and AOS severity as dependent variables was conducted to localize cortical damage related to these disorders. Analysis was completed using an in-house code written in MatLab. The threshold for significance was set to $p < 0.05$, with corrections for multiple comparisons completed using permutation thresholding with 4,000 permutations (Rorden, et al., 2009). Results: Thirteen patients presented with aphasia only; 15 presented with aphasia and AOS; two with aphasia and dysarthria; six with AOS, aphasia and dysarthria; and one patient with only AOS. 209 voxels survived thresholding for aphasia severity (z = 1.91-5.54), and 106 voxels survived for AOS severity (z=1.53-5.38). No voxels survived statistical significance for dysarthria severity. Significant regions were unique to each disorder. Lesions to the superior temporal gyrus and posterior insula were related to aphasia severity, while lesions to the premotor/supplementary motor and Broca's area were unique to AOS severity. There was no overlap in significant lesion locations. Discussion: This study is novel in that we aimed to localize damage unique to AOS, aphasia and dysarthria. Our results add to the growing body of work that supports the role of premotor and supplementary motor areas in AOS (Josephs et al., 2012; Josephs et al., 2013; Whitwell et al., 2013). Localizing brain areas unique to AOS has implications for current models of speech production, specifically with respect to refining the neuroanatomical localization of speech motor planning processes.

C16 A spreading activation model of lexical retrieval with sensorimotor integration

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The semantic-phonological (S-P) model of lexical retrieval has been successful in accounting for naming error data in aphasia (Schwartz et al., 2006). Here we show that the model is improved by adding a sensorimotor component motivated by the state-feedback control (SFC) model of speech production (Hickok et al., 2011; Hickok, 2012). The S-P model has Semantic, Lexical, and Phonological units and two adjustable parameters representing the weights of lexical-semantic and lexical-phonological connections. Weights are fit to picture-naming data from controls, then reduced to simulate lesions and fit aphasic data (N=255). Although simple, the model approximates the statistical properties of speech error opportunities in English and accounts for a range of normal and disordered speech data. Recent theorizing, motivated in part by the speech errors in conduction aphasia, has suggested that the phonological level is subdivided into auditory and motor components, with auditory units serving as the targets for motor planning. This predicts that adding an auditory-phonological level to the S-P model (i.e., making it a sensorimotor model) will improve the fits to naming error data, particularly for conduction aphasia. Our new model includes the S-P's Semantic and Lexical units, but adds a copy of the phonological units, designating one group Auditory and the other Motor (the SLAM model). Four parameters define weights: Semantic (S), Lexical-Auditory (LA), Lexical-Motor (LM), and Auditory-Motor (AM). To fit data, a map is generated by sampling the output of the model at sufficiently different parameter settings (points). We improved the efficiency of this procedure, redesigning both the sampling and point selection algorithms to run in parallel on a GPU. Allowing the parameters to vary independently [0.0001-0.04], we generated a SLAM map with 31,593 points (10,000 samples each). Diverting activation to the new circuit, we retained only the 17,786 points with LM <

LA, as the SFC model predicts. For comparison, we generated an S-P map with equal resolution to the SLAM map. The S-P model has 2 fewer dimensions, so its map only has 189 points; however, this map provided slightly better fits than Schwartz et al. (2006), who used a map with 3,782 points. For a conservative comparison, we generated an S-P map with 57,011 points. Compared with the equal-resolution S-P map, SLAM produced better fits for 95.5% of the patients. Mean improvement was 0.0051 RMSD, and mean reduction was -0.0009. 19 patients had >2 std of fit change (> 0.0151 RMSD): 11 Conduction (=58%, vs. 18% of cohort), 7 Wernicke's (=37%, vs. 14% of cohort), and 1 Broca's. Compared with the extremely high-resolution S-P map, the SLAM map produced an average fit improvement of 0.0007 RMSD. Although more patients actually had fit reductions (62%), the average fit reduction was only -0.0016 RMSD, while the average fit improvement was 0.0046. Thus, despite the resolution disadvantage, the SLAM model still improved fit, especially for Conduction patients. The SLAM model accounts for picture-naming data better than the S-P model, and specifically improves fits for Conduction patients using the predicted structure. Future work will involve simulating more tasks.

C17 Anatomy of motor speech network in frontal temporal dementia

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Frontal temporal dementia (FTD) comprises different clinical syndromes characterized by progressive impairment of language and/or behavior. Non-fluent variant primary progressive aphasia (nfvPPA) is primarily characterized by non-fluent, effortful, and agrammatic speech and apraxia of speech (AOS) while behavioral variant (bvFTD) is characterized by behavioral abnormalities due to social-emotional cognitive dysfunction. Even though each syndrome presents with a specific pattern of cortical atrophy, there is a striking amount of overlap between them. Previous studies analyzing each group separately showed that both groups present atrophy in the frontal operculum/insular region, supplementary motor area (SMA) and striatum, left-lateralized in nfvPPA and bilaterally in bvFTD. These regions are known to play an important role in motor speech planning and execution. Despite bilateral atrophy bvFTD patients usually do not present significant AOS at presentation. The aim of this study is to investigate the pattern of selective grey matter atrophy in different regions of the motor speech network in bvFTD and nfvPPA, in order to highlight brain regions associated with spared and impaired speech abilities in FTD. All the subjects underwent structural MR imaging on either a 1.5 T or 3 T scanner. MRI scans were acquired at UCSF Memory Aging Center. We performed a voxel-based morphometry (VBM) analysis to compare patterns of grey matter atrophy in nfvPPA patients (n=56), and in bvFTD patients (n=30) relatively to healthy controls (n=60). Statistical analyses were performed by using SPM8 software. Age, gender, scanner type, and total grey matter were included as nuisance variables in the analysis. NfvPPA patients showed significant grey matter atrophy in the left cortex including the inferior frontal and precentral gyri, as well as in the left supplementary motor area, in the left ventral and dorsal anterior insula, and in the bilateral striatum at $p<0.05$ Family Wise Error (FWE) corrected. BvFTD patients showed significant bilateral atrophy involving the orbitofrontal and ventromedial cortices, left-lateralized atrophy in the ventral anterior insula and right-lateralized atrophy in the ventral and dorsal anterior insula and striatum. Spared speech production in bvFTD is supported by anatomical preservation of the left premotor cortex, the left inferior frontal operculum, and the left dorsal anterior insula. In particular, the latter region has been previously shown to be specialized for the motor planning of speech. Consistently, atrophy in this region might contribute to AOS in the nfvPPA patients.

C18 Task-related modulations in large-scale cortical networks underlying language production: a combined fMRI and MEG study

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Functional connectivity in large-scale cortical networks has been studied extensively in task-free conditions. These studies systematically reveal large-scale connectivity patterns, and correlated networks that agree with known functional systems, including language. Here we studied the dynamic integration of language production processes at the level of large-scale neural circuits, while the participants performed a picture naming task. In a parallel functional magnetic resonance imaging (fMRI) and magnetoencephalography (MEG) experiment, we investigated the structural similarities between task-related haemodynamic networks and their electrophysiological counterparts. Our goal was to identify, in a data-driven all-to-all connectivity analysis, the connectivity patterns underlying action and object naming. Altogether 15 subjects participated in the experiment. MEG and fMRI data was measured from 10 subjects, while 5 participants completed only the fMRI part of the study. The experimental conditions were split into two contrasts: i) presentation of identical visual stimuli (action images) with participants required to undertake different tasks, i.e. naming of words from different grammatical categories (verbs/nouns), and ii) presentation of differing visual stimuli (actions/objects) with participants required to execute identical tasks, i.e. consistently naming words from the same grammatical category (nouns). As a metric of functional connectivity we adopted cross spectral coherence in both MEG and fMRI. In MEG we used a spatial filter for reconstruction of coherent sources. In both MEG and fMRI coherence estimates were computed for each cortical grid point with all other grid points in the frequency bands of interest. Task-related network modulations were determined by contrasting the connectivity results between tasks (pairwise student's t-test; $p<0.0005$) and applying a spatial pairwise clustering algorithm. MEG and fMRI

analyses revealed common network hubs modulated during action vs. object naming (from the same picture) in cortical regions typically associated with language processing; left middle and superior temporal gyri, left inferior frontal gyrus (pars triangularis and opercularis), left supramarginal gyrus and left superior parietal region. Modulation in functional connectivity between the left posterior temporal/inferior parietal and inferior frontal regions was observed, in good agreement with the known structural connectivity between these cortical regions. In contrasting action and object images while keeping the task constant, both fMRI and MEG networks exhibited an increase in connection density in the lateral occipital cortices, middle temporal cortex and sensorimotor regions. MEG-derived networks preferentially engaged low-level visual areas whereas fMRI networks preferentially modulated areas related to selective attention. Distinct frequency-specific network topologies were observed in the MEG data. The greatest similarity between electrophysiological and haemodynamic task-related networks was found in the low-frequency range (10-20 Hz), corresponding to high alpha/low beta activity. In conclusion, connectivity analysis revealed task-related network hubs, evident in both imaging modalities, in cortical regions previously associated with language processing, object recognition and visual processing. We observed a striking task-dependence in functional connectivity, revealing flexible reorganization of the large-scale connectivity networks that underlie language production during task performance. *The two first authors contributed equally to this work.

C19 Neural correlates of response latencies in the picture naming task

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The picture naming task is one of the most commonly used tasks to study the neurobiology of language production. In a typical experiment, on a typical trial, it takes a given participant around 700 ms to name a picture. It is generally assumed that this 700 ms reflects a composite of neural activities at least related to the visual identification and recognition of the picture, retrieval of the picture name, and articulation of the picture name. Many studies have attempted to find the neural correlates of these picture naming components by manipulating factors assumed to index a given component and then assessing the neural activation associated with the manipulation. Here we took a more general approach. We examined how natural variation in the response latencies in a simple picture naming experiment was determined by changes in the underlying neural activity. To this end, we used the high temporal precision of EEG in combination with a novel statistical technique. In the experiment, participants (N=30) named 100 pictures while their response latencies and EEG amplitudes were recorded. The pictures were black and white line-drawings selected from a standardized database. The mean response latency in the experiment was 760 ms, and the standard deviation was 181 ms. The EEG data were analyzed using a novel statistical technique called mixed effect modeling. Whereas conventional EEG studies rely on the analysis of by-subject averages using ANOVA models, mixed effect modeling is a regression technique that does not require any by-subject or by-item averaging. A major practical advantage of this technique is that it enables the analyses of variables at the single-trial level. Using this technique we examined how the natural variation that was present in the naming latencies across individual trials was determined by changes in the EEG amplitudes on these trials. Given that we had no a-priori expectations about a time window in which response latency would predict EEG amplitude, we conducted a global analysis in which the effect of response latency on EEG amplitude was considered at all time points, for all electrodes. We ensured protection against multiple comparisons using the method of Guthrie and Buchwald (1991). To improve the statistical detection of effects, we only considered naming latencies that fell between 0.25 SD above or below the mean naming latency in the experiment (i.e., those between 716 and 804 ms). Our results revealed that variation in response latencies was associated with neural activity around 100 ms post-picture onset, and with a larger activity extending between 400 and 800 ms post-picture onset. Surprisingly, between 100 and 400 ms, neural activity was uncorrelated with naming latencies. This suggests that with the particular picture naming task used here, response latencies are primarily determined by neural activities arising around 100 ms, and from 400-800 ms post-picture onset. Neural activities arising between 100 and 400 ms seem to play only a minor role.

C20 Brain mechanisms of semantic interference in spoken word production: An anodal Transcranial Direct Current Stimulation (atDCS) study

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In spoken word production tasks such as picture naming, categorically-related compared to unrelated contexts typically induce inhibitory effects on responses. These inhibitory effects can also be relatively persistent. We investigated recent proposals concerning various roles of the left inferior frontal cortex (IFC) and middle-posterior temporal cortex (MTC) in mediating inhibitory context effects (homogeneous vs. heterogeneous) in the blocked cyclic naming paradigm. Left IFC activity has not been observed reliably in neuroimaging experiments, while left MTC activity has been reported more consistently. Anodal Transcranial Direct Current Stimulation (atDCS) is an electrical brain stimulation technique that induces more efficient neural processing at the stimulation site and also affects functionally connected brain regions. In a 3-way cross-over, sham-controlled study, we applied atDCS to left IFC or MTC while 18 participants performed parallel versions of the blocked cyclic naming paradigm. Each stimulation session/version was conducted approximately 1 week apart to avoid

carry-over effects, and stimulation type and task version were counterbalanced across participants. Significant effects of semantic context and cycle, and interactions, were observed on naming latencies in all 3 stimulation sessions. In addition, atDCS influenced naming latencies and interacted with semantic context. Overall, naming latencies were significantly facilitated during atDCS over left MTC compared to both sham and IFC stimulation. In addition, atDCS over left MTC differentially facilitated naming latencies in homogeneous contexts, reducing but not eliminating the semantic interference effect. By contrast, naming latencies during atDCS over left IFC did not differ significantly to sham stimulation and showed a comparable semantic interference effect. These results confirm a necessary role for left MTC in mediating inhibitory semantic context effects. However, they do not support proposals of a necessary role for the left IFC.

Orthographic Processing, Writing, Spelling

C21 Revealing the cortical dynamics of letter string perception.

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Neurolinguistic studies on visual word recognition have established three primary responses, occurring around 100ms, 170ms and 300ms after lexical presentation (Tarkiainen, Helenius, Hansen, Cornelissen & Salmelin, 1999; Pylkkänen & Marantz, 2003). Each of these responses reflects a distinct aspect of linguistic processing: pre-lexical stage (Type I/M130), word-form identification (Type II/M170), and lexical access (M350). Magnetoencephalography (MEG) proves particularly well suited to measuring these components, due to the excellent spatial and temporal resolution it provides. However, as methods of source estimation have primarily utilized parameters that sign the direction of the current with respect to the head, rather than the cortex, little is known about the nature of these fundamental components relative to the cortical surface. In order to distinguish between possibly accurate source localization and reconstruction "bleed" to neighboring cortex, and to connect MEG responses to actual models of cortical activity, we need to understand whether head-anchored differences in current direction reflect different types of cortical responses or simply the difference in orientation of the cortical surfaces involved. We conducted an English adaptation of Tarkiainen at al.'s (1999) experiment, which reported robust effects in our components of interest. Stimuli consisted of rectangular patches in which single letters, two-letter syllables, four-letter words or length-matched symbols were displayed. Four levels of Gaussian noise were added to the letter strings to manipulate their level of visibility. Participants (N=16) focused on each of the images as they appeared on the screen. We processed the MEG data with MNE software to compare two orientation parameters for source localization: 1) free orientation, which indicates the direction of the current as defined by the head, and 2) fixed orientation, which defines the direction of the current with respect to the cortex. Our findings replicate the results of Tarkiainen et al., both when using cortically constrained and head-constrained estimation of source direction. The Type I response was reflected by activity ~100ms post-stimulus onset, modulated by reduced noise levels and originating bilaterally in occipital regions. Type II responses showed preference for visible letter strings over symbol strings, with greatest amplitude for highly visible words around ~160ms and ~210ms, and were found in left occipital regions, distributed more temporally than the Type I response. An M350 effect found ~300ms, which displayed greater activity for words over length-matched symbol strings, was located in the left superior temporal gyrus. When using free orientation, we find a single polarity in the identified region of response, with the directionality matching the single dipole models of Tarkiainen et al. However, when using fixed orientation, the same regions display neighboring patches of activation with opposing directionality. Our findings display a stronger correlation for negative polarity (current flowing into the cortical mass) for each of the three components, even in situations where a free orientation displays positive activity. These results motivate 1) using source reconstructions that fix the direction of sources orthogonal to the cortical surface, and 2) analyzing only the negative sources for estimates of these expected language-related MEG responses.

C22 An ERP Investigation of Orthographic Priming with Superset Primes

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Prime stimuli formed by inserting unrelated letters in a given target word, such as the prime "tafble" for the target "table" (called "superset" primes) provide a means to modify the relative positions of the letters shared by prime and target, while also examining the effects of unrelated letters on orthographic priming. Previous behavioural studies using the masked priming paradigm have shown that superset primes facilitate the recognition of target words compared to orthographically unrelated primes, and it has been shown that the size of priming effects varies as a function of the number of inserted letters, with a small processing cost associated with each additional inserted letter (Van Assche & Grainger, 2006; Welvaert et al., 2008). In the present ERP study we examined the relative contribution of unrelated letters and positional mismatch to this processing cost. In particular, we compared the effects of superset primes formed by the insertion of unrelated letters (e.g., maurkdet - MARKET), or by the insertion of hyphens (e.g., ma-rk-et - MARKET), with identity priming (e.g., market - MARKET), all measured relative to unrelated control primes. Behavioral data revealed significantly greater priming in the hyphen-insert condition compared with the letter-insert condition. In the ERP signal, hyphen-insert priming effects were first seen in the early N250 time-window, and continued to be robust

in following time-windows. On the other hand, effects of letter-insert primes emerged even later, and showed a reverse priming effect in the N400 time-window, with related primes generating greater negativity in central and frontal electrode sites. This reversed priming effect seen for letter-insert primes might reflect the interference generated by mismatching letters during target word processing. The different pattern of priming effects seen for letter-insert primes and hyphen-insert primes suggests that compared with identity priming, letter superset priming reflects the joint influence of: 1) a disruption in letter position information, and 2) an inhibitory influence of mismatching letters. While the effect of disrupting letter position information is in line with all recent accounts of letter position encoding (e.g., Grainger et al., 2006; Norris et al., 2010; Gomez et al., 2008; Whitney, 2001; Davis, 2010) we suggest that these models should include an appropriate bottom-up mechanism that would account for the inhibitory influence of unrelated letters in the prime. An example of such a mechanism can be found in the interactive-activation model (McClelland & Rumelhart, 1981) in which letter-word connectivity can be both excitatory and inhibitory.

C23 Anatomical connectivity of ventral occipitotemporal region involved in reading

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Very little is known about the connectivity of the ventral occipitotemporal (vOT) region involved in reading, partly due to the difficulties in establishing a clear anatomical homologue in macaques. Functional connectivity studies, however, demonstrate clear links between vOT and other cortical regions involved in visual word recognition including Broca's area, the supramarginal gyrus (SMG) and, less frequently, the angular gyrus (ANG). Here we investigated the anatomical basis of these functional interactions directly in humans using diffusion-weighted MRI and a series of probabilistic tractography analyses. The first analysis used seed masks placed within the cortical grey matter in three rostro-caudal positions centred on the occipitotemporal sulcus and the tractography algorithm generated the most probable paths from the masks to the rest of the brain. The results demonstrated: i) a clear path along the inferior longitudinal fasciculus linking the vOT anteriorly with the ventral surface of the temporal poles and posteriorly with the middle occipital gyrus (MOG), ii) a set of local U-fibres linking adjacent vOT regions, and iii) a path via the inferior fronto-occipital fasciculus linking vOT with Broca's area. There was, however, no evidence of a direct pathway linking vOT with either SMG or ANG despite reports of strong functional connectivity between the regions. A second analysis seeded both of these inferior parietal regions as well as vOT and successfully identified a path linking posterior ANG to posterior vOT, consistent with the vertical occipital fasciculus of Wernicke. The analysis also identified a pathway between vOT and SMG but an examination of this path demonstrated that it was false positive due to the crossing of multiple fibre tracts. Because no direct path was found linking vOT to SMG, a final analysis examined whether the functional connectivity between these regions could be due to a common driving input to both. The most likely candidate was the MOG region seen in the initial analysis. Therefore, the grey matter from the entire MOG was seeded to determine whether it produced paths to both vOT and SMG and if so, whether these paths originated in the same part of MOG. The analysis confirmed this hypothesis, indicating a bifurcation between a ventral path linking MOG to vOT and a dorsal path originating at the same point linking MOG to SMG. The current results are consistent with the parallel visual pathways seen in other primates and support a neuroanatomical model of reading that incorporates multiple routes from early visual cortices to higher-order language areas, of which only the ventral path goes through vOT. This suggests that despite the consensus that vOT plays an important role in reading, this region may not always be necessary for reading. They also challenge the idea from cognitive and computation models of reading that argue that visual information must first be mapped onto orthographic representations before making contact with other, non-visual aspects of the neurological reading system.

C24 The lexicality effect in the left ventral occipito-temporal cortex

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Introduction: Neuroimaging studies on visual word recognition consistently revealed that words and pseudowords (i.e., unfamiliar but pronounceable letter strings) activate the left ventral occipito-temporal (vOT) cortex. The predominant finding on this so termed lexicality effect (i.e., differences in response to words vs. pseudowords) is that pseudowords elicit a higher activation in the left vOT than words. Many of the studies, which reported higher activation for pseudowords, used tasks which required an overt behavioural response (e.g., lexical decision or reading aloud). Recent studies on the relationship between task and vOT activation indicated that the left vOT is very sensitive to variations in task demands. Thus, a higher activation for pseudowords could be a consequence of the tasks demands. We administered a novel technique to elucidate this issue: We co-registered eye movements and blood-oxygen-level dependent (BOLD) signals, while participants silently read words and pseudowords in a sentence-like fashion. Method: We used simultaneous eye tracking and functional magnetic resonance imaging (fMRI). Words and pseudowords were presented inter-mixed in a single row (5 stimuli per trial). Strings of backslashes served as a control condition ('\\\'). Trials started with a fixation cross at the left side of the screen (the fixation was detected by an eye-tracker). Thereafter, adult participants (n = 36) silently read the presented words and pseudowords or scanned the slash-strings. The novel technique of fixation-related fMRI allowed us the investigation of the haemodynamic response in relation to the point in

time of the first fixation on a stimulus. All contrasts were examined by t-tests thresholded at a voxel level of p < .001 and FWE-corrected (i.e., p < .05) at the cluster-level. Results: The eye movement data revealed that fixations on pseudowords were significantly prolonged in contrast to those on words. The neuroimaging data revealed that at the whole-brain level words and pseudowords elicited higher activations in the left vOT cortex when compared with the control condition (i.e., backslash-strings). Within this activation cluster, words elicited higher activation than pseudowords and, importantly, no voxel in the left vOT cortex exhibited a higher activation in response to pseudowords than words even when lowering the threshold to p < .5, uncorrected. Conclusions: In line with previous studies, our results suggest that the predominant finding in the literature (i.e., higher activation for pseudowords than words) is highly dependent on the task at hand. Since debates persist about the exact functioning of the left vOT cortex, our result that words elicit a higher activation relative to pseudowords during self-paced and silent reading adds to our understanding of visual word recognition and, thus, provides substantial implications for the conceptualization of the functional role of the left vOT. Specifically, the notion that higher activation for pseudowords results from an increased prediction error due to automatic top-down processing based on previous experience - as it is argued in one of the most prominent models (i.e., the Interactive Account) - does not seem applicable during an ecologically valid setting (i.e., self-paced and silent reading).

C25 An ERP investigation of hemispheric asymmetry: Is visual filed asymmetry of the optimal viewing position (OVP) effect for foveal stimuli similar to right visual field advantage for non-foveal stimuli?

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Visual half-field studies have shown that English words are more easily recognized when presented in the right visual field (RVF) than in the left visual field (LVF). This RVF advantage has been attributed to the superiority of the left hemisphere for language processing. Words presented foveally show a similar recognition asymmetry between the two visual fields (VFs) -- words are recognized faster and more accurately when fixated at a within-word position left-of-center (the optimal viewing position, OVP), and more so when words are presented to the right than left side of fixation. Some studies have argued that the OVP asymmetry may be caused by a similar mechanism as the RVF advantage, thereby attributing OVP asymmetry to the language dominance of the left hemisphere. We have demonstrated that the OVP asymmetry is not word specific. Here we ask whether a similar mechanism leads to the observed asymmetries for foveal (OVP effect) and non-foveal (RVF word advantage) stimuli. We recorded event-related brain potentials (ERPs) as participants tried to detect a target letter embedded in a 5-letter string that either randomly spanned fixation or was laterally presented to one of the VFs in foveal or non-foveal vision. Regardless of foveal or non-foveal presentation, the latency of the occipital P1 was delayed in the hemisphere ipsilateral to side of stimulus presentation. The occipital N170 also exhibited ipsi vs contralateral latency delay, and smaller amplitudes ipsilaterally, with a more pronounced amplitude reduction for LVF than RVF presentation. As long as the stimulus strings were at least partially within the fovea, the occipital N170 amplitude reductions increased as a function of distance to fixation, while the P1 amplitude did not change as a function of VFs or distance from fixation. By contrast, when stimulus strings were outside of the fovea, the occipital P1 was paradoxically larger in the hemisphere ipsilateral to the side of stimulus presentation (paradoxical lateralization of P1, Barrett et al 1976), more so for LVF than RVF presentation. The occipital N170 showed similar patterns as for lateralized stimuli in the fovea. The asymmetric patterns are qualitatively and quantitatively dissimilar for foveal lateralized and non-foveal lateralized stimuli. Our findings are consistent with the hypothesis that the OVP asymmetry and RVF advantage may not share similar mechanism.

C26 Task sensitivity in language-related ERP components is not restricted to the P600

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Language related ERP patterns are shaped by the nature of the linguistic information presented (single words, sentences, texts), its modality (written, auditory, signed) and - perhaps most importantly - the task environment (e.g. Haupt et al., 2008, Roehm et al., 2007). Nevertheless, some components are typically considered less prone to task-related influences than others. For example, while the task-sensitivity of the P600 is well-known (e.g. Kolk et al., 2003; see also the P600/P300 debate), the N400 is typically considered less susceptible to such influences (e.g. Rolke et al., 2001, for N400 effects even within the attentional blink). Here, we report an ERP study which demonstrates that even the N400 is highly task-sensitive. We employed a previously reported experimental manipulation (Lotze et al., 2011), in which a sentence-final plausibility manipulation was fully crossed with an orthographic change (final word in normal orthography versus all capitalised). In a second group of participants, the directionality of change was reversed (i.e. the sentence context was all capitalised and the final word was either also capitalised or written normally). Participants judged sentence plausibility. Lotze et al. reported three crucial findings: a. a frontal P200 effect for a change from normal orthography to a capitalised final word but not vice versa; b. a late positivity for all implausible sentences compared to plausible controls; and c. a reduced N400 effect for implausible sentence-final words with a concurrent change to capitalised letters relative to all other implausible conditions. The authors interpreted their findings as evidence that the emphatic nature of capitalisation in everyday communication serves as a bottom-up signal for a highly informative

/ less likely continuation. Here, we used the same design, materials and procedure as Lotze et al. with one important exception: participants (n=20 per directionality of change group) judged whether there was a physical change or not. In addition, to ensure that they would read the entire sentence, they performed a word recognition task. We replicated the early positivity (200-500 ms) for a change from normal to capitalised orthography but not vice versa. In contrast to previous results, an N400 effect for implausible continuations was only observable in sentences with unchanged normal orthography and a late positivity effect (500-700 ms) was now found for all contrasts of changed versus unchanged orthography irrespective of plausibility. We conclude that the early P200 effect is dependent primarily on a salient visual change, in line with previous reports of P200 modulations for visual "pop out" stimuli. Strikingly, the N400 effect was completely dependent on the task environment, thus suggesting that it is not functionally bound to lexical-semantic processing but rather to the circumstances under which interpretive relations are constructed. Finally, the occurrence of the late positivity for conditions with an orthographic change rather than for implausible conditions is completely explained by the change of the task, thus lending further credence to approaches claiming that the P600 is an instance of the – highly task-sensitive – P3.

C27 Overlapping brain potentials in a simplified reading situation: a fixation-related potentials study.

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In self-paced reading tasks, fixations on words generally last for 200–250ms, whereas later ERP components emerge from 300 to 600ms post-stimulus. At this time, the eyes have already moved to the subsequent word, which will also elicit a specific brain response. Hence, the late components of the currently fixated word (i.e., word n) overlap to a certain degree with the early components of the following word (i.e., word n+1). This issue was broadly circumvented by means of serially presenting the stimuli within fixed ISIs (SVP). However, SVP paradigms were criticized as being not apt for investigating natural reading in which the reader is free to move the eyes along the sentence at his/her own pace. In order to increase the feasibility of self-paced reading studies, the present research aimed at investigating possible solutions of dealing with overlapping brain responses during natural reading. Ten adult participants were instructed to silently read lines consisting of one, two, or three words (five-letter nouns matched for frequency of occurrence). Eye-movements were recorded monocular from the right eye combined with simultaneous recording of electrophysiological activity with a 64 channels EEG system. ERPs were averaged over trials in which all of the words were fixated once. Trials containing multiple fixations on a word, refixations, or skippings were excluded from further analysis. The eye tracking results revealed that the present study replicated commonly reported findings from the literature. To illustrate, average fixation durations were about 210ms – typical for those during self-paced silent reading. For the analysis of EEG data we first examined the effects of shifts in the latency of the early components by splitting words into those which received short (~180ms) and those which received long (~240ms) first fixation durations. ANOVAs comparing the P1 and N1 components in a central-occipital six electrodes cluster showed no significant differences within presentation formats (i.e., one/two/three word conditions), all Fs < .83, ps > .05. In a next step, we subtracted the ERP of the one word condition from the ERP of the two words condition. The resulting ERP did not resemble the usual shape of early electrophysiological components. Specifically, the P1 and N1 peaks are flattened, whereas the shape of the overlap is preserved in the later components. This study is to be considered as a first step in series of experiments aimed to further validate fixation-related potentials as a reliable technique in reading research. A prevailing problem is the influence of subsequent fixations on the shape of electrophysiological brain responses during self-paced reading since the shape of the overlap is not considered to be as regular as, for instance the blood-oxygen-dependent signal (BOLD). The results of the present study demonstrate that our simplified reading paradigm is well suited to control for different sources (fixation duration, onset of fixations, amplitude and latency of early components) of variability in the nature of the overlap. This was an essential prerequisite to further validate our procedure.

Phonology, Phonological Working Memory

C28 The interaction between phonology and semantics in late bilinguals: Evidence from ERPs

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How do phonological representations interact with semantic processing during silent reading in bilinguals? We addressed this question via a series of ERP experiments, which were systematically conducted in the second language of our French-English late-bilingual participants. We examined the processing of interlingual homophones (eg. the French word "flèche" meaning arrow in English) which bear strong phonological overlap but no semantic overlap and only partial orthographic overlap across languages. In isolation, interlingual homophones produce facilitation, as seen by a clear N400 effect to these words compared to non-homophonic words (Carrasco, Midgley & Frenck-Mestre, 2011). To determine whether the interlingual homophone effect is limited to phonological representations or extends to semantics we conducted 3 priming experiments, at different prime-target SOAs. Interlingual homophone primes, presented in the L2 (eg. flesh), were followed by L2 targets that were either the translation of the L1 meaning (arrow) or a semantic associate (blood). Our ERP results show that interlingual phonological priming

at the semantic level is elusive. Under masked priming, we found no variation in the ERP response to targets as a function of prime status (interlingual homophone vs. neutral). At short SOAs (200 ms) we found an N400 effect for all participants for within-language associative priming (flesh-blood), but only a subset of participants showed an N400 effect for interlingual homophone priming (flesh-arrow). At a longer SOA (1200 ms), no significant effect of interlingual homophone priming was found. Together, these studies suggest that while interlingual homophones simultaneously activate L1 and L2 phonological representations, the propagation to the "inappropriate" semantic representation is limited.

C29 Processing of phonotactic regularities in the lesioned language network. A combined lesion-symptom and ERP approach. *Hellmuth Obrig[1,2], Mentzel Julia[1], Dreyer Maria[1,2], Rossi Sonja[2,3]; [1]Clinic for Cognitive Neurology, University Hospital and Faculty of Medicine Leipzig, Germany, [2]Max-Planck-Institute for Human Cognitive and Brain Sciences, Leipzig, Germany, [3]Medical Psychology, Medical University Innsbruck, Austria*

Phonotactic regularities influence the processing of auditorily presented words (1). This even holds when no lexico-semantic or context information is available (2) and may indicate a prelexical selection process aiding segmentation and lexical access (3). We have shown that monosyllabic pseudowords with a CCVC structure modulate event related potentials (ERPs) depending on the phonotactic status of their onset cluster: clusters 'illegal' to the participants' native language elicit an N400 smaller in amplitude when compared to 'legal' onsets (e.g. /BZOP/ vs. /BROP/; German participants) (4). The key area for this processing may be localized in left BA44/45 as suggested by an fMRI study using the same material (5). Here we address the question whether and how acquired brain lesions in the left hemisphere interfere with prelexical processing. The approach combines clinical measures of word-level impairment with lesion-mapping and ERP recordings using the above described material and thus provides a multimodal assessment of phonological and phonotactic processing in the lesioned language network. •• 37 patients with chronic left hemispheric brain lesion and 33 age-matched controls were enrolled in the study. All participants underwent an EEG recording (32 channels) while listening to different randomizations of 252 stimuli: 84 'legal' (LEG), 84 'illegal' (ILL) pseudowords and 84 stimuli created by digitally reversing the audio trace (REV). 2 blocks consisting of different randomizations of the 252 different stimuli were acquired. Participants had to press a response key whenever a stimulus was repeated. Across the two blocks 100 such immediate repetitions occurred evenly balanced between LEG, ILL and REV at unpredictable intervals (on average ~ every 5th stimulus). Beyond clinically motivated testing patients underwent 3 subtests of the LEMO (6) assessing phonological, lexical and lexico-semantic skills upon auditory presentation. Also a high-resolution structural MRI was available in all patients (3T, Siemens Trio, 1mm3 isovoxel T1). •• For the clinical tests lesion-behavior analysis showed clearly dissociable lesion patterns for the phonological and the semantic task: posterior lesions interfere with performance in the phonological and anterior lesion with the semantic competence according to the LEMO-subtests. For the experimental task statistical analysis confirmed lesser performance for the reversed stimuli in both patients and controls and correlated with an additional lesion location in the anterior portion of the temporal lobe. EEG analysis disclosed a more pronounced difference between the stimulus categories in controls when compared to patients. Patients however showed a large variance. Qualitative analysis of the 'ERP-lesion mapping' suggests lesion location to correlate with the EEG marker of phonotactic processing. We thus show that brain lesion may interfere with sublexical processes not readily accessible to standard clinical testing. Additionally the approach converging clinical, behavioral and electrophysiological measures may bear some potential in the clinic-scientific research on aphasia. •• (1) Trask RL (1996). London: Routledge. (2) Steinberg J et al. (2011) Psychophysiology 48:1208-12163. (3) McQueen JM (1998) J Memory&Language, 39, 25. (4) Rossi S et al. (2011) J Cogn Neurosci, 23: 1752-64. (5) Rossi S et al (2010) Poster 16th OHBM; (6) De Bleser R et al. (2004) Amsterdam: Elsevier

C30 Direct electrophysiological registration of phonological and semantic perception in the human subthalamic nucleus *Miet De Letter[1], Annelies Aerts[2], Sarah Vanhoutte[3], John Van Borsel[4], Robrecht Raedt[5], Leen De Taeye[6], Pieter Van Mierlo[7], Paul Boon[8], Dirk Van Roost[9], Patrick Santens[10]; [1]Ghent University, Ghent University Hospital, [2]Ghent University, [3]Ghent University, [4]Ghent University, Universidade Veiga de Almeida, Rio de Janeiro, [5]Ghent University, [6]Ghent University, [7]Ghent University, [8]Ghent University, Ghent University Hospital, [9]Ghent University, Ghent University Hospital, [10]Ghent University, Ghent University Hospital*

Background: The subcortico-cortical interaction in verb processing is under the influence of three circuits: the direct, indirect and hyperdirect pathway. Action verb and phonological processing is established by a process of mutual cortico-subcortical interaction within these three neural circuits. Damage of these systems have been related to semantic and phonologic dysfunction in pathologies such as aphasia after stroke and Parkinson's Disease. Aims: Aside from the discussion about motor cortex involvement in action verb processing, this study determines if perception of action, non-action verbs, phonemes and words can be registered in the subthalamic nucleus (STN) and to what extent these semantic and phonological processes are sensitive for dopaminergic administration. Moreover we explore if the perception of action and non-action verbs as well as phonemes and words occurs at a different time frame in comparison with cortical regions. Method: Direct electrophysiological recording of the STN local field potential activity occurred one week after the implantations of the electrodes in seven patients with Parkinson's Disease. Semantic and phonologic related potentials were measured with and without dopaminergic administration. The results were compared

with semantic and phonological cortical event-related activity, using the same language paradigms as in the current study. Results: This study demonstrates that the STN is involved in the early stage (100 ms) of action and non-action verb detection, preceding cortical activity in the middle frontal gyrus at 100-140 ms and in the postrolandic area at 260-380 ms. After dopaminergic administration a second potential was elicited in the left STN at 200 ms. From phonological perspectives, the STN is involved in phonological perception, with shorter latencies of all the potentials in the STN than in the latencies obtained in the cerebral cortex in age-matched healthy controls. Discussion: The involvement of the STN in phonological and semantic perception is especially important in the early processing of both modalities, which puts the STN undoubtedly in a position to modify semantic and phonological perception in a larger cortico-subcortical network.

C31 Functional subdivisions in the supramarginal gyrus for phonology and semantics

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INTRODUCTION Previous studies have shown that the left supramarginal gyrus (SMG) is more activated for phonological than semantic decisions. However, when phonological and semantic processes are not manipulated independently, it is not possible to tell if SMG activation relates to the presence of phonological processing or increased demands on another process (e.g. attention) when semantic cues are absent. We therefore manipulated phonological and semantic processing independently in a fully factorial design, using fMRI to identify functionally specialised areas within the SMG. METHODS 26 healthy native English speakers participated. The four conditions of interest were Phonology (P), Semantics (S), both (SP) and neither (Baseline – B). To avoid the influence of sensory differences between stimuli, we looked for effects that were common across auditory and visual modalities. P stimuli were auditory or visual pseudowords. S stimuli were pictures of objects or the sounds they naturally make. SP stimuli were auditory or visual words, conveying the names of the objects used in the S stimuli. B stimuli were meaningless pictures in one of 8 possible colours (visual modality) or meaningless humming in a male of female voice (auditory modality). The object names for the SP and S conditions were counterbalanced across conditions and subjects. The task was to overtly read or repeat the words and pseudowords, name the objects and colours, or to say the gender of the humming voice (male or female). Statistical analyses identified the main effects (positive and negative) of (1) semantics, (2) phonology and (3) the interaction of semantics and phonology that were common to auditory and visual stimuli. We report activation in the left or right parietal lobes that survived correction for multiple comparisons across the whole brain in height or extent (p-corrected<0.05). RESULTS Semantic compared to non-semantic conditions enhanced activation in left angular gyrus (ANG) and reduced activation in bilateral dorsal anterior SMG. Phonological compared to non-phonological conditions enhanced activation at the junction of the left dorsal anterior SMG and postcentral gyrus with no significant reductions. The combination of semantic and phonological processing (i.e. word stimuli) enhanced activation in the posterior SMG on the border of ANG with no significant reductions. Finally, the presence of either semantics or phonology (i.e. all conditions except baselines) enhanced activation in the left ventral anterior SMG with no significant reductions. CONCLUSION By manipulating semantics and phonology independently, across two modalities, we show that (1) activation in bilateral dorsal anterior SMG is related to the absence of semantics rather than the presence of phonology; (2) a more anterior SMG region responded to phonological content; (3) a more ventral SMG region responded to either semantic or phonological content; and (4) a more posterior SMG region, on the border of ANG, responded to the combination of semantics and phonology. These findings dissociate four different SMG regions and indicate how processing that supports speech production in the absence of semantics has previously been mistaken for phonological processing. Further investigation is required to determine what types of processing increase in the absence of semantics.

C32 Site-specific modulation of lexicality effects in auditory verbal short-term memory using TMS

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The superior recall of real words compared to nonwords in short-term memory is well established. It is thought that the long-term semantic and phonological-lexical representations activated by a spoken word help to bind its phonemes in order in short-term memory. This study sought to test whether TMS applied to a region associated with processing phonological-lexical forms, the left supramarginal gyrus (SMG), would have a greater relative impact on immediate serial recall (ISR) performance of nonword lists compared to word lists, while stimulation of a semantic site, left anterior temporal pole (ATL), would not affect meaningless nonwords and only affect word recall. Twelve participants were tested in two separate TMS sessions on their recall of lists of words and nonwords adapted in length according to participants' word and nonword span, and a control visual pattern memory task in 10 minute tasks before and after 10 minutes of 1 Hz rTMS. After removing one participant showing blanket facilitation across all tasks, recall data showed that TMS interacted with ISR performance in a site- and stimulus-specific way: The number of nonwords recalled correctly in position declined after SMG stimulation, but not ATL, and number of words recalled correctly in position showed greater decline after ATL stimulation than after SMG. This pattern was reflected in significant TMS-related increases in the number of incorrect phoneme

productions for words following ATL stimulation and for nonwords following SMG stimulation, in addition to relative increases in phoneme migration errors for nonwords following SMG stimulation. The visual control task performed alongside ISR, on the other hand, was not modulated by TMS applied to either site. These data indicate that, without independent support of lexical and semantic knowledge, the stability of nonwords is more vulnerable to interference in phonological input processing than words while the word advantage in recall may be diminished when contributions from representational knowledge supported by anterior temporal function is compromised.

Signed Language

C33 Functional network rewiring from manual gesture to language

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Introduction: Previous studies have demonstrated that neural correlates corresponding to language processing were also involved in non-linguistic manual gesture processing, supporting the claim of the gesture origin of language. However, it remains unclear how the sharing neural network is structurally organized and how it generates complex dynamics to support language and non-linguistic gesture processing respectively. Considering that language is unique and sophisticated, we hypothesized that the functional network for non-linguistic gestures is rewired to afford the unique language processing. If it is true, the brain regions in the network will interact with one another in different way in language processing compared to non-linguistic gesture. Using fMRI and graph analysis, we tested the hypothesis by investigating the interregional connectivity structure of the functional network in processing language and non-linguistic gesture. Method: 13 hearing signers (bimodal bilinguals) and 13 hearing non-signers were scanned while they watching visually presented sign sentences (for the non-signers, the stimuli were non-linguistic manual gestures).Whole-brain activation pattern was analyzed first. Next, Graph analysis was performed using the Gretna toolbox. Based on the peaks got from conjunction analysis on hearing signer group (for sign language processing) and non-signers (for non-linguistic gesture processing), we acquired a sharing network consists of 22 nodes (ROIs).Then we calculated functional connectivity for every possible pair of ROI, generating an N-by-N matrix C (here N = 22) for each subject. A wide range of thresholds (network cost value ranging from 0.1 to 0.6) were applied to binarize the matrices. Finally, Small-worldness, network global efficiency and local efficiency were measured for each group. To qualitatively understand how the network was organized, we further analyzed the modular structure. Results: Activity analysis reveals largely similar pattern for sign language processing and non-linguistic gesture processing. No significant group difference is found (FDR=0.05). Conjunction analysis reveals a network including the left pars triangularis, middle frontal gyrus, precentral gyrus, superior and middle temporal gyrus, occipital gyrus, fusiform gyrus, inferior parietal lobule, supramarginal gyrus, and right inferior parietal lobule, precentral gyrus, inferior ,middle temporal gyrus. Compared with non-signers, hearing signers present higher local efficiency and better small-world property. Modularity analysis reveals that module components and module hubs vary across groups. Conclusion: Although the activity patterns for processing language and non-linguistic gesture are largely similar, graph analysis reveals the functional network for language has better local network efficiency and small-world property, indicating more efficient communication within the network. Besides, modularity analysis demonstrates the network is differentially organized for processing sign (for singers) and non-linguistic gesture (for non-signers). In conclusion, our results indicate that, from gesture to language, the functional network has rewired itself into a more efficient system. * Dinggsh@bnu.edu.cn

C34 Brain-based individual difference measures of reading skill in deaf adults

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A majority of deaf students leave high school reading at or below a fourth grade level, but some deaf individuals do become highly proficient readers. There is disagreement about the causes of this reading difficulty, and by association, disagreement about the effectiveness of different strategies for teaching reading to deaf children. One hypothesis is that a focus on teaching the phonology of language will help deaf children learn to read; a competing hypothesis is that early skill in a signed language is more important. The goal of this study was to use real-time measures of neural language processing to better assess what is associated with successful reading in deaf adults. Two groups of participants took part in this study: 1) adults who became severely or profoundly deaf before two years of age, and 2) age-matched normal hearing adults. Event-related potentials (ERPs) were recorded while participants read: a) sentences that were either well-formed or contained a subject-verb agreement, semantic, or combined semantic-agreement error, and b) pairs of words that were either unrelated or related in semantics, phonology, orthography, or both phonology and orthography (with a lexical decision task). Standardized reading comprehension skill, speechreading skill, and comprehensive information about participants' language, education, and family background was also obtained. While deaf participants showed a reliable P600 to agreement violations, an N400 response dominated the grand mean response to combination semantic-agreement violations. This suggests that the semantic and syntactic processing streams are less independent for deaf participants than hearing participants. After controlling for factors of speechreading skill, language background, years of education, and familial sinistrality, reading comprehension skill was a significant predictor of a more N400-like (rather than P600-like) response to combination semantic-agreement violations. This suggests that more skilled deaf readers may be focusing

primarily on the meaning of a sentence, rather than its syntax. In terms of word priming results, deaf and hearing participants both showed large N400 priming responses to words related in semantics, orthography, and a combination of orthography and phonology. Both groups showed no significant priming response to words related only in phonology. For deaf participants, the size of the phonological priming response was not a predictor of standardized reading skill, even after accounting for differences in speechreading skill, years of education, and language background. The size of the orthographic priming response, however, was a significant predictor of standardized reading skill when accounting for differences in these subject variables. These results do not support the hypothesis that phonological knowledge is necessary for skilled reading in deaf individuals. Rather, they indicate that skilled deaf readers may be relying on different reading strategies than proficient hearing readers, such as a focus on the overall meaning of a sentence rather than a thorough parsing of the syntax (Ferreira & Patson, 2007). Overall, our results begin to answer questions about what is and is not associated with skilled reading in deaf individuals, which is paramount to improving the strategies used to teach reading to deaf children.

C35 Heschl's gyrus responses to visual language in deaf individuals are driven by auditory deprivation, and not by language modality

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Sensory cortices in the brain preferentially process inputs from a single modality. However, if the input from the preferred modality is absent, cortices reorganise to process other sensory modalities. Congenital deafness in humans represents a particular case with respect to other types of sensory deprivation, because the plastic reorganisation observed in the cortex is not only the result of auditory deprivation, but also of language-driven mechanisms, such as speechreading, sign language, and potential late language acquisition. Studies of language and sensory processing in deaf and hearing populations have provided understanding about the contribution of each of these factors to plastic changes in "higher auditory regions". However, it is still unclear if plastic reorganisation also takes place in primary auditory areas, and what the effects of language experience and sensory deprivation are. Here, we dissociated the effects of language experience and auditory deprivation on visual crossmodal plasticity in cytoarchitectonic regions of Heschl's gyrus (HG). Using fMRI, we measured the BOLD response to viewing British Sign Language in congenitally or early deaf individuals with and without sign language knowledge, and in hearing controls. Results show that differences between hearing and deaf individuals in HG are mainly due to a deactivation driven by visual stimulation in the hearing group. There were no significant differences between the group of deaf individuals with knowledge of British Sign Language and those who use English as their only form of communication. Therefore, differences between deaf and hearing groups are due to auditory deprivation, and not due to the modality of their preferred language (i.e. sign language or spoken language).

Language Development, Plasticity, Multilingualism

C36 Proficiency and age of acquisition predict brain activation and white matter connectivity in Mandarin-English bilinguals

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Past research has shown that both and age of acquisition (AoA) and proficiency affect L2 processing (Perani et al., 2003; Wartenburger et al., 2003). However, AoA and proficiency are often examined individually, and few studies have investigated how these two factors jointly influence the brain organization of L1 and L2. The present study investigated the semi-independent effects of L2 proficiency and AoA on both functional activation and white-matter structural differences. Twenty-three Mandarin-English bilinguals of various L2 AoAs and proficiency levels completed a picture-word matching task in both English and Mandarin while undergoing functional MRI, followed by a diffusion tensor imaging (DTI) scan. Proficiency levels and AoA were assessed by means of a proficiency test and a background questionnaire, respectively. Using multiple regression, it was possible to treat these variables as continuous, rather than dividing subjects into discrete groups of high/low proficiency and early/late AoA. Likewise, although these two measures are generally tightly correlated, by using multiple regression we were able to tease apart the independent effects of either on the fMRI and DTI measures. Analyses of fMRI data indicated that AoA and proficiency both independently modulated brain activity during L2 lexical processing. Specifically, proficiency predicted activity in areas including the right insula, right middle temporal gyrus, and left parahippocampal gyrus, while AoA predicted activation levels in the left superior temporal gyrus and right parahippocampal gyrus. DTI analyses revealed congruent effects; we performed probabilistic tractography using functionally defined regions of interest as seeds, then calculated mean fractional anisotropy (FA) and mean diffusivity (MD) values for each set of tracts. Analyses revealed that AoA predicted FA in white matter tracts emerging from the left middle temporal gyrus and the right supramarginal gyrus, and predicted MD in the white matter tracts emerging from the left parahippocampal gyrus and right insula. While proficiency was correlated with FA in white matter tracts emerging from the right supramarginal gyrus, it was not correlated with MD. These results suggest that proficiency and AoA explain separate networks of both functional and structural organization in the bilingual brain, suggesting distinct types of plasticity for age-dependent effects (i.e., AoA) and experience and/or predisposition (i.e., proficiency) in second language learning. We conclude by discussing

how to disentangle the direction of the relationship between behavioural measures and white-matter structural differences.

C37 Neural Oscillations provide insight into developmental differences between children and adults during auditory sentence processing.

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Introduction. Although even young children seem to process natural language with ease, behavioral and neuroimaging studies reveal subtle differences in abilities and neural engagement through early adolescence compared to adults (Clark, 2003; Holland et al., 2007). Time-frequency analysis of the EEG allows for a detailed, temporally precise investigation of changes in neural oscillations which may elucidate these later-developing differences in neural recruitment (Maguire & Abel, 2013). Specifically, in adults, previous research indicates that theta changes relate to semantic retrieval and integration (Wang et al., 2012; Bastiaansen et al., 2005), alpha changes relate to verbal working memory (Meyer et al., 2013) and beta changes relate to syntactic integration (Bastiaansen et al, 2010; Meyer et al, 2013). In this study we use time frequency analysis of the EEG to study developmental changes in the neural underpinnings of natural language comprehension in children and adults. Methods. Twenty-three adults and sixteen children ages 10-12 years (all right-handed, monolingual English-speakers) performed grammaticality judgments of 160 sentences as their EEG was recorded. Stimuli were naturally paced auditory recordings of simple active sentences. Errors were verb agreement errors; however, because we are interested in typical processing, only data from grammatically correct sentences are presented here. Analysis. EEG data were epoched from 500 msec before the onset of the first word (baseline) to 3500 msec into the sentence. Time–frequency analysis was used to quantify event-related spectral perturbations. Throughout the epoch, data was Fourier transformed, magnitude squared, and normalized to obtain the power spectral density. Data were averaged across trials and subjects, and computed using the log power values minus the baseline (Delorme & Makeig, 2004). Within EEGLAB, an interactive Matlab toolbox, we performed random permutation statistical analysis of the EEG data, computing p-values for both the time and frequency points for each comparison of interest. Results. As expected, children and adults exhibited significant changes in theta, alpha, and beta during sentence processing compared to baseline. When comparing age groups, the largest differences were in the beta frequency (13-30 Hz), where multiple central electrodes revealed significant differences between groups over the course of the 3500 msec time window. This difference was driven by adults exhibiting widespread, consistent beta synchrony compared to children who were more variable. Within the theta band, children and adults engaged frontal theta until approximately 2400 msec, after which adults demonstrated desynchrony while children continued to maintain frontal synchrony. Engagement of alpha was relatively similar between groups. Conclusion. These findings indicate that the largest developmental differences between children and adults when processing naturally paced oral language are due to adults' more efficient and consistent engagement of beta, potentially for syntactic integration. Both children and adults engaged theta similarly, related to semantic retrieval and integration, though it was more prolonged in children. Both groups revealed similar use of alpha, likely related to verbal working memory. These results highlight important differences between children and adults in neural engagement during natural language comprehension, potentially explaining why adults process complex linguistic features more efficiently than children.

C38 Visual ERP repetition effects to novel objects predict word fast-mapping ability in 20-month-olds

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Vocabulary development between 18 and 24 months shows enormous individual variability (Fenson et al., 1994). Although the causes of individual differences are many and complex, one factor that has been found to predict productive vocabulary at this age is the ability to receptively fast map a novel word to a novel object (Torkildsen et al., 2009; Torkildsen et al., 2008). In other words, productive vocabulary is dependent on effective receptive processing of novel words and their referents. Previous research has demonstrated this link using ERP measures of word processing during learning, and later mismatch responses (N400) to incongruous word and object pairings. We wanted to investigate if efficiency of visual object processing could also be predictive of subsequent measures of successful fast mapping. A sample of 20 months old children (n = 38) contributed data in an ERP experiment showing pictures of fantasy objects paired with auditory presentations of pseudowords. Familiar words and objects were also included as a control. The experiment contained 30 items of each stimulus type, divided into 10 independent presentation blocks. During a learning phase each picture was presented 5 times together with the same label, always with other interleaving pictures/words, and the picture was presented 1000 ms before onset of the word stimulus. In a test phase directly following the learning phase, the same pictures were presented with a label that was incorrect but equally familiar. The semantic incongruity effect as measured by N400 amplitude was used as an index of successful fast mapping, and this was related to a negative central (Nc) response to the picture stimuli, modulated by repetition. EEG data was recorded with Electrical Geodesic's (EGI) HydroCel Geodesic Sensor Nets (HCGSN) with 128 channels. To test the relationship between ERP responses and vocabulary, the children were divided into two groups based on productive vocabulary size. Repeated-measures ANOVAs were carried out to test the statistical effects of differences in ERP waveforms, and productive vocabulary group was entered as a between-subjects factor. The relation between ERP effects was tested with a linear regression model. The sample as a whole did not produce a significant N400 incongruity effect to

newly learned pseudowords, regardless of vocabulary size, although the effect was present in the real word condition. However, the size of the Nc repetition effect to fantasy object pictures was found to predict the size of the N400 amplitude difference between congruous and incongruous pseudoword presentations, r = 0.462, p = 0.004, and in fact, when grouped according to their repetition difference scores, a group of 11 children with the biggest amplitude difference due to repetition showed a significant N400 incongruity effect to the pseudowords, F (1,10) = 5.69, p = 0.038. The results suggest that the ability to successfully fast map novel words to novel objects is not only related to efficient word processing but also dependent on efficient processing of the visual object information.

C39 L-dopa modulates frontostriatal signalling during encoding of new unfamiliar picture-pseudoword pairings

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BACKGROUND: The dopamine precursor L-dopa has been shown to improve new word learning in healthy adults and modulate activity in frontotemporal regions involved in language, learning and executive function. However the neurocognitive mechanisms by which L-dopa modulates word learning, particularly initial word encoding, are not yet clear. This study used functional magnetic resonance imaging (fMRI) and a double-blind, placebo-controlled, within-subjects study design to investigate the neurocognitive and behavioural effects of acute L-dopa administration on the encoding of novel words. Following drug administration, healthy young adults learnt 25 novel pseudoword-picture pairings through the course of a single fMRI scanning session. METHODS: 31 (13 female) healthy adults were randomly distributed between two drug arms. Participants received either Madopar 125mg or placebo 30 minutes prior to event-related fMRI at 4 Tesla with blood oxygen level-dependent (BOLD) contrast. Participants were trained with 25 pairings of auditory pseudowords with pictures of unfamiliar objects over seven explicit training blocks, interspersed with three multiple-choice recognition test blocks. An additional 25 pictures with inconsistent pseudoword pairings were included to form a baseline condition. All image processing and analysis was conducted in SPM8. RESULTS: We conducted region-of-interest analysis in eight regions: bilateral hippocampi, left middle and superior temporal gyri, left inferior frontal, inferior parietal and anterior cingulate cortices, and left striatum. Analysis focused on changes in BOLD signal in the three recognition blocks. We performed repeated-measures ANOVAs for each region, with task condition (Learning, Baseline) and recognition block (1, 2, 3) as within-subject factors, and drug arm (L-dopa, Placebo) as a between-subject factor. Changes in BOLD signal related to L-dopa (regardless of recognition block) were observed in the left striatum (drug x condition interaction, F(1.519, 44.043) = 4.081, p = 0.034). Further investigation of a marginal three-way interaction in the left inferior frontal gyrus (drug x block x condition, F(4.000, 26.000) = 2.746, p = 0.050) revealed a drug x condition interaction in the final recognition test block (F(2.000, 28.000) = 6.245, p = 0.006). Changes in BOLD signal related to the word learning task (regardless of drug arm) were seen in the left inferior parietal lobule (main effect of condition, F(2.000, 28.000) = 4.953, p = 0.014) and right hippocampus (block x condition interaction, F(4.000, 26.000) = 3.073, p = 0.034). CONCLUSIONS: These findings suggest that L-dopa may modulate recruitment of the striatum and inferior frontal gyrus during retrieval of newly-learnt picture-pseudoword pairings. In the left striatum, L-dopa appeared to reduce differences in BOLD signal between the different task conditions. In the left inferior frontal gyrus, modulation was particularly evident in the final recognition block, where the pattern of differences in BOLD signal between the different task conditions in the L-dopa group was opposite to that of the placebo group. These results could reflect modulation of salience signalling by L-dopa related to stimuli in the task, through alterations in frontostriatal signalling. This research provides insight into the neurocognitive mechanisms supporting encoding and retrieval of new lexical-semantic representations, and how this process may be modulated by dopamine.

C40 Tracking the neural dynamics of the formation of a novel language schema

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Humans use schematic knowledge to guide behaviour. Schematic knowledge contains organizing principles of features in the environment that often occur in association. Schema acquisition relies on the abstraction and generalization across repeated interleaved learning experiences. The application of schematic knowledge to language is evident. Language ascribes a sufficiently consistent and unique vocabulary to label similar concepts. The retrieval of this schematic knowledge by the brain has been investigated extensively. However, it is less understood how the brain gradually accumulates initial knowledge across novel repeated associative exemplars to build a schema. Moreover, this process of schema consolidation has often been thought to be long-term, requiring overnight consolidation and exposures on multiple days. After this process is completed, the medial prefrontal cortex is proposed to act as a hub in the neocortical retrieval network of these stored schematic associative memory traces. However, could schema formation already occur across a relatively short interleaved learning session? Here, we systematically track the neural dynamics of the formation of a novel language schema across a learning task, which relies

on the extraction of rules underlying these object-word associations. Importantly, the participants had no prior knowledge of the organizing principles governing these associations. In our experiment, 32 participants learned object-word combinations across trials in an hour-long learning session inside the MRI-scanner. In each trial, they were first presented with a multi-feature object (the cue phase). This object comprised a characteristic colour, shape and movement presented on a grey background. Subsequently, participants were asked to select the corresponding tri-syllabic word from presented choice options (the response phase). Responses were collected by asking the participant to select for each of three syllable locations, the corresponding syllable out of three response options. After each response they received feedback on the accuracy of their choice (the feedback-phase). Across the learning session, 27 participants were able to learn the vocabulary up to criterion (i.e. more than 33% correct in the last run) by associating colour, shapes and movements with syllables at particular locations of the words. Participants' knowledge of these deterministic rules was confirmed by a debriefing questionnaire at the end of the session, confirming that subjects had acquired the schema. The learning curves based on trial-by-trial performance were formally characterized by fitting power curves as well as an adapted state-space model. BOLD-activation during the cue-phase was parametrically modulated by accuracy of the retrieved syllables in the medial prefrontal cortex, and also the left mid-temporal gyrus, right inferior frontal gyrus and left angular gyrus. The left angular gyrus, left midtemporal gyrus and right inferior frontal gyrus are brain regions that have previously been found to support word learning. Here, our findings extend these findings to novel arbitrary words associated with arbitrary objects. Our initial results suggest that the medial prefrontal cortex might already accumulate schematic knowledge and act as a hub in the retrieval of schematic knowledge across shorter delays within a relatively short learning session.

C41 Consolidation of newly learned words with or without meanings: fMRI study on young adults

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Declarative memory is considered to entail episodic memory (memory for episodes that are confined to specific spatial and temporal contexts) and semantic memory (memory for generic knowledge or concepts). Although these two types of memories are not independent and they interact extensively, they seem to involve different brain structures at retrieval, with the hippocampus often regarded to be important for retrieving arbitrary associative information encoded in a specific episodic context, whereas widely distributed neocortical areas, especially higher order associative areas, seem to be important in retrieving semantic or conceptual information. In this word-learning study, we asked if there is more involvement of the episodic memory network when retrieval occurs directly after learning, and if there is a shift towards more involvement of the semantic network as the word becomes more de-contextualized with time. Furthermore, we were interested to see the effect of having extra information at encoding, namely, visual information (a picture depicting the word or a definition describing the word) associated with the phonological form of the novel word. Two groups of participants (picture group n=24; definition group n=24) learned phonological novel word forms with meanings (a picture or a definition) or without corresponding meanings (form-only). Participants' memory for the words was tested in an fMRI scanner directly after training (recent), and again a week later (remote). To test whether novel words were integrated into their lexicon, pause detection and cued-recall of meaning association tests were administered behaviourally. Retrieval success was greater for meaningful words than for form-only words on both recent and remote tests, with the difference becoming larger at remote test. There was evidence of lexicalization (as measured with the pause detection task) for the meaningful words. In cued recall, although participants were quicker to choose the associated meanings if they were presented in the trained form (identical picture/definition), there was less slowing down over time for concept associations (similar picture/definition). Imaging results revealed that hippocampal involvement decreased for form-only words in the picture group, whereas for the meaningful words hippocampal involvement was maintained at remote test. Differences between meaningful and form-only words in the remote session were found in a wide range of neocortical areas for successful recognition of the trained words including the fusiform gyrus, medial prefrontal cortex, precuneus and left angular/supramarginal gyrus. Episodic memory decay over time is unavoidable, but meaningful novel words are better retained. These words also interfered more strongly in judgment of similar sounding existing words, and showed less slowing down for cued recall of meaning associations, both indicating more integration and lexicalization for the meaningful novel words. Better memory for meaningful novel words may be due to the use of both the episodic memory network (hippocampus) and the semantic memory network (left fusiform gyrus, left angular/supramarginal gyrus) at remote test.

C42 Neurophysiological correlates of first-language (L1) attrition and second-language (L2) acquisition: A continuum based on proficiency

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It is controversial whether maturational limits on neuroplasticity impede the "native-likeness" of neurocognitive mechanisms underlying L2-processing, or whether factors such as proficiency or exposure have a greater impact than age-of-acquisition on language-processing in the brain. Immigrants immersed in a new language in adulthood shed light on this question, as they become highly-proficient in the late-acquired L2, while experiencing changes or "attrition" in the native-L1. Our aim was to explore the neural correlates

of L1-attrition, and determine whether it parallels L2-acquisition but in reverse, with proficiency modulating language-processing patterns. Using ERPs and several behavioral measures, we examined lexical-semantic processing in Italian and English in 24 Italian-English immigrants (highly-proficient in English and reporting attrition in Italian), and 20 highly-proficient English-Italian late-L2-learners, compared to monolingual Italian and English native-speakers (30 each). Exp.1 tested whether attriters and/or L2-learners confuse Italian words that are similar in form but different in meaning (mento (chin) vs. menta (mint)), failing to detect when a word is swapped with its minimal pair in a sentence context. These "swap" violations were compared to outright "mismatch" violations where the target noun was replaced by a dissimilar word (mento vs. colpa (fault)). Both violations elicited large N400-effects in Italian native-speakers. Attriters showed a large N400 for "mismatches", but a smaller N400 followed by a large P600 for "swaps", suggesting more elaborated/controlled processing further downstream of the semantic anomaly. L2-learners showed an N400-effect only in the "mismatch" condition, and neither an N400 nor a P600 for "swaps". However, ERP patterns were dependent on proficiency, regardless of whether Italian was the L1 or L2. Attriters in the higher-proficiency range in Italian (L1) showed large N400-effects and P600s for both violations, whereas those in the lower range (i.e.,more attrition) did not automatically detect the "swap" (no N400-effect), and showed only a small P600. Similarly, only L2-learners with the highest Italian (L2) proficiency showed an N400-effect for "swaps". Exp.2 assessed whether the Italian lexicon of attriters and L2-learners was automatically co-activated while reading in English, and whether proficiency-levels modulated such co-activation. Participants were shown sentences where target nouns were interlingual "false-friend" homographs (estate (property vs. summer) or frequency- and length-matched interlingual cognates (music/musica). The critical comparison involved a correct condition where the homograph appeared in its English context (EH), compared to a context priming its Italian meaning (IH). While English-native-speakers elicited as large an N400-effect for "IH" as for other semantic violations, only attriters and L2-learners in the lower Italian proficiency range showed a large N400; participants with higher proficiency-levels showed a reduced N400-effect, indicating co-activation of the Italian meaning. Moreover, when considering attriters' relative proficiency-levels (Italian-English), attriters in the Low-High group most resembled English-native-speakers, while attriters in the High-Low group failed to show significant N400-effects in any of the semantic violations. These findings not only provide novel evidence of L1-attrition in online processing, but also suggest that advancing L1-attrition and L2-acquisition have something in common – proficiency seems key in determining the neural correlates underlying language-processing, whether the language is the early-acquired-L1 or the late-learned-L2.

C43 Motor cortex involvement in neurosemantics of L1 and L2: evidence from rapid mu-rhythm desynchronisation

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What are the neurobiological mechanisms which enable us to use and understand language? In traditional accounts, words become meaningful through links they have with other symbols in our lexicon, which is supposed to be represented in an amodal system operating independently from primary modality-specific neurobiological structures. Recent neuroimaging studies in monolinguals, however, give increasing support to an alternative claim. According to this research, semantic representations of words are supported by basic sensorimotor structures and are thus biologically grounded in the same neural substrates and mechanisms which enable human action and perception. Because of the central role these theories give to experience, it is important to test whether the kinds of sensorimotor cortical areas which seem to underpin native language (L1) comprehension are also active during second language (L2) processing. In L2, people most commonly lack the high level of expertise which they possess in their native language. It is therefore possible that L2 words may not be characterised by the same strong action-perception circuits which in monolingual studies have been taken as proof of the embodied nature of lexical semantics. This possibility would have important implications for the current theories: if L2 action words are understood without motor cortex involvement, then the claim that the latter is an integral part of the semantic network is questionable. Our study asked whether the motor cortex, thus far absent in bilingualism research, shows differential responses depending on the language of the stimuli and their action semantics. We used high-density EEG to dynamically measure changes in the cortical motor system's activity, as indexed by event-related desynchronisation (ERD) of the mu-rhythm. Our task employed a passive word-reading paradigm (in both L1 and L2) which eliminates task demands encouraging deep semantic processing, while at the same time ensuring that word meaning and language differences could be evaluated separately. Analysis of motor-related EEG oscillations at the sensor level revealed an early (starting before 200 ms) and left-lateralised coupling between action and semantics during both L1 and L2 processing. The finding is important because it is, to the best of our knowledge, the first confirmation that motor cortex oscillatory dynamics exhibit similar patterns in both languages of bilingual subjects. Crucially, source-level activation in the motor areas showed that mu-rhythm ERD, while present for both languages, is significantly stronger for L1 words. This finding suggests that increasing linguistic experience leads to greater sensorimotor involvement, whereby word meaning is embodied in strongly integrated neural networks formed through associative learning mechanisms. This clearly demonstrates that the motor cortex is sensitive to both the action semantic content as well as the language of

written words. In conclusion, our results both strengthen embodied cognition evidence obtained previously in monolinguals and, at the same time, reveal important quantitative differences at the level of L1 and L2 neurosemantic representation.

C44 Context affects L1 but not L2 during bilingual word recognition: an MEG study

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How do bilinguals manage the activation levels of the two languages and prevent interference from the irrelevant language? The mechanisms that control the use of languages and the factors that potentially affect their activation levels are not yet well understood. Does the surrounding context in which the words appear modulate the basic activation levels of the languages: for example, is the language not currently in use actively inhibited to prevent its interfering influence? Are such effects modulated by the relative language dominance (L1 / L2) within the individual? Models of bilingual lexical processing differ with regard to the effect context is assumed to play in actual word recognition processes. We utilized magnetoencephalography (MEG) to obtain a detailed view on the time-course of auditory L1 and L2 word recognition processes in the left and right temporal cortex and to study the effect of context on these processes in late Finnish-English bilinguals. In the experiment, late Finnish-English bilinguals (N=16) listened to Finnish (L1) and English (L2) spoken words presented once every 2300 ms. In one session 80 % of the words were in L2 English and 20 % of the words in L1 Finnish, and in the other session 80 % in Finnish and 20 % in English. The task of the participants was to respond to all words denoting food, irrespective of language. The signals detected by the MEG sensors were localized in each individual subject using Equivalent Current Dipole (ECD) analysis. From the source activation patterns we first determined the upper limit time-window for semantic access by comparing the semantic (food – non-food) conditions. The main analysis focused on the preceding part of the N400m responses when the actual word recognition processes were assumedly still ongoing. During this time-window brain responses for L1 and L2 words were compared between L2 and L1 contexts. The responses between the semantic conditions started to differ at around 500 ms in Finnish and at around 550 ms in English. At an earlier time-window, between 300-500 ms in the temporal cortices, we found an asymmetric effect: The N400m responses were significantly amplified for L1 Finnish words presented in a predominantly English context when compared to Finnish words in a predominantly Finnish context. In contrast, the responses for L2 English words did not differ with respect to the context in which they were presented. This result supports the view that the stronger language needs to be suppressed in an L2 context to prevent its interference, but the weaker language does not require such measures in an L1 context. This finding is in line with models that allow auditory word recognition to be affected by contextual factors and the lexical systems to be subject to inhibitory influences.

C45 Hemispheric Involvement in Native and Non-Native Comprehension of Conventional Metaphors

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Introduction: Metaphoric language is extremely pervasive in everyday communication. Previous research in native language (L1) speakers has reported either left hemisphere (LH) superiority or no hemispheric differences (Faust & Mashal, 2007) in the processing of conventional metaphors. However, the hemispheric mechanisms underlying processing of metaphoric expressions in second language (L2) are largely unknown. According to the Graded Salience Hypothesis (Giora, 1997), there is a LH advantage when processing salient, familiar semantic relationship between the meanings of single words, whereas the right hemisphere (RH) benefits more from nonsalient, unfamiliar semantic relationship. We hypothesized that L1 metaphors whose figurative meanings are strongly coded in the lexicon and have salient, familiar meanings, would thus rely more on LH processing. In contrast, L2 metaphors represent less salient meanings and therefore would be associated with greater RH involvement. Methods: Twenty-four early bilingual English-Hebrew speakers (mean age = 22.88 years) and 25 monolingual Hebrew speakers (mean age = 24.47 years) participated in the study. The bilingual participants learned English as L1 and were first exposed to Hebrew before the age of 10. All participants were right handed according to self-report. In Experiment 1, the two groups performed a semantic judgment task on conventional metaphors, literal word pairs, and unrelated word pairs in Hebrew, and in Experiment 2, the processing of the expressions was compared between the two L1s (English in bilinguals and Hebrew in monolinguals). In both experiments, the divided visual field paradigm was applied. The participants also completed a Hebrew word decoding task. Results: The analysis of reaction times collected in Experiment 1 (Hebrew expressions) controlled for differences in Hebrew word decoding ability. The results indicated that the groups had differential patterns of hemispheric asymmetries for metaphoric but not literal expressions processing. As predicted, L1 Hebrew speakers were faster to RVF/LH than to LVF/RH metaphoric expressions, whereas L2 Hebrew speakers showed a reversed pattern. They were slower to RVF/LH than to LVF/RH metaphoric expressions. There was no visual field difference for literal expressions in monolingual or bilingual groups. Reaction time patterns observed in Experiment 2 were also consistent with our hypotheses and indicated that there was a RVF/LH advantage in both groups performing the task in their respective L1s for processing conventional as well as literal expressions. Conclusions: In line with the Graded Salience Hypothesis (Giora, 1997), the findings of the present study indicate that the RH plays a unique role in processing the less salient meanings, as in L2

metaphors, whereas L1 metaphors representing the salient meanings show LH advantage. More generally, the study indicates that figurative language is processed differently in L1 compared to L2, even in early bilinguals. References Faust, M., & Mashal, N. (2007). RH advantage in processing novel metaphoric expressions: Behavioral data. Neuropsychologia, 45, 860-870. Giora, R. (1997). Understanding figurative and literal language: The graded salience hypothesis. Cognitive Linguistics, 7, 183–206.

C46 Game based second-language vocabulary training strategies; implications for learning outcomes and brain function

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The goal of the current study was to assess the efficacy of two second-language (L2) vocabulary training strategies on learning outcomes and brain activation. Words in a language novel to participants (Spanish) were taught using LANGA (Copernicus Studios, Halifax, NS), a set of computer games using automated speech recognition. A vocabulary of 72 words (none of which were English cognates) were taught over 6 half-hour sessions. Half the words were taught via paired association (i.e. a picture paired with an individual spoken Spanish word) and half were taught contextually (i.e. visual representation paired with 3-word spoken Spanish sentences), with word assignment balanced across participants. Participants were assessed on Spanish vocabulary knowledge before and after training, using both a picture naming task and a picture-word match/mismatch task. ERPs (event-related potentials) were recorded during the latter task. As the N400 is an index of lexical access, we predicted a N400 ERP mismatch-match difference after, but not before training. After training, subjects were able to name significantly more items than before training. Mismatched picture-word pairs elicited an N400 effect after, but not before training. Initial analyses suggested that the N400 was greater for words taught contextually than for those taught by paired association. This research demonstrates the efficacy of automated speech recognition in teaching vocabulary in a new language, and suggests that contextual teaching strategies appear to foster better second language retention.

C47 Effect of Levodopa on Learning New Words with Semantic Attributes

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BACKGROUND L-Dopa is a dopamine precursor that has been shown to improve implicit word learning in healthy adults. L-Dopa has also been shown to modulate semantic processing and enhance semantic salience, which may be of relevance to mechanisms of new word learning. The present study aimed to investigate whether augmenting brain dopamine levels with L-Dopa would enhance new word learning in healthy adults. We also sought to evaluate whether words paired with semantic information would be learnt more effectively than words paired with non-semantic information, and whether L-Dopa would influence this process. METHODS 21 (12 female) healthy young adults participated in an initial word learning session. Prior to the learning session, each participant received either L-Dopa (as Madopar 125mg) or placebo in a double-blind randomised design. Participants learned written names for 20 pictures of novel aliens, with each name consisting of a legal nonword and either two adjectives (the Semantic condition) or two uncommon surnames (the Non-Semantic condition). Written recall and multiple-choice recognition of the new names was tested during the learning session, and at a follow-up session 7-10 days later. RESULTS Participants who had taken L-Dopa prior to learning exhibited higher recall accuracy during the learning session and at follow-up than those who had taken placebo. There was no influence of learning condition (Semantic or Non-Semantic) on recall accuracy at either timepoint. However, there was an influence of learning condition on recognition accuracy at the follow-up session, with the L-Dopa group displaying greater accuracy for stimuli in the Semantic condition than the Placebo group. This effect was not observed for stimuli in the Non-Semantic condition. CONCLUSIONS The differences in recall performance between drug groups suggest that L-Dopa improved the speed and success of new word learning, and also improved retention of the new words. The difference observed in recognition performance between the two groups at follow-up, exclusively for the Semantic condition, suggests that L-Dopa enhances semantic-based encoding of new words resulting in superior consolidation.

Lexical Semantics

C48 The Processing of Figurative Two-part Allegorical Sayings: An ERP Study

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The paper employed ERP technique and Chinese traditional riddle-solving paradigm to explore the time courses and dynamic neural mechanisms of processing figurative two-part allegorical sayings. The results showed significant differences for two ERP components (N170 and N380) between highly familiar and highly unfamiliar linguistic stimuli: for both N170 and N380, highly familiar linguistic stimuli elicited significantly smaller ERP effects, whereas highly unfamiliar linguistic stimuli significantly larger. The N170 may be an ERP component which is related to an early recognition of perceptual discrepancy between the two parts of figurative two-part allegorical sayings, which can also be regarded as early preliminary context integration. The N380 is probably a significant index for the identification and solution of the semantic gap between the two parts. In the process, insight phenomenon was engendered when highly unfamiliar figurative two-part allegorical

sayings were processed. What is worth mentioning is that the N170 and N380 have been reported for the first time in ERP studies in which Chinese idioms are chosen as linguistic stimuli. The paper has demonstrated empirically that it is the different activation relations between the first parts and the answers of the two different types of figurative two-part allegorical sayings that lead to the different time courses and dynamic neural mechanisms.

C49 Dissociating Lexical-semantic Activation and Combinatorial Processing in the Human Language System

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Language comprehension relies on two critical fundamental linguistic computations. One is the retrieval of lexical-semantic information with the spread of activation to related concepts, which contribute the basic building blocks to other higher-level language processing. The other is the combinatorial processing, which allows us to combine limited semantic units into infinite possible meanings. Moreover, effectively incorporating lexical-semantic activation and combinatorial processing can improve the comprehension of phrases, the building of coherence across sentences, and the construction of predictions within a meaningful context. Previous studies have revealed that language comprehension relies on the ventral language system. However, it is not yet clear which sub-regions within the ventral system are specifically associated with lexical-semantic activation, combinatorial processing, or both of them. The goal of our study was to investigate the neuroanatomical bases of these two processes, and to further reveal how these specified regions are anatomically connected with each other. These goals were achieved by defining cortical regions within the language system using functional MRI (fMRI) activations and tracking the white matter fibers linking these activated regions using DTI-based tractography. Twenty-six subjects were recruited in the present study, in which subjects were required to participant in a fMRI experiments with three task sessions. In the first session, we used the contrast of lexical-semantic matching task versus pseudoword visual matching task to localize brain regions sensitive to lexical-semantic activation. In the second localization session, we used the contrast of correct sentences versus random noun lists to identify brain regions associated with combinatorial processing. These regions were further used as regions of interest in the following task. In the third task session, we used a lexical-semantic priming paradigm and manipulated the linguistic/semantic relationship between prime and target. Two-character word pairs in Chinese with four types of relationships were constructed: combinatorial (e.g. "Lemon - Cake"), semantically associated (e.g. "Bread - Cake"), unrelated (e.g. "Driver - Cake"), or pseudoword-word (e.g. "Kibol - Cake"). The participants were required to decide whether the target word was a real word or not. The combinatorial condition and the semantically-associated condition were separated in different fMRI sessions to maximize the priming effect. Our results showed that combinatorial processing modulated the activity in the left anterior inferior frontal gyrus (aIFG), left anterior superior temporal gyrus (aSTG), left anterior temporal lobe (ATL), and left angular gyrus (AG), while a semantically-associated effect was found in the posterior inferior frontal gyrus (pIFG), middle section of middle temporal gyrus (mMTG), and posterior superior temporal gyrus (pSTG). Probability fiber tracking analysis further revealed that combinatorial-related regions (aIFG, aSTG, and ATL) were anatomically connected with each other through the extreme capsule (Emc), while the regions in the temporal cortex associated with lexical-semantic activation (mMTG and pSTG) were connected with pIFG through both ventral (Emc) and dorsal (Arcuate Fascicle) pathways. These results suggest that there is a functional dissociation in location between lexical-semantic activation and combinatorial processing during language comprehension. While these regions are functionally specified, they are anatomically connected to form the language system.

C50 "What is Concrete and Abstract and Read All Over!?": An fMRI Study of Polysemy

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The neural representation of word meaning is a central topic of concept representation. Recently functional Magnetic Resonance Imaging (fMRI) has been widely used to look into this topic, and has shed much light on our understanding of human conceptual knowledge. For instance it has been shown that neural activity patterns associated with viewing concrete nouns can be reliably identified and linked to object properties and functions (e.g. Binder et al., 2009; Mitchell et al., 2008; Just et al., 2010). On the other hand most words in natural language have multiple but related meanings, a phenomenon that has been fascinating philosophers and linguistics for centuries but has thus far been made peripheral in Cognitive Neuroscience. One of the most typical examples is the word "book"; it is considered as polysemous because it can be seen as a physical object (e.g. a heavy book) or abstract information (e.g. John does not agree with the book). According to the Generic Lexicon Theory by Pustejovsky, such concepts, which are termed dot-objects, can be seen as a coherent combination of two distinct components, moreover the two senses can be accessed simultaneously as well as being selected exclusively by means of a coercion operation (Pustejovsky, 1995, 2011). In this study we used fMRI to examine the neural basis of an archetypal class of polysemous words, "informational print matter", whose behaviours have been well documented in linguistic literature. Five such nouns were selected (book, magazine, catalogue, sketch, diary), and adjectives were used as contexts to coerce them into either the concrete object sense or the abstract information sense (e.g. worn book and scientific book), which we referred to as the complex contrast. Additionally a simple contrast was constructed as a comparison using two unambiguous categories, FURNITURE and INFORMATION (e.g. desk

and story respectively) to approximate the corresponding partial senses. Eight subjects participated in the fMRI experiment in which they were presented with the written words and performed a semantic decision task. We applied Multivariate Pattern Analysis (MVPA) to analyze the neural activity patterns. Specifically the whole cerebral cortex was divided into 96 Region-Of-Interest (ROIs), and a Support Vector Machine classifier was applied within each ROI to distinguish the two categories in each contrast. The results demonstrated that there was no overlapping region for the two contrast. The simple contrast (FURNITURE v.s. INFORMATION) showed a left-hemisphere dominance, and the two categories were most distinguishable in the bilateral precuneus. This result was in agreement with previous findings of the neural distinction between concrete and abstract concepts. Meanwhile the complex (coercion) contrast recruited regions across the bilateral posterior inferior temporal gyrus, which has been associated with high level visual features, object representation, and less reported in studies using written text. These results suggest that the neural representation of the coerced dot-object concepts is more complex than simply representing the partial sense, highlighting the importance of contextual influence in future studies of language processing and concept representation.

C51 Identifying objects at different levels of specificity: Cortical dynamics in hub and spokes

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Semantic processing emerges from the interaction of an amodal conceptual hub in the anterior temporal lobes (ATL) and modality-specific 'spoke' regions capturing the perceptual and motor features of concrete objects (Patterson et al., 2007). This study used MEG to examine how these components are recruited through time in a semantic categorisation task, and how their involvement is modulated by (1) the level of conceptual identification required (specific vs. general decisions – i.e., contrasting the verbal labels 'poodle' and 'animal' for the same picture) and (2) semantic category (animals vs. manipulable man-made objects). Linearly-Constrained Minimum-Variance beamforming was used to examine task-related changes in oscillatory power in each condition within three ROIs taken from the hub and spoke model, in left ATL (hub), fusiform cortex (FC; visual spoke), and central sulcus (CS; motor/somatosensory hand spoke). The results show a rapid response after stimulus presentation (within 150ms) in both hub and spoke regions. In ATL, these early responses were reductions in oscillatory power (associated with increases in asynchronous neural firing), modulated by both category and specificity from around 100ms post-onset and at 30-40 Hz – with stronger power changes for man-made objects and specific judgements. In the spoke regions, there were marked initial increases in power which did not show specificity effects (peaking at 150ms), and then slightly later power decreases (from 200ms) which were greater for specific-level judgements. These power changes were stronger in FC when animals were identified at the specific level (reflecting the recruitment of visual features when distinguishing between similar animals), and greater in CS when man-made objects were identified at the specific level (since motor/somatosensory features are important for identifying manipulable objects). Our results therefore show early recruitment of both hub and spoke components for semantic categorisation, with effects of semantic variables in the ATL hub from around 100ms, and modality-specific 'spokes' becoming involved in a task-sensitive way from around 200ms.

C52 Context-dependent interpretation of words: MEG evidence for interactive neural processes

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One of the most important aspects of language is that words can receive different interpretations in different contexts. Word meanings are not fixed entities or lists of features, but encompass flexible sets of features that may or may not be activated according to context. This is particularly clear for ambiguous words, but even non-ambiguous ones can activate different features depending on context (the meaning of "piano" after "moving" or "playing"). Here, we used MEG to investigate the mechanisms by which we interpret ambiguous words in minimally different contexts that change the interpretation into an object or action. Specifically, we compare equi-biased noun-verb ambiguous words in minimally different "to" or "the" contexts to unambiguous counterparts matched for frequency, as in [1]. We thus investigate the effect of context on interpretation. Methods: Participants read noun-contexts ("the hammer"/"the hatchet") or a verb-context ("to hammer"/"to knead") containing either ambiguous or unambiguous words. They had to read the phrases for meaning to answer upcoming comprehension questions (e.g., "used with nails"?). Questions occurred on 25% of the trials, which were excluded from the analyses. Virtual Electrode analysis was performed on left inferior frontal gyrus (LIFG) and left posterior middle temporal lobe (LpMTG). The time series for these regions were reconstructed using a Linearly-Constrained Minimum-Variance beamforming approach [2]. Stockwell transforms were used for computing time-frequency representations for each epoch in each condition. Generalized Linear Mixed Models were used to compare conditions at the group level. Results: In LIFG, there were early differences in oscillatory power between ambiguous and unambiguous words in any context (within 200ms of stimulus onset) and between "to" and "the" contexts (within 100 ms). Conditions involving more context-dependent interpretation elicited stronger changes in oscillatory power that continue until after 500ms. There were also effects of ambiguity for LpMTG, but these were subtle/later (from 550ms) except for ambiguous words in a verb ("to") context (within 200ms). These findings show that LIFG and pMTG are both recruited from about 200ms when contextual information is used to disambiguate the meaning of ambiguous items. Conclusions: The results suggest interplay between LIFG

and LpMTG, consistent with findings in [1]. LIFG plays an early role in resolving ambiguity and in retrieving event/action knowledge that is relevant for "to" contexts [3,1]. LpMTG contributes to ambiguity resolution slightly later than LIFG, but is engaged together with LIFG when context can be used to disambiguate meaning. The later involvement of LIFG for ambiguous words, particularly for "to"-context, suggests settling of the network into an action representation. References [1] Gennari, S. P., McDonald, M.C., Postle, B.R., and Seidenberg, S. M. (2007), Context-dependent interpretation of words: Evidence for interactive neural processes, Neuroimage, 35, 1278-1286. [2] Van Veen, B.D., van Drongelen, W., Yuchtman, M., Suzuki, A. (1997), Localization of brain electrical activity via linearly constrained minimum variance spatial filtering, IEEE Transactions on Biomedical Engineering, 44, 867- 880 [3] Thompson-Schill, S. L, Bedny, M., Goldberg, R. F. (2005), The frontal lobes and the regulation of mental activity, Current Opinion in Neurobiology, 15, 219-224.

C53 On the processing of negated meanings: A chronometric-TMS study

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While great progress has been achieved towards the understanding of the processing of meanings (e.g., objects, places, actions) in the brain, it is unknown how negated meanings are computed. Two main models are currently being forwarded. The two-step model sees negation as a computation operating secondly, after the corresponding positive meaning is activated: the positive meaning and related cortical activations would be first activated and then suppressed. Alternatively, negation may be computed online and immediately as a modulation (i.e., reduction) of cortical activations. Neuroimaging studies have addressed this issue, taking advantage of word-related motor activity. This phenomenon refers to increased activation of regions responsible for action execution (e.g. the precentral gyrus), during the semantic processing of words implying motor actions. Thus, word-related motor activity is considered a neural signature of the semantic access to action-words. Several studies found that affirmative action-verb phrases elicit higher activity in the precentral gyrus than the same verbs preceded by negation. However, this corpus of studies used fMRI or Mu-rhythm suppression methodologies, which lack the temporal resolution to adjudicate between the two models of negation. At stake is whether the precentral gyrus is first activated before being inhibited in response to a negated action-verb. To address this question, we used the chronometric approach of Transcranial Magnetic Stimulation (TMS), which provided a measure of motor activity at different points in time, during the processing of affirmative and negative phrases. TMS over the primary motor cortex (M1) in the precentral gyrus induces twitches in the peripheral muscles responding to the stimulated area. The effect of TMS on the target area is punctual. By recording TMS-induced muscle activity in the form of motor-evoked potentials (MEPs), we obtained a direct measure of corticospinal excitability reflecting the level of activity in the precentral gyrus. Verbs denoting motor actions or cognitive/psychological states were presented (700 ms) preceded by a context-adverb (either "ora", now, or "non", don't, 250 ms). TMS was delivered over the left hand-M1 at 250 ms, 400 ms and 550 ms after the verb-onset. Action and non-action verbs were presented in the first person of the present tense (e.g., ora/non prendo – now I/I don't take). Replicating previous results, we found larger MEPs for action verbs with respect to non-action verbs in the affirmative context (ora-now) at 250 and 550 ms. This pattern was modulated by the negative context (non-don't). No difference was observed between action and non-action verbs at 250, 400 or 550 ms. Contrary to the predictions of the two-step model, M1 activation differed between affirmative and negative contexts at all probed timings. Our results support an online computation of negation, whereby negation is immediately encoded by the brain as a reduced activation of the network that represents features of the negated meaning.

C54 No Squirrel Likes Collecting Nuts. An ERP Study on Quantification, Prediction, and Cloze Probability.

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When is the information a quantifier provides available in online sentence processing? And how does a sentence-initial negative quantifier influence the processing of words that are strongly predictable in the non-negated/ affirmative version of the sentence? We used 60 German affirmative sentences where the sentence-final noun was either highly predictable (1A: Eichhörnchen sammeln gerne NÜSSE. Literal translation: Squirrels collect like-to NUTS.) or unpredictable but still plausible (1B: Vögel fangen häufig RATTEN. Literal translation: Birds catch often RATS.) according to a cloze probability pre-test. To test the influence of quantification, an initial negative quantifier was added to those 60 sentences (2A: Kein Eichhörnchen sammelt gerne NÜSSE. Literal translation: No squirrel collects likes-to NUTS./ 2B: Kein Vogel fängt häufig RATTEN. Literal translation: No bird catches often RATS.). Corresponding cloze probabilities were: 1A: .93, 1B: .03, 2A: .15, 2B: .01; thus, one condition (1A) with a very high, and three conditions (1B, 2A, 2B) with a very low cloze probability. Importantly, all sentences were plausible. An additional 200 sentences served as fillers. We recorded the EEG of 23 German native speakers while they were reading the sentences word by word. After each sentence, participants were asked to judge the sentences' acceptability by pressing one of two buttons. ERPs were calculated for the sentence-final, critical nouns (capitalized in the examples above). As expected, words with a high cloze probability from 1A led to a pronounced posterior P300 ERP component, which has been shown – under certain conditions – to be related to an integration process when prediction is confirmed. Unexpected words in the affirmative sentences (1B) engendered a strong N400 ERP component with a subsequent globally distributed P600. Strikingly, despite the low cloze probability of only .15, nouns from

condition 2A led to a comparable posterior P300 ERP component as condition 1A. Nouns from 2B – as expected – engendered an N400. In contrast, the behavioural results show that both negated conditions were judged as far less acceptable than the affirmative sentences (in %; 1A: 99.28, 1B: 88.64, 2A: 2.62, 2B: 11.52). To sum up, a first glance, the results suggest that the initial quantifier has not been processed immediately (comparable ERPs irrespecitvely of quantifier). However, given the dissimilarity of the ERPs and behavioural measures – e.g. a cloze probability of .93 (1A) as well as .15 (2A) leading to a P300 – this interpretation needs careful consideration. We will discuss the results in relation to current findings about (negative) quantifier interpretation, possible consequences for the relation of ERPs and offline cloze probability measures, as well as functional interpretations of the P300 ERP component.

C55 Oscillatory brain dynamics associated with the automatic emotional processing of words

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This study examines the automaticity of emotional processing of words, and characterizes the oscillatory EEG dynamics that accompany this automatic processing. Participants read emotionally negative, neutral and positive nouns while performing a color detection task in which only perceptual-level analysis was required. Event-related potentials and time-frequency representations of negative, positive and neutral nouns were computed from the concurrently measured EEG. Negative words elicited a larger P2 and a larger late positivity than positive and neutral words, indicating deeper semantic/evaluative processing of negative words. In addition, a sustained alpha power suppression was found over occipital electrode sites for emotional compared to neutral words, in the time range from 500 to 1000 ms post-stimulus. These results suggest that even when the emotional content of the words is task-irrelevant, sustained attention is allocated to emotional words, whereas the attention allocated to neutral words is released after an initial analysis.

C56 Marbles and metaphor: Language processing in the brain is sensitive to motion congruency

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Grounded theories of meaning implicate sensory motor regions in the coding of word meaning. Previous work has shown that motor-related brain areas are involved in language processing. However, prior research leaves open the stage or stages of processing at which motor activations occur, and whether their time course is similar in literal and metaphorical words. Our study used event-related brain potentials (ERPs) to investigate the effects of motor actions on the processing of individual concrete and metaphorical words. EEG from 24 participants was recorded as they read visually presented words while performing a one-handed motor task in which they were asked to move marbles from either a red tray to a green one (i.e. an upward-directed movement), or from a green tray to a red one (a downward-directed movement). Half of the participants performed the task with their right hand, and half performed the task with their left. The experiment was divided into 4 blocks, half of which involved moving marbles to the green tray, and half to the red. Participants saw each word twice, i.e. while moving marbles both upward and downward. Target words were either concrete and associated with spatial location (e.g., upward, downward, ceiling, floor) or associated with spatial metaphor (e.g., genius, stupid, victory, failure). Within participants, each word was presented in a Congruent (e.g., an "up" word during upward hand motion) and an Incongruent (e.g., a "down" word during upward motion) condition. ERP results revealed an early effect of congruency for concrete words, with words seen in the Incongruent condition eliciting a more positive voltage 200-300ms after word onset ($p<0.01$). In a late time window (700-1100ms), Incongruent concrete and metaphorical words elicited a larger positivity over central channels ($p<0.05$), possibly indicating processing difficulty due to an incompatibility between direction of hand movement and direction associated with the words being presented. No congruity effects were observed 300-500ms post-onset, the interval associated with the N400, the ERP component most clearly related to retrieval from semantic memory. However, there was an effect of valence in a 300-500ms window ($p<0.05$), with positive words (metaphorically "up") eliciting an enhanced positivity compared to negative (metaphorically "down") words. We show that brain activity elicited by the very same words differed as a function of the direction of hand movement. Moreover, these differences emerged much sooner for words literally related to the vertical dimension than for metaphorically related words. For literally – but not metaphorically – related words, movement direction impacted ERPs elicited 200-300ms, during a portion of the ERP waveform sensitive to both phonological and semantic factors. In later intervals, 700- 900ms post-onset, both literally and metaphorically related words were similarly impacted by the movement manipulation, consistent with the claim that lexically induced motor system activation occurs during a relatively late stage of processing following the initial stages of semantic retrieval indexed by the N400 component.

Discourse, Combinatorial Semantics

C57 Simulating fiction: Individual differences in literature comprehension revealed with fMRI

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Engaging literature moves us: when we read, we are transported to fictional places, and we feel and think along with the characters. Despite the importance of narrative in adult life and during development, the neurocognitive mechanisms underlying fiction comprehension are still unclear. Several theories state that there are individual differences in the kind of simulation that people use when they read or listen to

narrative, but so far little research has been done to study this claim. For the current study, we used functional magnetic resonance imaging (fMRI) to investigate how individuals differently employ neural networks important for simulation during fiction comprehension. We focused on two kinds of simulation: understanding others' beliefs and intentions ('mentalizing'), and sensori-motor simulation. Participants (N = 18) in the MR scanner listened attentively to three excerpts from literary novels, presented over headphones. The fragments were coded beforehand for descriptions of characters' intentions and beliefs, and of motion events. As a control baseline, participants listened to the fragments played backwards. They also carried out two localizer tasks, from which regions of interest (ROIs) could be created. The first was a localizer of the mentalizing network (a 'false belief' task), the second of the action network (motor execution). Results show that participants with high activation in the mentalizing network when listening to mentalizing content of literary fiction, had lower activation in motor regions when they listened to action-related content of the stories, and vice versa. This indicates that people who rely most on mentalizing during story comprehension, rely less on sensori-motor simulation, and vice versa. This study provides for the first time on-line neural evidence for the existence of qualitatively different styles of moving into literary worlds. Also, it shows the feasibility of measuring neural responses to natural language comprehension, fiction in particular. It should provide an impetus for a continued fruitful combination of the literary sciences and cognitive neuroscience.

C58 Narrative perspective influences immersion in fiction reading: Evidence from Skin Conductance Response

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Narrative perspective, or focalization, is regarded as an important tool in storytelling. With this tool, story writers can modulate the point of view out of which readers perceive ongoing events and generate mental representations, e.g. make readers 'see' through the eyes of one of the characters (internal perspective) or take a spectator's view (external perspective). Despite the fact that narrative perspective is generally considered a fundamental element in narrative comprehension, its effect on story reading and immersion remain unclear. In the present study, we combined an online measure of nervous system activation (skin conductance response, SCR) with off-line questionnaires to investigate cognitive processes during natural reading. Subjects read 8 short stories from Dutch fiction writers on paper (mean number of words = 1043.25, sd.=723.05, min = 338, max = 2090). The original stories varied in several features such as narrative perspective, length and style. Half of the original stories were narrated in 1st and half in 3rd person perspective. We created a second version of each story by changing personal pronouns and their respective verb forms to test the influence of personal pronouns on the reading experience in a very tight comparison between 1st and a 3rd person perspective across subjects. We used a block design in which subjects read 4 stories in one condition first and then the other 4 stories in the corresponding condition. SCR was measured continuously while subjects read the stories at their natural reading speed. After each story, subjects indicated how much they like the story on a 10 point scale and filled out a questionnaire testing engagement in the story. After reading all stories, subjects ranked the stories in the order of which one they liked the most. Finally, subjects filled in a test battery concerning general reading habits, author recognition test and the Empathy Quotient questionnaire. We found appreciation and immersion to be closely connected and for both measures robust preferences for 1st person perspective narration. To get a more nuanced understanding of the underlying components of the reading experience, we performed an exploratory factor analysis on the immersion questionnaire data, revealing 5 reliable components: Understanding, Self-Loss, Emotional identification, Mental imagery and Compassion. Especially Understanding, Self-loss and imagery show a preference for 1st person perspective narratives. For the SCR measure we used peaks in the signal as dependent variables and found more peaks in 3rd person perspective compared to 1st person perspective. The difference in mean number of peaks was correlated with the Emotional identification component of the questionnaire. People who empathized little with the main characters of the stories showed more peaks in 1st person perspective, while high empathizers showed more peaks in reading 3rd person perspective. Our findings indicate that narrative perspective affects immersion and has substantial influence on our perception and appreciation of literature. The combination of on-line and off-line methodologies allows us to get to a fuller understanding of the influence of narrative perspective on story comprehension and immersion.

C59 Imaging dyadic conversation: Measures of interactive alignment and social interaction independently modulate patterns of interbrain coherence

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We used real-time hyperscanning methods to explore dynamic processes in the brains of interlocutors engaged in dyadic conversation. True dyadic conversation is a prototypical example of ecologically valid language use and its emergent features can only be observed during naturalistic interactions, which are inherently difficult to control experimentally. To address these issues, we developed a novel paradigm in which two subjects were imaged simultaneously during unscripted conversation. Using noise-cancelling headphones and live audio feed, we acquired fMRI data and recorded interactions during three conversation types: 1) autobiographical - affiliative

exchanges in which subjects shared personal experiences; 2) problem-solving - also affiliative exchanges, in which subjects collaborated to solve a problem and reach a common goal and 3) debate – antagonistic exchanges in which subject took opposing sides in a political argument. Imaging artifacts associated with continuous overt speech production were removed with an automated denoising method based on spatial independent component analysis (sICA) carried out at the individual subject level. Group sICA - performed on fMRI time series after removing the envelope of BOLD response related to alternating turns - yielded a set of spatial components representing independent self-organizing networks associated with time courses computed using PCA back-projection. Interbrain coherence – i.e. temporally synchronized activity between brains – was assessed for all component time courses in each subject-pair and conversation. Time locked recordings were transcribed and coded for measures of sensorimotor, linguistic and social alignment. We were interested in how interbrain coherence would be modulated by conversation type, by the alignment measures and by the interaction between them. An emerging theory suggests that interactive alignment at sensorimotor and linguistic levels drives intersubject coherence and on this basis facilitates situation model construction. This theory may be incomplete, since it does not incorporate the social features that constitute the central elements of other conversational theories. We predicted that all of these features would have significant, independent effects on measures of coherence between interlocutors' brains For all conversation types we found evidence of significant interbrain coupling in well-defined networks that included right hemisphere frontoparietal association areas (incorporating angular gyrus/TPJ), dorsal precuneus, and dorsal attention network (intraparietal sulci and dorsolateral prefrontal cortices). These relationships may reflect connections between regions that support interoceptive and exteroceptive attention and awareness, both of which should be involved in establishing and maintaining common ground. Affiliative conversations showed additional between-brain correlations that included perisylvian language areas and medial prefrontal cortices. Some measures of sensorimotor alignment (e.g. matching patterns of turn duration) had a significant impact on the strength of interbrain connections. In contrast measures of linguistic alignment (e.g. co-constructed phrases, shared lexical items and syntactic structures) did not appear to have such an effect. By far, however, the most robust modulations were related to social features (e.g. joint intention, bids for joint action, active listening, shared irony or laughter) particularly during affiliative conversations. These results demonstrate the feasibility of imaging dyadic conversation and suggest that incorporation of less automatic aspects of social interaction may enrich current models of interactive alignment.

C60 Neural Adaptability During Sentence Reading: Higher Language Ability but not Semantic Sentence Complexity Increases Neural Activity

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High task performance in healthy adults is often manifested as increased neural adaptability. The high-performing brain can adapt by recruiting more supporting brain regions when needed. Neural adaptability has shown to increase during demanding language tasks (Schafer, 1982; Just et al., 1996). Studies that combined neuroimaging of individual performance differences with modulation of task difficulty has deepened our understanding of neural adaptability. Neural adaptability in relation to semantic processing has been investigated in a recent study that showed an increase of neural activation for subjects with higher working memory performance when reading sentences with high syntactic complexity (Prat and Just, 2011). Our first aim was to investigate whether neural adaptability could be observed in participants with high language ability. Therefore we specifically assessed language ability and correlated performance scores to neuroimaging data. Our second aim was to further investigate the effect of complexity modulation on neural adaptability, focusing on modulating semantic complexity. We measured neural activation during sentence processing in healthy Swedish adults with the use of functional Magnetic Resonance Imaging (fMRI). Semantic sentence complexity was modulated by including congruent and incongruent sentences. Language ability was assessed using the BeSS test, sensitive also to subtle language dysfunctions (Laakso et al., 2000). The test includes tasks that measure sentence repetition, sentence construction, inference, comprehension of complex embedded sentences, understanding garden-path sentences, understanding metaphors, and vocabulary. Performance scores on the language ability test were used to determine the effect of language ability on neural activity and neural adaptability. Our regions of interest were located bilaterally in the inferior frontal gyrus (IFG) and in the temporoparietal lobe. We found that bilateral BA 45 in the inferior frontal gyrus (IFG) was more activated for the incongruent sentence condition, in concordance with previous findings on increased IFG activation for increased task complexity (Just et al., 1996). Left BA 47 in the IFG and the left angular gyrus were both more activated in individuals with higher language during the congruent condition and, for the angular gyrus, also during the incongruent condition. Both the congruent and the incongruent condition proved to be demanding in terms of signficant increased reaction time compared to the control condition. No activation increase specific for the most demanding incongruent condition was found. Thus, we cannot conclude a modulation of neural adaptability specific for semantic sentence complexity.

Based on our findings of increased activation in functionally supportive language areas in the left BA 47 and left angular gyrus we pose that the congruent sentence reading task is of high enough complexity to evoke neural adaptability. Just MA, Carpenter PA, Keller TA, Eddy WF, Thulborn KR. 1996. Brain activation modulated by sentence comprehension. Science 274(5284):114-116. Laakso K, Brunnegård K, Hartelius L, Ahlsén E (2000): Assessing high-level language in individuals with multiple sclerosis: a pilot study. Clin Linguist Phon 14:329–349. Prat CS, Just MA. 2011. Exploring the neural dynamics underpinning individual differences in sentence comprehension. Cereb Cortex 21(8):1747-1760. Schafer EW. 1982. Neural adaptability: a biological determinant of behavioral intelligence. Int J Neurosci 17(3):183-191.

C61 Patterns of activation and connectivity in fronto-temporal language networks during sentence processing in patients with schizophrenia: A multimodal imaging investigation

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During sentence comprehension, we bind words together to form a coherent message-level representation. To this end, areas of the language network, such as the inferior frontal and temporal gyri, need to communicate with each other. There is evidence that in patients with schizophrenia fronto-temporal connectivity is abnormal (Friston and Frith, 1995; Li et al., 2010), and that this may contribute to patients' impairments in building and using context (Kuperberg, 2010). We conducted an MEG and fMRI experiment in which 17 patients with schizophrenia and 18 demographically matched controls read sentences and random lists of words (presented in pseudorandom order). Using both MEG and fMRI techniques, we looked at differences between patients and controls across the language network in contrasting sentences and word lists. With MEG, we examined sources of power modulation in the beta frequency band using beamformer source localization techniques. With fMRI, we examined BOLD activity. Both MEG and fMRI revealed differences between patients with schizophrenia and healthy controls in the modulation of inferior frontal and temporal regions. The control group showed the expected pattern of more activity within both regions to sentences versus random word lists. Patients, however, showed the opposite pattern of modulation, with more activity to the word lists than to the sentences. In the fMRI experiment, this abnormal increase in activity to the word lists was seen in both left temporal and left inferior frontal cortices, whereas in the MEG experiment, it was primarily seen in the bilateral inferior frontal cortices. Using fMRI, we also examined task-related functional connectivity patterns (McLaren et al., 2012). We defined a seed in the left posterior temporal gyrus and looked for brain-wide connectivity changes. Relative to controls, patients showed significantly reduced connectivity to the left inferior frontal gyrus when reading the sentences. Interestingly, relative to controls, patients also showed significantly increased connectivity to more anterior temporal regions when comparing word lists to sentences. These abnormal activation and connectivity patterns across frontal and temporal areas within the language network in patients with schizophrenia might contribute to their impairments in building and using context. Specifically, we suggest that the increased activity in temporal and/or frontal cortices to the word lists might reflect an inappropriate tendency to make sense of unrelated lists of words, contributing to the language and thought disorganization that can characterize schizophrenia.

C62 Narrative production related to cognitive constructs in Alzheimer's Disease, Mild Cognitive Impairment and major depression: comparative case studies

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Introduction: The worldwide rate of the elderly population has been increasing substantially in the past decades. Thus, cognitive impairment and neurodegenerative diseases which emerge isolated or concomitantly in aging are amongst the most prominent topics in the neurocognitive research agenda. Aim: To analyze narrative production and its association to cognitive constructs generated in different neurodegenerative and psychiatric disorders compared to performance in normal aging. Method: The 8 participants (3 males, including the control participant), whose ages range from 60 to 89 (mean 71.1), with 0 to 11 years of education (3 illiterate, 1 with 11years of schooling – mean 4.4), attend the Project of Cerebral Aging (PENCE – Programa de Envelhecimento Cerebral) at the Institute of Geriatrics and Gerontology at São Lucas Hospital, affiliated to the Pontifical Catholic University of Rio Grande do Sul (PUCRS). This project works in association with the public municipal health system and attends mainly people of low literacy (or illiteracy) and low socioeconomic status. Participants underwent a cognitive assessment (Adenbrook) and a psychiatric evaluation (GDS, Hamilton Scale and MINI 6.0). The 7 patients presented one of the following disorders: 2 with major depression, 2 Alzheimer's Disease (AD), 2 Mild Cognitive Impairment (MCI), 1 vascular MCI. Their cognitive and linguistic performances were compared to a healthy control's performance, matched within the range of the patients' age and schooling levels. The tasks were of two types, linguistic or related to a cognitive construct. The linguistic task was the oral production of a narrative story based on seven scenes (The dog story) presented all together in the correct sequence. The cognitive tasks comprised the assessment of executive functions (verbal fluency of a semantic category – animals), naming and verbal episodic memory. Results: Among the results, it can be highlighted that the probable DA participants were not able to tell a story based on the sequence of scenes – they did not associate the characters and were not able to establish a link between the pictures to

narrate the story; the MCI and vascular MCI participants performed similarly and better than the probable AD patients; the participants with major depression showed a poorer performance as compared to the control participant's one, and were able to narrate the three first scenes of the story. Perseverations, word finding difficulties, inappropriate topic changes and incoherence were present in the patients' narratives in different levels of frequency. Naming and semantic episodic memory were more impaired in DA, followed by MCI and major depression. Semantic fluency was lower in vascular MCI, major depression and DA as compared to the other diseases. Conclusion: Data analyzed in this study suggest that linguistic performance, more specifically oral narrative production, may be an efficient complementary tool to assess certain psychiatric and neurodegenerative diseases. Furthermore, relating this assessment to cognitive performance evaluation may provide an even more consistent assessment necessary to disentangle different diagnoses and, thus, accompany neurological and psychiatric assessment.

Syntax, Morphology

C63 Brain correlates of chunk size in Chinese

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In a recent fMRI experiment (Pallier, Devauchelle, & Dehaene, 2011), participants were asked to read sequences of words organized into syntactic chunks of varying lengths. This allowed the identification of brain regions where the activation increased with the syntactic coherence of words within the sentences. This experiment was performed in French, and our first aim here is to see if it generalizes to another language, Mandarin Chinese. Furthermore, relying on the fact that Mandarin Chinese permits complex nominal compounds, we investigated the effect of compound size, asking whether the same of different regions are involved in syntactic chunk building processes and in noun-noun composition. We first generated six words sentences and four words nominal compounds, from which chucks were extracted and concatenated into stimuli of smaller chunk size but the same number of words. For the sentence condition, stimuli with chuck size of one, three, and six words were created. For the nominal compound condition, stimuli with chuck size of one, two, and four words were created. fMRI data for the sentence condition were obtained from twenty-two participants, eighteen of whom were also tested in the nominal compound condition. During the scanning, the stimuli were presented using rapid serial presentations and the participants were asked to detect embedded commands to press a button. After scanning, they were asked to estimate the number of chucks for every stimulus and their estimations were used for the fMRI analyses. We searched for regions where activation correlated with chunk size. For the whole-brain analyses, no significant effect was found under a stringent threshold ($p < .005$, cluster size FDR corr.). We then concentrated on regions reported in the French study (Pallier, Devauchelle, & Dehaene, 2011), including IFGtri, IFGorb, TP, aSTS, pSTS, TPJ, and putamen. Under the sentence condition, all ROIs except putamen showed significant chunk size effects. Under the nominal compound condition, only pSTS showed significant chunk size effect. However, the difference between the chunk size effect in compound and in sentences does not reach significance. Our results showed chunk size effect in Chinese sentence and in nominal compound. Moreover, coherence in sentences engages similar regions in Chinese & French readers.

C64 Impairment in Sentence Comprehension in Patients with the Behavioral Variant of Frontotemporal Degeneration (bvFTD)

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Language impairments have been observed in patients with the behavioral variant of frontotemporal lobar degeneration (bvFTD), who have executive and social deficits but are not aphasic (Ash et al, 2006; Farag et al, 2010). This deficit was attributed to impaired organization of hierarchically organized discourses. The objective of this study was to assess sentence processing in patients with bvFTD. To elucidate the basis for a comprehension impairment while minimizing task-related resource demands that may confound interpretation of performance, we assessed grammatical comprehension using a two-alternative forced-choice sentence –picutre matching task, and we analyzed the relationship between grammatical comprehension and performance on other measures of language, working memory, and executive functioning. Patients with bvFTD (n=23), a brain-damaged control group with amnestic Mild Cognitive Impairment (aMCI) (n=13) and healthy seniors (n=20) were evaluated with a sentence-picture matching task, and asked to choose between 2 pictures best described by a sentence. The pictures depicted two familiar, semantically-unconstrained actors (e.g. a boy and a girl) engaging in a transitive action (e.g. chasing), where each of the pictures depicted one of the actors as the agent. Brief, length-matched sentences were cleft or center-embedded in structure, and these were equally divided into subject-relative or object-relative. Half of each type of sentence was strategically lengthened by the insertion of a 3-word prepositional phrase between the subject of the main clause and the location of the trace in the subordinate clause, while other sentences were lengthened by including the phrase at the end of the sentence. We obtained independent measures of language with the Pyramids and Palm Trees (PPT) and Boston Naming (BNT) Tests, assessed working memory with Digit Span backwards (DB), and examined executive functioning with Trails B (TB), FAS Category Fluency (CF), and the Visual Verbal tests. Results showed that bvFTD participants were significantly impaired in overall sentence comprehension compared to controls ($p < .001$),

and marginally in comparison to aMCI subjects (p=.052). bvFTD patients were more impaired with center-embedded sentences than their own performance with cleft sentences (p>.005), and were more impaired with object-relative sentences than subject-relative sentences (p>.001). bvFTD patients' sentence comprehension impairment correlated with a measure of semantic memory (PPT; p< .002) a verbal executive measure of mental flexibility (FAS; p< .05) and a measure of working memory (DB; p< .05). These results lead us to conclude that bvFTD patients are impaired in grammatical comprehension. Although not aphasic, semantic memory difficulty and resource limitations appear to play a role in their comprehension impairment.

C65 Structural size matters: ERP signatures of strategies to recover meaning of elliptical sentences

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The interpretation of elliptical sentences (e.g. "The man bought a book in Amsterdam and the woman [...] a cd in Rotterdam") requires a process of semantic recovery. Ellipsis may be resolved by inserting a copy of the missing structure (e.g. "bought"). Such a 'copy-paste' procedure predicts a low processing cost - regardless of the size of the antecedent. In contrast, a more laborious inferencing mechanism may be required for ellipsis resolution, which predicts the recruitment of relatively more processing resources. We studied the online processing of a particular type of ellipsis, i.e. 'gapping', in Dutch. We recorded event-related brain potentials while Dutch participants read sentences containing gapping constructions interspersed with filler sentences. Three elliptical conditions were compared with the non-gapped counterpart (control condition). The gapped sentences differed with respect to the size of the omitted structure: verb only (condition B), verb plus object (condition C), or verb plus object and adjunct with replacement by "ook" (too) (condition D). Every stimulus sentence was followed by a comprehension question. We counterbalanced which sentence parts (also elliptical phrases) were questioned. Participants performed an additional working memory task to control for individual differences. Compared to the control condition we observed no significant difference in condition B. However, we established a broadly distributed early negativity following the occurrence of omitted structures in conditions C and D. In addition, the negativity appeared to be more sustained in condition D. The participants' performance on the comprehension questions revealed that sentences in which the most structure was elided (condition D) were best understood. A weak but insignificant positive correlation could be established between the accuracy of the comprehension questions and the scores on the working memory test. These results suggest that different resolution strategies are involved in the recovery of meaning during gapping resolution. If only a verb is gapped, a copy-paste procedure applies. Recovery of larger structures requires more effort reflected by the recruitment of broadly distributed processing resources. Possibly, the involvement of relatively more brain areas feeds the understanding of the conveyed, yet elided, message - regardless of the performance of one's working memory.

C66 A meta-analysis on syntactic vs. semantic unification

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We will present the results of a new meta-analysis of neuroimaging studies on sentence processing to establish, among other things, to which degree the network for semantic unification can be segregated from the network for syntactic unification. We analyzed 151 hemodynamic studies on sentence processing. The most robust result that we obtained is a distinctive activation pattern in the posterior LIFG with syntactic demands activating more dorsal parts (BA 44/45) and semantic demands more ventral parts (BA 45/47) across all kinds of increased demands (violations, ambiguity, complexity) and in studies performing direct comparisons of high syntactic and semantic demands. This result means that syntactic unification cannot be simply reduced to semantic unification. In particular BA 44 activation is clearly driven more strongly by syntactic than by semantic demands, suggesting that this region either contains neuronal populations involved in syntactic operations as such or that the semantic consequences of syntactic demands (difficulty of thematic role assignment) are processed by neuronal populations that are different from those processing other kinds of semantic unification. A novel observation is that the dorsal/ventral gradient observed in the left posterior IFG seems to be mirrored in the left posterior temporal lobe. Higher syntactic demands reliably activate STG and MTG, higher semantic demands MTG and ITG. These correspondences are remarkably consistent with a functional connectivity pattern found by Xiang et al. (2010), linking seed regions in BA 44, BA45, and BA 45/47 to left posterior STG, MTG and ITG. This finding clearly supports the idea that sentence-level unification relies on the co-activation of neuronal populations in a network of posterior frontal and temporal regions, with a similar functional gradient in both parts of the brain. A further important observation is a dissociation of the degree of posterior temporal lobe involvement between violations and other kinds of higher processing demands. Syntactic violations do not seem to reliably elicit posterior temporal lobe activations at all, and reports about such activations are relatively infrequent for semantic violations. A plausible account for this dissociation may be based on a distinction between Broca's region subserving sentence-level compositional processes, and the posterior temporal lobe subserving the retrieval of lexical syntactic and semantic information (Hagoort 2005). Violation paradigms might relatively specifically tap into a unification stage whereas ambiguities and complexity manipulations typically also involve additional retrieval of lexical syntactic and semantic specifications. Finally, our results suggest that the neuronal substrate underlying the processing of

ironic and indirect utterances differs from that activated in other kinds of high-demand sentences. Such utterances do not seem to induce reliable activation of Broca's area (BA 44/45) and Wernicke's area but, instead, show the most reliable activation in the medial prefrontal cortex and the right temporo-parietal cortex. The difficulty of these sentences does not seem to be in decoding the meaning of the sentence but in a different aspect of comprehension.

C67 Subject vs. object asymmetry of 'floating' numeral classifiers in Korean: An ERP study

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This paper investigates the sentence processing of 'floating' numeral classifiers (FNCs) in Korean by using the event-related potentials (ERP) paradigm. The experimental materials consisted of 120 sets of 6 items, which varied in terms of (i) the grammatical role (subject vs. object) that FNCs associate with and (ii) the type of a Case/particle marker on FNCs (Case-less vs. Nom/Acc Case-marked vs. Focus-particle-marked). Schematically (using English words), one sample set of 6 items have the following structure: (i) Subject-related Case-less FNC [here student-Nom shoes-Acc 2-FNC stole] I heard. (ii) Subject-related Nom-Case-marked FNC [here student-Nom shoes-Acc 2-FNC-Nom stole] I heard. (iii) Subject-related Focus-particle-marked FNC [here student-Nom shoes-Acc 2-FNC-Foc particle stole] I heard. (iv) Object-related Case-less FNC [here shoes-Acc student-Nom 2-FNC stole] I heard. (v) Object-related Acc-Case-marked FNC [here shoes-Acc student-Nom 2-FNC-Acc stole] I heard. (vi) Object-related Focus-particle-marked FNC [here shoes-Acc student-Nom 2-FNC-Foc particle stole] I heard. Using the materials, we examined the following three questions. First, is there a difference between Case-marked and Case-less forms of FNCs? Second, is there a contrast between subject- and object-related FNCs? Third, is there a distinction between Case-marked and focus-particle-marked FNCs? We found from the ERP experiment that, first, subject-related Case-less forms of FNCs elicited N400 followed by P600 in comparison to the corresponding Case-marked ones, but object-related ones didn't. We attribute the N400 effects to the parser's attempt to incorrectly link the Case-less FNC with the immediately preceding object. The P600 effects may, on the other hand, be ascribed to a second-pass, revised integration process that now correctly links the Case-less FNC with the relatively more 'distant' subject. Second, subject-related Case-less FNCs are greater in the amplitude of P600 than object-related ones. In the literature on the subject vs. object asymmetry involving FNCs, Ko and Oh (2012) argue that syntax matters, whereas Miyagawa and Akiyama (2007) argue that intonational phrasing comes into play. Our result seems to support the former approach, because despite the absence of intonation phrasing, the participants distinguished subject- and object-related FNCs successfully. Third, subject-related focus-particle-marked FNCs also elicit N400 followed by P600 in comparison to the corresponding both Case-less and Case-marked ones, but object-related ones didn't. These N400 and P600 are taken to be additive, as they are greater in amplitude than the ones found for Case-less FNCs. These additive effects are imputed to the discourse roles of the focus particle. In particular, N400 stems from evoking a set of alternatives including the focus-marked expression (cf. Dimontrova (2012)), whereas P600 arises from the attempt to integrate the evoked referents syntactico-semantically in the discourse structure (cf. Burkhardt (2005)). Overall, we take all the three results above to render neuroelectrophysiological evidence that our mind detects subject vs. object asymmetry in the case of processing subject-related focus-particle-marked FNCs as well as subject-related Case-less ones. Based on the results from the ERP study, allowing subject scrambling, we suggest a unified 'stranding'/movement (rather than hybrid (i.e., 'stranding' plus base-generation)) approach to 'floating' numeral classifiers in Korean.

C68 ERP effects of the processing of preferentially long-distance bound anaphor caki in Korean

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This study investigates whether the violation of the locality condition on anaphor binding comes with processing costs during referential resolution of the Korean anaphor caki, which has been reported to have a (strong) preference for the long-distance (LD) over the short-distance (SD) antecedent (cf. Choi and Kim (2007) that used eye-tracking; J-H Kim and H-S Yoon (2008) that used the Truth Value Judgment Task with pictures). For this purpose we manipulated the hierarchical/linear distance between the Korean anaphor and its antecedent, forcing either an SD or LD interpretation in the following way. (1) [matrix clause ... DP1(gender-denoting) ... [embedded clause ... DP2(gender-denoting) ... [... caki-Genitive NP(gender-sensitive) ...] embedded verb] main verb]. Functioning as an intermediator for indirect gender match/mismatch between DP1/DP2 and the gender-sensitive NP, the Korean anaphor caki can take as its antecedent only one of the two DPs, either of them, and neither of them. Thereby, the anaphor caki has to be SD-bound, LD-bound, ambiguously (A) bound, or intra-sententially unbound (U), generating the four different conditions of the materials. In the SD reference condition, caki refers to the local embedded subject (DP2), and in the LD reference condition, to the distant matrix subject (DP1). Caki can also refer either to the local or to the distant antecedent in the A-bound condition, but it does not refer to any DP in the U reference condition. Event-related potentials (ERPs) were employed to record the neural responses to the post-anaphor gender-sensitive critical NP in the embedded object position as in (1), using 120 sets of items for the target conditions. We found that, compared with the LD reference condition, ERP responses to the caki-mediated gender-dependent NP were significantly more positive in the SD reference condition in the earliest time window (P300). However, the critical NP elicited a right anterior negativity (RAN) in the later time window, followed by a positivity in the ensuing time window (P600) in the LD, relative to the SD, reference condition. It is suggested that the initial P300 effects observed in the SD reference condition

reflect a breach of the lexical requirement of caki that it tend to take an LD antecedent. It is also suggested that linking the anaphor with an LD, rather than an SD, antecedent during its referential resolution requires more processing resources. The RAN effects may, on the one hand, reflect the detection of incongruence between the mental representation dictated by the general locality condition on anaphors and the representation based on the processing of the NP that matches in gender with the distant matrix subject. The P600 effects may, on the other hand, be associated with a second-pass, revised integration process that binds the anaphor caki with the distant matrix subject. We take the last two ERP components (i.e., RAN and P600) to reveal that SD antecedents are accessed with less processing costs than LD antecedents, suggesting that the information necessary to complete SD antecedent dependencies is present before the information necessary to complete LD antecedent dependencies.

C69 The middle temporal and inferior parietal cortex contributions to inferior frontal unification across complex sentences

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In spoken and written discourse, words are unified into sentences: the basic unit for conveying information about who did what to whom. In this FMRI-study (N=204), we investigate unification on the brain level by varying sentence complexity within-subject. We compared unification of complex relative clause (RC+) sentences with simpler sentences structures (RC-) containing a main clause and an optional simple subordinate clause. We predicted increased activity in unification regions across the unfolding sentence, e.g. since each incoming word increase maintenance load of already unified structure. Moreover, we expected a greater increase of unification related activation across the RC+ sentences for two reasons: (1) maintenance of the unified sentence initial main clause while the mid-sentence relative clause is unified and (2) complex sentence-final unification includes resolving long-distance dependencies for RC+ sentences. We thus created contrasts assessing increased activity across the unfolding sentence for RC+ and RC- sentences and compared them. RC+ sentences showed a greater increase across the sentence than RC- sentences, most strongly in bilateral insula and frontal operculum (FOP), extending into the inferior frontal gyrus (IFG). This is consistent with the observation that lesions in this locus often induce language comprehension difficulties. The inferior frontal sulcus (IFS), precentral gyrus and visual cortex were also active. To control for e.g. lexical frequency effects of lexical items used in the RC+ and RC- condition, we created corresponding contrasts testing for increasing activation during scrambled versions of the sentences. These contrasts, testing word lists, showed no effects, excluding potential contribution of the different lexical items in the RC+ and RC- sentences. An analysis comparing the corresponding complexity contrasts for sentences and scrambled word lists directly showed left IFG (rather than the FOP and insula), bilateral medial temporal gyrus (MTG), and left inferior parietal cortex (IPC). In summary, we found increasing activation related to unification across the sentence for complex more than simple sentence structure, most consistently in the frontal lobe. For instance, the left IFG was activated across all sentence complexity contrasts. There was an interesting effect in posterior language regions (MTG and IPC) when we introduced a control for lexical items. Our interpretation is that lexical processing in MTG might be enhanced in the sentence context. Semantic processes in IPC might help constrain unification of complex sentences. For instance, thematic role assignment might help resolve long distance noun-verb agreement in RC+ sentences. Finally, the insula/FOP, IFS, precentral gyrus and visual cortex were modulated by sentence complexity, but not when controlling for effects of lexical items. These regions might play a non-trivial role, yet to be determined, during unification of complex sentences. However, we conclude that the left IFG is most clearly active during unification across complex sentence structure, while MTG and IPC also participate in this process, independent of the particular lexical items in the sentence. When comparing the complexity effects for spoken and written sentences, the results were similar for both input modalities (manipulated between subjects), showing the robustness of these results across slightly different versions of the paradigm.

C70 Direct evidence for structural prediction from the processing of auxiliary dependencies: An ERP investigation in French

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While language comprehension is now widely assumed to involve predictive mechanisms, little direct evidence exists for prediction of upcoming syntactic structure, which, unlike lexical predictions that rely on highly constraining contexts, may be deployed more broadly given the tight relationships established between structure and interpretation. For instance, an animate subject like The man… may predict an underived transitive or unergative structure, while an inanimate subject like The rose… strongly predicts a derived passive or unaccusative structure (Carrithers, 1989; VanDyke-Lyon et al., 2011). These predictions are driven by semantic properties of the subject and thematic properties of the structure (Dowty, 1991). Since an animate subject is compatible with an agent interpretation, it can receive an agent theta-role of an underived structure. An inanimate subject, however, is incompatible with an agent interpretation, and thus is highly likely to be derived from a different syntactic position, for instance, as sister to the verb to receive a theme interpretation. Recent research has provided convincing evidence for prediction by examining the processing of probe words whose form depends on upcoming words. The basic hypothesis that a probe word mismatching in form for a predicted word would signal a prediction failure and elicit differential ERP components (DeLong

et al., 2005; Otten & Van Berkum, 2008; Van Berkum et al., 2005; Wicha et al., 2004). In the current study, we examined the processing of French auxiliaries where there is a dependency between auxiliary verb form, être/avoir, and the upcoming verb phrase's derived/underived structure, respectively (Kayne, 1993). We manipulated these auxiliary forms to probe for confirmed or disconfirmed of a structural prediction formulated on the basis of the animacy of the subject prior to the actual verb phrase. For instance, if an inanimate subject predicts an upcoming derived structure, reading avoir, which depends on an upcoming underived structure, would disconfirm that prediction. We hypothesized that disconfirmed predictions would elicit ERP components like the N400 that are sensitive to expectation (Lau, Holcomb, & Kuperberg 2013) and late positivities/negativities that index the costs of prediction more generally (Van Petten, Cyma, & Luka 2012). We recorded EEG while participants read 144 sentences (36/condition) using word-by-word rapid serial visual presentation (86 fillers). Acceptability was judged after each sentence. EEG was acquired on a 64-channel BioSemi system. ERPs were timelocked to the auxiliary onset and preprocessing and analysis was done using eeglab/erplab in Matlab and R. We found an N400-like component between 300-400 msec, with disconfirmed predictions (i.e. animate+être and inanimate+avoir) both more negative than confirmed predictions (i.e. inanimate+être and animate+avoir) as observed in lexical prediction, and a late sustained negativity between 500-800 msec for inanimate+avoir only, suggesting that the disconfirmation and revision of a predication for a derived structure is particularly costly. These results provide strong evidence for a mechanism of structural prediction in language comprehension. By taking advantage of the subject's expected interpretation based on animacy and the structures related to such interpretation, language comprehension can preprocess structural aspects of the unfolding sentence, potentially facilitating the analysis of upcoming phrases.

C71 Overlap and segregation in activation for syntax and semantics: a meta-analysis of 13 fMRI studies

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and semantics are generally seen as largely separate components in language. In this study we have investigated to what extent the neural machinery for syntax and semantics overlap and segregate through a meta-analysis of 13 fMRI published studies from our lab. These studies had different manipulations of syntactic and semantic factors. Our analysis was based on the activation maps from all subjects across studies. More traditional meta-analysis methods for fMRI data only use the coordinates of peak activation at the group level from each study. In contrast, our method allowed us to take into account the full extent of activation from each subject as well as its variability across subjects and studies. The manipulations of the studies used for our meta-analysis included: syntactic ambiguity (SynA) (1 study), syntactic repetition suppression (SynRS) (4 studies), artificial grammar learning (SynAGL) (2 studies) and semantic anomaly (SemA) (6 studies). In total, data from 407 subjects were analyzed. The contrasts reflecting syntactic or semantic processing from each study were entered into a multiple regression random effects model, using study as a factor. To prevent studies with large effect sizes dominating the analysis, contrasts were first variance-normalized within each study. Second level contrasts were formed testing for common effects across study designs within syntax/semantics and differences between syntax and semantics. Results showed that both syntax and semantics yielded extensive activations in bilateral inferior frontal gyri (IFG) and bilateral superior and middle temporal gyri (STG/MTG). Additionally, syntax significantly activated the supramarginal gyrus, the preSMA, the caudate nucleus and thalamus (all bilaterally), whereas semantics activated bilateral angular gyri. Performing separate analyses for each study type in syntax revealed large overlap across study types in the left IFG. Besides activating left IFG, SynAGL activated right IFG and bilateral occipital cortex, whereas SynA and SynRS both activated the left posterior MTG. The direct comparison between syntax and semantics yielded sparser activation maps, with substantial divergence when computed for each study type separately. For instance SynAGL showed more activation than semantics in frontal operculum/insula and the lateral occipital cortex (all bilaterally), whereas SynA showed more activation than semantics in left BA 44, left frontal operculum/insula and left posterior MTG. In conclusion, our meta-analysis shows that both syntax and semantics consistently activate the IFG and MTG. For syntax, we observed substantial overlap across different study types. Although a meta-analysis of a larger series of studies found a clear separation for syntactic and semantic processing (Hagoort & Indefrey, 2014), our analysis showed considerable overlap between both processes in the IFG. One potential reason for this difference is the fact that the current analysis has emphasized full activation extent instead of the location of peak activation. Future studies should investigate whether this overlap in activation is evidence for shared machinery subserving both processes, an artefact of commonly used preprocessing steps, such as smoothing, or whether paradigms that manipulate syntax or semantics have consequences in the other domain.

C72 Event Roles and Temporal Structure: Electrophysiological correlates of grammatical verb aspect processing

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The present study investigated the neurological mechanisms by which grammatical aspect influences our temporal perspective on described situations. Behavioral and ERP responses were recorded from 16 participants performing a semantic acceptability task on sentences describing actions performed on an object using an instrument (John was peeling an apple with a peeler). Sentences were presented one word at a time, and the object word (apple) was replaced by an image of that object in progress (half peeled apple) or fully completed (fully peeled apple). The instrument word (peeler) was also replaced by an image either in-use (peeler in hand) or not in-use (hanging on kitchen rack). We manipulated the grammatical aspect of the verb (perfect: completed action, had peeled; imperfective: ongoing action, was peeling) and analyzed the effect of verb aspect on the processing of the congruent or incongruent object and instrument images (fully peeled apple and not in-use peeler are congruent with perfect, half peeled apple and in-use peeler are congruent with imperfective). The behavioral results (post-sentence sensibility judgments) showed a clear effect of congruence on the picture of the resulting object (apple) that was driven by the imperfective sentences. When the resulting object is inconsistent (fully peeled apple) with the imperfective verb (was peeling), sensibility judgments took longer, a difference not significant for perfect sentences. There was no main effect of congruence on the picture of the instrument (peeler), although there was a marginally significant interaction between picture congruence and verb aspect, again driven by imperfective sentences. EEG results on the first image (apple) showed several interactions suggesting that the effect of congruence is dependent on the aspect of the preceding verb. In perfect sentences, pictures of aspect incongruent objects (i.e., half peeled apple) were detected very early at a coarse level, leading to P2/N300 effects, while congruent objects (i.e., peeled apple) were integrated at a fine-grained semantic level, reflected in a P300/N400 complex. On the contrary in imperfective sentences, objects displayed the more traditional eeg pattern, whereby pictures of congruent objects were detected and integrated rapidly, whereas incongruent objects invoked a deeper, later processing (P300/N400). EEG results on the second image (peeler) showed a larger and slightly later P300 peak for aspect-congruent instruments, and only for imperfective sentences. The interaction yielded a significant cluster even earlier in the P2 time-window, demonstrating a reduced P2 component when the aspect of the verb was imperfective (describing an ongoing action) and the instrument was congruent (in-use tool/instrument). The behavioral and ERP results extend previous findings (e.g., Madden & Therriault, 2009) in providing evidence that grammatical verb aspect modulates the types of predictions and inferences comprehenders make about events. There was a greater focus on the instrument for imperfective rather than perfect sentences. Both perfect and imperfective sentences showed clear focus on the recipient object of an action, but the perfect aspect seemed to create stronger (and earlier) constraints on this sentence role. These results are discussed in the context of how verb aspect affects mental simulations of described events.

Control, Selection, Working Memory

C73 P3 amplitude indexes the degree of similarity-based interference in memory retrieval during sentence comprehension

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In contrast to traditional multistore memory models, which view working memory (WM) and long-term memory (LTM) as separate systems, recent approaches posit comparable retrieval mechanisms for WM and LTM (Jonides et al., 2008). Retrieval is modelled as a cue-based process, with difficulty increasing due to similarity-based interference from cue overlap. For language, this perspective is supported by numerous behavioural studies (Van Dyke & McElree, 2011, for a recent overview). However, the neurobiological basis of cue-based retrieval in sentence processing remains insufficiently understood (but see Martin et al., 2012 for initial ERP evidence). We present two ERP experiments on memory retrieval during sentence comprehension in German using sluiced sentences (e.g. "They wanted to ask someone, but didn't know who [to ask]"). Successful comprehension of these sentences requires information retrieval from the matrix clause at the wh-pronoun (i.e. "ask someone"), with pronoun features serving as retrieval cues. Pronoun case marking must match that required by the matrix verb. Experiment 1 (n=24) manipulated interference by changing the type of case retrieval cue (accusative, the default object case, or dative, an exceptional object case, examples 1/2) and sentence grammaticality (1/2 versus sentences with inverted accusative/dative marking on the wh-pronoun). The exceptional status of the dative should render it a more robust retrieval cue. Experiment 2 (n=24) adopted the same basic design but additionally manipulated the intervening noun phrase (pronoun; high interference NP: highly plausible object of the matrix verb; low interference NP: less likely object of the matrix verb; illustrated for a grammatical accusative sentence in 3). Experiment 1 showed a P3 effect for grammatical versus ungrammatical conditions, followed by a late positivity (LPS) for ungrammatical versus grammatical conditions. The P3 effect was reduced for sentences with accusative versus dative verbs. Experiment 2 replicated the P3-LPS pattern and the P3 reduction for accusatives. Additionally, for grammatical dative sentences, P3 amplitude was reduced by increasing interference: the high interference NP condition engendered a reduced P3 in comparison to the other conditions. These results provide the first demonstration that similarity-based interference during retrieval in sentence processing

modulates the P3, a component that robustly correlates with memory retrieval in non-linguistic paradigms (e.g. Sternberg, n-back tasks). In these tasks, P3 latency varies with memory set size (Verleger, 1997 for review) and P3 amplitude is modulated by the number of features involved in retrieval (Busch & Herrmann, 2003). A P3 reduction for high interference conditions is corroborated by results from a letter-detection/attentional-blink paradigm (Craston et al., 2009). Examples (German originals, literal English translations) (1) Er möchte jemandem schmeicheln, aber sie ahnen nicht, wem. he wanted someone-DAT to.flatter but they suspect not whom-DAT (2) Er muss jemanden entlassen, aber sie ahnen nicht, wen. he must someone-ACC fire but they suspect not whom-ACC (3) Thomas wollte jemanden pflegen, aber sie / die Senioren / die Verbrecher verstehen nicht, wen. Thomas wanted someone to.take.care.of but they / the elderly / the criminals understand not whom-ACC

C74 Evidence for domain general error detection in speech *Hanna Gauvin[1], Wouter De Baene[1], Marcel Brass[1], Robert Hartsuiker[1]; [1]Ghent University*

In the language production domain there is consensus about the existence of an internal speech monitoring system. However, there is debate about the underlying error detection mechanism. Currently there are roughly two classes of theories: perception based (e.g. perceptual loop theory, Levelt 1989; forward models, Pickering & Garrod, 2013) and production based error detection mechanisms (Local monitors Laver, 1980; Conflict monitors, Nozari, Dell & Schwartz 2011). Perception-based theories assume error detection in speech production and perception both take place trough the speech perception system. Production-based theories do not necessarily assume a parallel system. To test whether speech error detection in production and perception apply similar mechanisms an fMRI study was conducted. In this study 24 participants judged correctness on the production of 66 tongue twister sentences (e.g. Dutch analogues of She sells sea shells) in a production and a perception condition. In the production condition participants repeated the sentence. In the perception condition a recording of another participant was played. Error percentages in the perception condition were matched to the percentage of errors produced in the production condition. To test whether the perception system plays a role in internal error detection, overt self-perception during production was ruled out by providing white noise trough headphones during production. Images were collected with a 3T MRI scanner system using a standard eight-channel radio-frequency head coil. Whole brain functional images were collected using a T2*-weighted EPI sequence, sensitive to BOLD contrast. The subject-level analyses were performed using the GLM. Events of interest were the periods after the correctness judgment was given. The events of interest were Correct trials (repetition was correct) and Incorrect trials (repetition contained an error). Trials that were judged incorrectly formed a regressor of no interest. Vectors containing the event onsets were convolved with the canonical HRF to form the main regressors in the regression model. The vectors were also convolved with the temporal derivatives. The resulting vectors were entered into the model. Statistical parameter estimates were computed separately for each voxel for all columns in the design matrix. Contrast images were constructed per individual to compare the relevant parameter estimates for the regressors containing the canonical HRF. Contrast maps were entered in a full-factorial design (whole-brain family-wise error corrected, $p<0.01$) The contrast erroneous > correct sentences revealed similar activation patterns in production and perception, including language specific areas and rostral cingulate zone (RCZ). Differences between production and perception were seen at the RCZ, which showed greater involvement during production. Perception on the other hand recruited more task related cortical activations. A conjunction analysis revealed bilateral activations in the inferior frontal gyrus and RCZ. Results are highly compatible with the conflict monitor theory of Nozari, Dell & Schwartz (2011) which proposes speech-monitoring to take place trough conflict between response options, which is then relayed to a domain general executive center (e.g. the RCZ). Although production and perception recruit similar areas, as proposed by perception-based accounts, we do not find perception-based activation during error detection in production as hypothesized by these accounts.

C75 Locus of Stroop-like effects in color and picture naming: Evidence from electrophysiology *Natalia Shitova[1], Ardi Roelofs[1], Herbert Schriefers[1], Marcel Bastiaansen[2], Jan-Mathijs Schoffelen[1,3]; [1]Radboud University Nijmegen, [2]NHTV Breda University of Applied Sciences, [3]Max Planck Institute for Psycholinguistics Nijmegen*

The color-word Stroop task and the picture-word interference task (PWI) have been used extensively to study the processes underlying spoken word production. One of the consistent behavioral effects in both tasks is the Stroop-like effect: The reaction time (RT) is longer on incongruent trials (e.g., 'blue' written in red; 'dog' superimposed on a picture of a cat) than on congruent trials (e.g., 'red' written in red; 'cat' superimposed on a picture of a cat). The effect in the Stroop task is usually linked to response selection (Roelofs, 2003; van Maanen et al., 2009), whereas the effect in the PWI task is associated with either response selection (Roelofs, 2003) or perceptual encoding (van Maanen et al., 2009). To adjudicate between the response selection and perceptual encoding accounts of the effect in PWI, we conducted an EEG experiment consisting of three tasks: a standard color-word Stroop task (3 colors), a standard PWI task (39 pictures), and a Stroop-like version of the PWI task (3 pictures). Participants overtly named the colors and pictures while their EEG was recorded. The mean RTs for the Stroop and Stroop-like PWI tasks did not differ (≈ 680 ms), but for the standard PWI task the RT was significantly longer (≈ 795 ms). EEG amplitude modulations were assessed using cluster-based permutation tests, which showed that ERPs within clusters of centro-parietal sensors started to

deflect negatively for incongruent relative to congruent stimuli around 300 ms post-stimulus onset for the Stroop and Stroop-like PWI tasks, and around 425 ms for the standard PWI task: an N400 effect. No statistically significant clusters were found before these negative deflections. These ERP data provide two main pieces of evidence. First, the timing of the N400 effects in all three tasks links the interference effect to response selection rather than perceptual encoding, which has been estimated to be finished around 200 ms post-stimulus onset (Indefrey, 2011). Second, the N400 effect occurs later in the standard PWI than in the Stroop and Stroop-like PWI (while the time interval between the onset of the ERP effects and articulation onset does not differ). These findings contradict the perceptual encoding account: the Stroop-like interference effect arises at the response selection stage in both Stroop and PWI with an even later effect in PWI as compared to Stroop. [1] Indefrey, P. (2011). The spatial and temporal signatures of word production components: a critical update. Frontiers in psychology, 2, 255. [2] Roelofs, A. (2003). Goal-referenced selection of verbal action: modeling attentional control in the Stroop task. Psychological review, 110(1), 88. [3] van Maanen, L., van Rijn, H., & Borst, J. P. (2009). Stroop and picture-word interference are two sides of the same coin. Psychonomic Bulletin & Review,16(6), 987-999.

C76 Does language production use response conflict monitoring?

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Although monitoring and subsequent control have received quite some attention for cognitive systems other than language, few studies have probed the neural mechanisms underlying monitoring and control in overt speech production. Recently, it has been hypothesized that conflict signals within the language production system might serve as cues to increase monitoring and control (Nozari, Dell & Schwartz, 2011; Cognitive Psychology). This hypothesis was linked directly to the conflict monitoring hypothesis in non-linguistic action control, which hypothesizes that one of the critical cues to self-monitoring is the co-activation of multiple response candidates (Yeung, Botvinick & Cohen, 2004; Psychological Review). A region of the medial prefrontal cortex (mPFC), the dorsal anterior cingulate cortex (dACC), as well as the basal ganglia have consistently been observed in both errors of commission and high conflict.. Hence these regions serve as an important testing ground for whether comparable monitoring mechanisms are at play in language production. The current study tests whether these regions are also implicated in response to speech errors and high conflict situations that precede the response. 32 native Dutch subjects performed a tongue twister task and a factorial combination of the Simon and Flanker task. In the tongue twister task, participants overtly produced a string of 4 nonwords 3 times. In tongue twister trials (TT), the onset phonemes followed a pattern of A-B-B-A, whereas rhymes followed an A-B-A-B pattern (e.g. wep ruust rep wuust). In non-tongue twister trials (nonTT), the nonwords contained minimal phonological overlap (e.g. jots brauk woelp zieg). These two conditions correspond to a high conflict and a low conflict condition respectively. In an arrow version of the the Simon-Flanker task, subjects responded to the direction of a middle arrow while flanking arrows faced in the same (i.e., congruent; >>>>>) or different (i.e., incongruent; >><>>) directions. These stimuli were presented either on the right side or the left side of the screen, potentially creating a spatial incongruency with their response as well. Behavioral results demonstrated sensitivity to conflict in both tasks, as subjects generated more speech errors in tongue twister trials than non-tongue twister trials, and were slower to incongruent relative to congruent flanker trials. No difference between spatial incongruency was observed. Neuroimaging results showed that activation in the ACC significantly increased in response to the high conflict flanker trials. In addition, regions of interest analyses in the basal ganglia showed a significant difference between correct high and low conflict flanker trials in the left putamen and right caudate nucleus. For the tongue twister task, a large region in the mPFC - overlapping with the ACC region from the flanker task - was significantly more active in response to errors than correct trials. Significant differences were also found in the left and right caudate nuclei and left putamen. No differences were found between correct TT and nonTT trials. The study therefore provides evidence for overlap in monitoring between language production and non-linguistic action at the time of response (i.e. errors), but little evidence for pre-response conflict engaging the same system.

C77 Verbal working memory recruits distinct manipulation and maintenance neural processes

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Verbal working memory (vWM) involves the maintenance and manipulation of speech information over short time periods. Based on behavioral performance, as well as studies of patients with brain damage, vWM has been proposed to contain multiple sub-components. The maintenance component of vWM is supported by a phonological store which contains an auditory based representation of speech. Motor processes are linked to these sensory processes forming a phonological loop that allows for covert motor-based rehearsal. In addition to the maintenance components, vWM also consists of a central executive component that supports the manipulation of items in vWM (Baddeley 2003). The division of vWM into maintenance and manipulation components explains a range of behavioral findings. Despite this, whether the neuronal mechanisms of vWM are also organized into distinct components supporting maintenance and manipulation remains unknown. This is because, distinguishing maintenance and manipulation requires neural access to the contents of vWM and neural processes are not often studied at

a resolution that can reveal the composition of vWM. Electrocorticography (ECoG) that records directly from the surface of the human brain offers a unique opportunity to study neural activity with the requisite temporal resolution to examine the specificity of the sub-components of vWM. Here, we recorded from 6 subjects (2 males, mean age 33 years, range 17-44 years) using ECoG and a delayed sensory-motor dissociation task designed to test the manipulation and specific speech components of the maintenance separately. Our results demonstrate that vWM recruits both a central executive in the prefrontal cortex, and auditory and motor based components. These components are linked together via a sensory-motor system that links perception and production. The neural activity of these components is reflected in the delay period as the auditory and motor systems represent content in sensory and motor space respectively, while the sensory-motor system's representation changes from sensory to motor. Taken together, these results support the theory that vWM is composed of two major systems, one for manipulation and one for maintenance as well as a parcellation of the phonological loop into three distinct sub-systems that link sensory and motor speech processes. These findings therefore integrate models of vWM that posit a role for sensory and motor processes (Baddeley 2003) as well as models that propose a privileged role for sensory-motor processes (Jacquemot and Scott 2006).

C78 On the existence of buffers for semantic and phonological short-term memory (STM): insights from functional neuroimaging and lesion analyses

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Researchers taking a buffer approach to STM have argued that the left inferior parietal lobe (esp. supramarginal gyrus) serves as a buffer for maintaining phonological information whereas the left inferior frontal gyrus (LIFG) serves as a buffer for maintaining semantic information (Martin, 2006). In contrast, those taking an embedded process approach argue that STM consists of the persisting activation of areas involved in processing phonological information (superior temporal lobe) and semantic information (middle and inferior temporal regions). We report an fMRI study and a lesion study to examine whether left frontal and parietal regions play the roles postulated by the buffer approach. Methods. Study 1: During fMRI scanning, 13 subjects performed STM tasks involving visually presented word lists, followed by a variable maintenance interval (between 2 and 8 seconds) and a subsequent probe item. Subjects indicated whether the probe was synonymous with any list items (semantic condition) or rhymed with any list items (phonological condition). Study 2: Seventeen individuals with left hemisphere stroke were administered a digit matching span task (determine whether two auditorily presented digit lists were identical or different) tapping phonological STM, a category probe task to tap semantic STM (indicate whether a probe was in the same semantic category as a list item) and a consonant discrimination task tapping speech perception. Lesions for each patient were traced on a T1 weighted MRI scan and warped to the MNI template, then overlaid on the AAL atlas to calculate % damage to anatomical regions. Results. Study 1: Maintenance-related activation for semantic representations was obtained along the LIFG (x=-39, y= 10, z = 23) and middle frontal gyrus. Functional connectivity analysis revealed correlated activity in the left middle temporal gyrus. Activation unique to phonological maintenance (during rhyme probe task) was less reliable, with no areas surviving cluster-based statistical thresholding. However, most individual subjects showed maintenance-related activation in the left inferior parietal lobe, although the location of this activation varied over different subregions. Study 2: Correlations were calculated between percent of damaged voxels in anatomical regions and performance on digit matching span and category span after regressing out performance on consonant discrimination. Performance on digit matching span correlated most strongly with greater damage to the supramarginal gyrus ($r = -.72$, $p = .001$), although significant correlations were also obtained with nearby temporal and parietal regions. Performance on the category probe task correlated with greater damage to the left inferior frontal gyrus ($r = -.52$, $p = .04$) and temporal pole ($r = -.5$, $p = .05$). Conclusion. We take these findings as consistent with a combined buffer/embedded process approach. For both semantic and phonological maintenance, both studies showed the involvement of temporal regions that support processing in these domains as well as the involvement of frontal and parietal regions which we argue serve to support activation in the processing regions. We also surmise that the weaker support for parietal regions in the fMRI study is due to the adoption of different strategies for phonological maintenance involving input phonological or articulatory representations.

Language Disorders

C79 Can non-invasive brain stimulation increase fluency in people who stutter?

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Transcranial direct current stimulation (TDCS) can increase the effects of behavioural treatment for acquired language disorders, such as aphasia. The aim of our study was to see if TDCS could improve fluency in developmental stuttering. We combined TDCS with training using choral speech, which involves speaking in unison with another voice and temporarily induces fluency during the task in people who stutter. 16 adults who stutter completed a training task in which sentences were repeated 10 times using choral speech. There were two sessions of training, which took place a week apart; order was counterbalanced across participants. In one session, anodal TDCS was applied to left inferior frontal cortex during training. In the control session, sham stimulation was used. Participants and researchers were blind to the session. Fluency was measured when reading the training and matched untrained sentences before training, immediately after, and again one hour later. We also used a passage reading task to investigate whether

the anticipated fluency enhancement generalized to other stimuli. Participants varied widely in the amount of stuttered speech produced at baseline in the two sessions (<1% to 34% syllables stuttered). Choral speech was effective in inducing complete fluency in all participants during training. For the sentence task, 5 participants were excluded from statistical analysis due to fluency at baseline (< 2% stuttered syllables). For the remaining 11 participants, stuttering was significantly reduced on trained and untrained sentences both immediately following the training and one hour later (mean ± SEM: pre = 14.6 ± 2.7%; post = 9.7 ± 2.6%; 1-hour post = 10.3 ± 2.5%). The size of the effect was significantly bigger for trained (immediate reduction: 6.3%; one hour later: 4.2%) than for untrained sentences (3.4% and 3.6%). However, combining TDCS with the training did not further improve fluency. For passage reading, data in two participants were excluded due to fluency at baseline (< 2% stuttered syllables). For the remaining 13 participants TDCS produced a small but significant reduction in stuttering when tested immediately following training (1.2% ± 0.5%), and a trend towards significant reduction one hour later (1.7% ± 0.8%). There was no significant change in stuttering due to training alone (0.1% and 0.3% decrease at the respective time-points). Training with choral speech significantly improved fluency for the trained sentences. This result is likely due to repetition adaptation, which is known to improve fluency for rehearsed stimuli. The improved fluency also transferred to untrained sentence stimuli. TDCS did not have any additional fluency-enhancing effect, however, possibly due to ceiling effects. The additional effect of TDCS on speech fluency was seen on the passage reading measure, where anodal stimulation significantly reduced stuttering, and training alone had no effect. Note that baseline stuttering rates were higher for the passages and also each one was only read once. These results show promise for future studies implementing repeated sessions of brain stimulation to improve fluency in people who stutter.

C80 Altered activity in language-related left fronto-tempro-parietal network in aphasic stroke. *Fatemeh Geranmayeh[1], Robert Leech[2], Richard J.S. Wise[3]; [1]Computational, Cognitive and Clinical Neuroimaging Laboratory . Imperial College London. UK., [2]Computational, Cognitive and Clinical Neuroimaging Laboratory . Imperial College London. UK., [3]Computational, Cognitive and Clinical Neuroimaging Laboratory . Imperial College London. UK.*

Introduction: We have previously shown that a left lateralized frontal-temporal-parietal (FTP) system, is involved in spoken discourse production in healthy controls1. The aim of this study was to investigate alterations of activity in the left FTP network and the default mode network (DMN) in the lesioned brain. The DMN is deactivated during externally driven tasks. It was hypothesized that patients with lesions resulting in aphasia would show reduced activity in the left FTP network and be unable to deactivate their DMN during language processing to the same extent as those patients without aphasia. Methods: Three groups of subjects were scanned; 24 older subjects without neurological disease (HV), 17 non-aphasic stroke patients (Non_Aphasic), and 35 patients with aphasic stroke (Aphasic). All patients had lesions in the left hemisphere and were on average 4 months post stroke. Subjects underwent a "sparse" fMRI paradigm consisting of 3 runs, each containing 20 Speech, 16 Count, 16 Decision (non verbal task), and 15 Rest. Group temporal concatenation independent component analysis (ICA) was used to decompose the fMRI data from HVs into 55 independent components that included the left FTP network and the DMN. A dual regression analysis was carried out to extract the timecourse of these components of interest for each subject in the Aphasic and Non-aphasic groups, taking into account variance associated with timecourses from the other 53 components.2, 3 The timecourses associated with these two components of interest were regressed against the experiment design matrix (i.e., Speech, Count and Decision with an implicit rest baseline). Parameter estimates were subsequently entered into a higher level analysis to test for group difference. Results: The three groups showed a significant difference (Aphasic < Non-Aphasic < HV) in measures of speech production during the Speech task, including syllable rate and the amount of appropriate information carrying words produced. In keeping with the findings in healthy controls, the left FTP network was significantly activated during Speech against all three baselines in Non-Aphasic patients (P < 0.008 Bonferroni corrected). In the Aphasic patients, left FTP showed significant activation for Speech>Rest, and Speech>Decision but not Speech>Count (P = 0.03 NS). Importantly, compared to the Non-Aphasic controls, the Aphasic group showed reduced activity in this network during the contrast of Speech>Count (P = 0.0009), with a similar trend for Speech>Rest. The contrast of Speech>Count is expected to capture higher-level speech processes which were also impaired in the Aphasic group. In the HV group, the DMN shows most deactivation during Speech followed by Decision and Count. A similar pattern was observed in the Non-Aphasic controls. However, compared to the Non-Aphasic controls the Aphasic patients did not show the same relative deactivation of the DMN in the contrast of Speech>Count Conclusion: Patients with lesions resulting in aphasia show a reduced activity in the left FTP network and an altered deactivation pattern in the DMN during propositional speech production compared to patients with lesions that spared language function. 1. Brain Lang. 2012;12:47–57. 4. IEEE Trans Med Imaging. 2004;23(2):137-52 5. PNAS. 2009;106(17):7209-14.

C81 Predicting extent of aphasia recovery using lesion location *Helga Thors[1], Paul Fillmore[1], Sigridur Magnusdottir[2], Chris Rorden[1], Julius Fridriksson[1]; [1]University of South Carolina, Columbia, SC, USA, [2]Landspitali-University Hospital, Reykjavik, Iceland*

Recovery from stroke varies substantially among patients, even in cases where the initial severity of impairment may be similar (Lazar & Antoniello, 2008). The prognosis for aphasia recovery depends in large part upon the underlying etiology, location and

extent of brain damage (Pedersen et al., 1995). Most patients with post-stroke aphasia improve to some extent (e.g. Pedersen et al., 1995), but some only make minimal improvement. Advances in neuroimaging have greatly improved our understanding of stroke not only in the acute, but also in the subacute and chronic stages of recovery. MRI and computed tomography allow clinicians to more accurately diagnose stroke subtypes, optimize treatment, and predict prognosis. Neuroimaging in stroke may also be utilized to monitor response to both medical treatment and physical rehabilitation (Gale & Pearson, 2012). Although some early studies may have argued that lesion volume was likely to be more important than lesion location when predicting outcome (e.g. see Brott et al., 1989), more recent studies have increasingly demonstrated the importance of lesion location (Gale & Pearson, 2012). In the current study we sought to determine the sites and extent of brain damage that predicted a lesser extent of aphasia recovery, as determined by neuropsychological testing. The participants included in this study were 34 left-hemisphere stroke patients, who were originally tested at the acute phase of stroke and again at the chronic phase. All participants were administered a neuropsychological workup, which included the Bedside Evaluation Screening Test, 2nd edition (BEST-2; West, Sands, & Ross-Swain, 1998). The BEST-2's 'Conversational Expression' sub-test served to quantify the severity of speech production impairment and the 'Pointing to Parts of a Picture' subtest served to quantify the severity of speech comprehension impairment. A voxelwise correlation analysis of structural damage as a predictor of recovery was conducted in MATLAB via custom software. The dependent factor was change in scores on the two subtests; the independent factor was structural damage (identified on diffusion weighted MRI and co-registered to high-resolution T1 images for subsequent analysis). In order to control for severity of the initial language impairment, baseline scores were included in the model as a cofactor. The crucial question was whether patients with common damage to specific brain region(s) tended to make less recovery, when compared to those patients in which the same region remained intact following stroke. We found that damage to the left posterior middle temporal gyrus (MTG) and left pars triangularis was found to predict less recovery in speech production. Damage to a similar, but distinct region in the left posterior MTG was associated with less recovery in speech comprehension. Our findings suggest that brain changes associated with recovery of language function rely on preservation and recruitment of the aforementioned areas of cortex in the left hemisphere. In general, it also seems likely that a similar relationship between cortical preservation and recruitment may pertain to recovery from other functional impairments in chronic stroke. Our findings contribute to research regarding the neuroanatomical mechanism of aphasia recovery, and may ultimately improve its treatment.

C82 Right hemisphere lesion sites that result in speech production and comprehension difficulties

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INTRODUCTION. Traditionally, the left hemisphere (LH) has been associated with language processing because acquired aphasia is typically observed after LH but not right hemisphere (RH) damage. However, in the last two decades, the contribution of the RH to language processing has been demonstrated in numerous functional imaging studies. There is thus a discrepancy between the conclusions drawn from lesion and neuroimaging studies. Our goal was to identify the RH lesion sites that are most consistently associated with aphasic performance. METHODS. We selected 216 right handed patients with strokes larger than 1cm3 from the PLORAS database. An automated method delineated the lesions on high-resolution T1-weighted scans: 63 had RH lesions, 153 had LH lesions. Aphasic performance was assessed using 2 sentence tasks (picture description and auditory sentence comprehension) and 3 single word tasks (auditory comprehension, repetition and naming). First, we identified RH lesions in patients with aphasic sentence production and comprehension. Then we validated the results by testing whether other patients with the same lesion sites had aphasic performance on any one or more of the 5 tests. Lesion identification was repeated separately for RH patients 5-10 and 0-5 years post stroke. We then compared the frequency and severity of aphasia in RH patients to those in LH patients with damage to the LH homologues of the RH lesions. RESULTS. In the 5-10 RH group, 3 patients had aphasic sentence production and comprehension. All 3 had damage to the right posterior superior longitudinal fasciculus. This parietal area defined RH_Lesion_1. In the remaining sample (n=213), 12 had RH_Lesions_1 and 7/12 (58%) had aphasic scores on at least one of the 5 language tasks. All patients with RH_Lesion_1 were then removed from further analyses, leaving 201 patients. In the 0-5 RH group, we found 3 patients with aphasic sentence production and comprehension. All 3 had damage in the right anterior superior longitudinal fasciculus. This area defined RH_Lesion_2. In the remaining sample (n=198), 9 had RH_Lesion_2 and 7/9 (78%) had aphasic scores on at least one of the 5 language tasks. When the lesions were flipped into the left hemisphere, we found 51 LH stroke patients who had damage to one or both regions, 48/51 (94%) had aphasic scores. Moreover, the scores were more aphasic after LH stroke than RH stroke. For example, on sentence production task, mean: range = 50:39-60 in LH patients and 56:52-60 in RH patients ($p<0.001$, 2-sample t-test). CONCLUSION. As expected, aphasia was much more likely after LH lesions than RH lesions and, when observed, aphasia was also less severe after RH lesions than LH lesions. Nevertheless, we have revealed two RH lesion sites that have a high likelihood of causing aphasia

(58% for Lesion_1 and 78% for Lesion_2). The importance of the RH for language production and comprehension is consistent with RH involvement in previous fMRI and transcranial magnetic resonance studies of neurologically normal participants.

C83 Evaluating a dorsal-pathway account of aphasic language production *Ardi Roelofs[1]; [1]Donders Institute for Brain, Cognition, and Behaviour, Radboud University Nijmegen, The Netherlands*

Introduction: Based on aphasic evidence, it has long been assumed that a dorsal pathway running from temporal to inferior frontal cortex underpinned by the left arcuate fasciculus (AF) underlies both repetition and spoken language production (e.g., Geschwind, 1970). However, according to a recent proposal (Ueno et al., 2011), computationally implemented in the Lichtheim 2 model, a ventral pathway underpinned by the extreme capsule (EmC) and uncinate fasciculus (UF) is primarily responsible for language production, whereas the AF underlies repetition. The aim of the present study was to computationally implement a dorsal-pathway production model and to assess its ability to account for the typical patterns of relatively impaired and spared language production, comprehension, and repetition performance in acute-onset and progressive aphasias, and recent evidence from AF and EmC/UF damage. Methods: A computational implementation was developed, called WEAVER++/ARC (for WEAVER++ Arcuate Repetition and Conversation), that synthesizes behavioral psycholinguistic, functional neuroimaging, tractographic, and aphasic evidence: (1) a computationally implemented psycholinguistic model of the functional processes underlying spoken word production, comprehension, and repetition (i.e., the WEAVER++ model; Levelt, Roelofs, and Meyer, 1999; Roelofs, 2008), accounting for a wide range of behavioral findings; (2) an extensive meta-analysis of neuroimaging studies localizing the functional processes assumed by the psycholinguistic model (i.e., WEAVER++) to anatomical gray-matter areas (Indefrey and Levelt, 2004); (3) tractographic evidence concerning the structure and anatomical white-matter connections of the AF (Glasser and Rilling, 2008); and (4) lesion-deficit analyses that relate anatomical evidence concerning damaged brain areas and connections to aphasic syndromes, including Broca's, Wernicke's, conduction, transcortical motor, transcortical sensory, and mixed transcortical aphasia (Hillis, 2007). The network structure and parameter values of the WEAVER++/ARC model were the same as in earlier WEAVER++ simulations (e.g., Levelt et al., 1999; Roelofs, 2008). Damage severity was simulated by manipulating connection weights or decay rate at specific network loci. Production, comprehension, and repetition accuracy were assessed. Results: The computer simulations revealed that the model accounts for the typical patterns of relatively impaired and spared language production, comprehension, and repetition performance associated with classic acute-onset and progressive aphasias: (1) impairment of production in Broca's and transcortical motor aphasia, impairment of comprehension in Wernicke's and transcortical sensory aphasia, and impairment of both production and comprehension in mixed transcortical aphasia and semantic dementia; (2) impairment of repetition in Broca's, Wernicke's, and conduction aphasia, but relatively sparing of repetition in the transcortical aphasias and semantic dementia. Most importantly, the model accounts for recent evidence from stroke patients that damage to the AF but not the EmC/UF predicts impaired production performance (Marchina et al., 2011; Wang et al., 2013). Language production impairment and AF lesion severity were linearly related in the model, in agreement with the empirical findings. Conclusion: The present study demonstrates that a dorsal-pathway production model accounts for the patterns of impaired language performance in classic acute-onset and progressive aphasias. Moreover, the model accounts for the evidence that damage to the AF but not the EmC or UF predicts impaired production performance, which challenges the ventral-pathway production view.

C84 Abnormal putamen activity is an indicator of dysfluent speech in stuttering *Emily L Connally[1], David Ward[2], Christos Pliatsikas[2], Kate E Watkins[1]; [1]University of Oxford, UK, [2]University of Reading, UK*

Stuttering is a developmental disorder affecting the normal flow of speech. Adults who stutter (AWS) show functional abnormalities in the speech and motor system, but it is unclear which differences reflect general traits of the disorder and which are related to the dysfluent state. We used functional MRI to identify brain activity related to the dysfluent state by (i) examining differences between groups of AWS who were either fluent or dysfluent during scanning and (ii) within subjects comparing utterances that were either fluent or dysfluent. We collected overt speech samples and related BOLD activity under two conditions (picture description and sentence reading) using sparse-sampling functional MRI (3T, 32 axial slices 4 mm3, TR=9s, TA=2s, TE=30ms) in 17 AWS (aged 19 – 54 yrs, 4 females). Each condition was contrasted with a silent baseline. Spatial maps were thresholded at $p<0.01$ (uncorrected), with an extent threshold of 30 voxels. For the between-subjects analysis, we subdivided our sample of 17 AWS into individuals who were mostly fluent (FLU, n=8) or dysfluent (DYS, n=9) based on an arbitrary cutoff: DYS individuals had >10 dysfluent utterances per scan session. Strikingly, during overt speech production (i.e. both conditions), the DYS group showed no regions with greater activity compared to the FLU group. The DYS group had less activity than FLU in the putamen bilaterally, left posterior cerebellum and right central operculum during picture description and sentence reading. Next, within DYS individuals we compared fluent to dysfluent speech production directly. During picture description, several subcortical regions were underactive during dysfluency compared to fluency: the putamen, amygdala and ventral striatum on the right and the caudate nucleus on the left. At the cortical level there was significantly less activity for dysfluent utterances relative to fluent ones in the posterior inferior frontal gyrus, and anterior and posterior portions of the superior temporal

sulcus bilaterally; the extent of this underactivity was considerably greater in the right hemisphere. No areas showed greater activity for dysfluent than fluent utterances during picture description. In contrast, in the sentence reading condition, dysfluency tended to elicit more activity than did fluency. In fact, only the motor cortex, bilaterally, was less active during dysfluency than fluency. The putamen and preSMA were overactive bilaterally during dysfluent sentence reading relative to fluent. At the cortical level, there was significantly more activity for dysfluent utterances relative to fluent ones in posterior inferior frontal gyrus and insular cortex extending to premotor and sensorimotor cortices bilaterally; the extent of this overactivity was considerably greater in the left hemisphere. In sum, abnormal activity in the putamen, bilaterally, appears to be a good indicator of the dysfluent state: not only does underactivity in this nucleus distinguish subgroups, who share trait dysfluency, but also, during dysfluent epochs in the scanner, there is abnormal over or underactivation of this nucleus, depending on task demands. Our data emphasize the complexity of state and trait effects in stuttering that may contribute to lack of consensus regarding the contribution of basal ganglia dysfunction in previous imaging studies.

C85 A new strategy to optimize aphasic naming capabilities based on the assumptions of the Mirror Neuron System: a pilot study

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Objectives: Several studies report the execution of action gestures to enhance naming abilities in aphasic patients with word retrieval deficits after stroke. This effect is explained with a multimodal communication system, based on partly overlapping networks of gesture and language production in the left hemisphere. Since only gestures executed with the right limb activate this left hemispherical multimodal network, this kind of therapy induces a problem for aphasics, who typically suffer from right hemiplegia. The actual study is a two single cases pilot that aims at finding a solution for this problem in order to give hemiplegic patients the chance to benefit from gesture based naming therapy, too. Based on the assumption that the mentioned interconnected neural networks may be part of the so-called mirror-neuron system (MNS), whose neurons are equally involved in both, action observation and execution, even the observation of action gestures should stimulate this multimodal neural network. Hence, we integrated the so-called mirror therapy, known from the treatment of motor disorders, into gesture related naming therapy. In our pilot study, we compared the effect of left limb gestures and mirrored left limb gestures on word retrieval in aphasic patients. Methods: Two aphasic patients with a severe naming deficit participated in an intensive naming treatment that included one daily session over three consecutive weeks. Each patient received a different treatment procedure. Patient A had to name 24 objects several times after manipulating them with the left hand (object related action gestures) and observing his own gestures in a mirror, placed perpendicularly to his front body (condition: "+ mirror"). Patient B had to name the same 24 objects simply after manipulating them with the left hand (condition: "– mirror"). The naming performances of both patients were evaluated and compared before and after the treatment. Results: In both patients a significant improvement from baseline testing to after treatment testing was found, but Patient A (+ mirror) showed a significantly higher improvement in naming performance than patient B (– mirror). Conclusions: In support of a multimodal representation of language and action, these findings put forward the idea that the observation as well as the execution of gestures are part of a multimodal system that interacts with word retrieval. The results are promising and encourage further investigation of bigger patient groups.

C86 Narrative Language Production Impairment in Amyotrophic Lateral Sclerosis

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Background: Amyotrophic lateral sclerosis (ALS) is generally viewed as a motor system disorder, but cognitive impairments in ALS have been reported with increasing frequency. Impairments are observed in executive functioning and language, among other domains. Most reports of language functioning in ALS have centered on the comprehension or production of single words; there have been few studies of connected, spontaneous speech in these patients. We hypothesized that narrative speech in ALS would exhibit deficits related in part to impaired executive functioning and to disease in prefrontal regions. Methods: We studied 26 patients with ALS and 19 healthy seniors. The subjects were asked to narrate the story from a wordless children's picture book, Frog, Where Are You?, by Mercer Mayer. The narrations were recorded digitally, transcribed, and coded for narrative discourse features of coherence, including local connectedness, global connectedness, and maintenance of the theme of searching for the frog. To examine the neuroanatomic basis of narrative discourse deficits in ALS, we related performance on local connectedness to gray matter (GM) atrophy and white matter (WM) reduced fractional anisotropy (FA) in a subset of patients (n=10). Results: Patients with ALS were impaired relative to controls on measures of discourse coherence, including local connectedness and maintenance of the search theme. They were not impaired on global connectedness, which depends on memory of a single element, rather than on the organizational demands of narrative production. The measures of discourse coherence were related to measures of executive functioning in the entire cohort of patients, in the subset of patients who did not exhibit significant executive deficits (n=22), and in the subset of patients who did not have a motor impairment causing dysarthria (n=20). Regressions related local connectedness to GM atrophy in right dorsolateral prefrontal and bilateral inferior frontal

regions. Regressions also related local connectedness to reduced FA in WM tracts mediating projections between prefrontal regions. Conclusions: ALS patients are deficient in their ability to organize narrative discourse, as is demonstrated by their impairments of discourse cohesion. These deficits appear to be related in part to executive limitations, independent of a motor disorder. Consistent with the hypothesis that ALS is a multisystem disorder, these deficits are related to disease in frontal regions that are associated with executive functioning.

Poster Session D

Gesture, Prosody, Social and Emotional Processes

D1 When reality and beliefs differ: oxytocin biases communicative choices towards reality

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Human referential communication is often adjusted to the presumed knowledge and characteristics of addressees ("audience design"; Clark, 1996). For instance, utterances directed towards children show systematic verbal and gestural adjustments (Snow and Ferguson, 1977; Campisi and Ozyurek, 2013). However, it remains unclear which neurobiological mechanisms drive communicators to implement those adjustments, and alter them on the basis of the ongoing communicative behaviour. Here we explore whether oxytocin, a neuropeptide known to promote prosocial behaviours and to sharpen processing of socially-relevant information (Bartz et al., 2011), biases communicative adjustments towards prosocial beliefs or towards the information acquired during an interaction. Fifty-eight healthy male adults participated in a randomized, double-blind, placebo controlled experiment involving the intranasal administration of oxytocin (24 IU). Participants communicated to an addressee the location of a token in a 3x3 grid (visible only to the communicator) by means of their movements on the grid (visible to both communicator and addressee). Participants spontaneously marked the token's position by waiting longer on that location as compared to other locations visited during their movements on the grid ("TimeOnTarget" effect). Crucially, participants were made to believe that they interacted with a child and with another adult, in alternation. In fact, an adult confederate performed the role of both addressees, while remaining blind to which one of the two roles she was performing in any given trial. Accordingly, both performance and response times of the two presumed addressees were matched. This feature of this previously validated protocol (Newman-Norlund et al., 2009; Stolk et al., 2013) allowed us to test how oxytocin modulates communicative adjustments driven by the mere belief of interacting with addressees with different abilities, while matching their behaviour. If oxytocin up-regulates prosocial behaviours, then intranasal oxytocin should enhance belief-driven communicative adjustments, increasing audience design effects when compared to placebo administration. Alternatively, if oxytocin sharpens the perception and saliency of social information, then intranasal oxytocin should enhance behaviour-related communicative adjustments, reducing audience design effects when compared to placebo administration. Participants believed they interacted with different addressees, attributing to them different age and cognitive abilities. Communication was effective (69% correct, chance-level: 6.6%), with participants spending longer time on the field containing the target. Participants receiving placebo showed a larger TimeOnTarget effect when they thought they were communicating with a child. Crucially, participants receiving oxytocin did not show a differential TimeOnTarget effect between the two addressees. Further exploration of the temporal dynamics of this between-group difference in communicative adjustments revealed that, at the onset of the communicative game, participants receiving oxytocin had a longer TimeOnTarget when addressing a presumed child. This effect disappeared over the course of the experiment. Participants that received placebo showed the opposite pattern. These findings shed light on a neurobiological mechanism that modulates the balance between two elements of audience design: belief-driven and behaviour-driven adjustments. Oxytocin drives interlocutors to adjust their communicative utterances towards the actual behaviour experienced in addressees, and away from their beliefs on the abilities of those addressees.

D2 Beat gestures modulate the processing focused and non-focused words in context

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Information in language is organized according to a principle called information structure: new and important information (focus) is highlighted and distinguished from less important information (non-focus). Most studies so far have been concerned with how focused information is emphasized linguistically and suggest that listeners expect focus to be accented and process it more deeply than non-focus (Wang et al., 2011). Little is known about how listeners deal with non-verbal cues like beat gestures, which also emphasize the words they accompany, similarly to pitch accent. ERP studies suggest that beat gestures facilitate the processing of phonological, syntactic, and semantic aspects of speech (Biau, & Soto-Faraco, 2013; Holle et al., 2012; Wang & Chu, 2013). It is unclear whether listeners expect beat gestures to be aligned with the information structure of the message. The present ERP study addresses this question by testing whether beat gestures modulate the processing of accented-focused vs. unaccented-non focused words in context in a similar way. Participants

watched movies with short dialogues and performed a comprehension task. In each dialogue, the answer "He bought the books via amazon" contained a target word ("books") which was combined with a beat gesture, a control hand movement (e.g., self touching movement) or no gesture. Based on the preceding context, the target word was either in focus and accented, when preceded by a question like "Did the student buy the books or the magazines via Amazon?", or the target word was in non-focus and unaccented, when preceded by a question like "Did the student buy the books via Amazon or via Marktplaats?". The gestures started 500 ms prior to the target word. All gesture parameters (hand shape, naturalness, emphasis, duration, and gesture-speech alignment) were determined in behavioural tests. ERPs were time-locked to gesture onset to examine gesture effects, and to target word onset for pitch accent effects. We applied a cluster-based random permutation analysis to test for main effects and gesture-accent interactions in both time-locking procedures. We found that accented words elicited a positive main effect between 300-600 ms post target onset. Words accompanied by a beat gesture and a control movement elicited sustained positivities between 200-1300 ms post gesture onset. These independent effects of pitch accent and beat gesture are in line with previous findings (Dimitrova et al., 2012; Wang & Chu, 2013). We also found an interaction between control gesture and pitch accent (1200-1300 ms post gesture onset), showing that accented words accompanied by a control movement elicited a negativity relative to unaccented words. The present data show that beat gestures do not differentially modulate the processing of accented-focused vs. unaccented-non focused words. Beat gestures engage a positive and long lasting neural signature, which appears independent from the information structure of the message. Our study suggests that non-verbal cues like beat gestures play a unique role in emphasizing information in speech.

D3 Taking the listener into account: Computing common ground requires mentalising

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In order to communicate efficiently, speakers have to take into account which information they share with their addressee (common ground) and which information they do not share (privileged ground). Two views have emerged about how and when common ground influences language production. In one view, speakers take common ground into account early on during utterance planning (e.g., Brennan & Hanna, 2009). Alternatively, it has been proposed that speakers' initial utterance plans are egocentric, but that they monitor their plans and revise them if needed (Horton & Keysar, 1996). In an fMRI study, we investigated which neural mechanisms support speakers' ability to take into account common ground, and at what stage during speech planning these mechanisms come into play. We tested 22 pairs of native Dutch speakers (20 pairs retained in the analysis), who were assigned to the roles of speaker or listener for the course of the experiment. The speaker performed the experiment in the MRI scanner, while the listener sat behind a computer in the MRI control room. The speaker performed a communicative and a non-communicative task in the scanner. The communicative task was a referential communication game in which the speaker described objects in an array to the listener. The listener could hear the speaker's descriptions over headphones and tried to select the intended object on her screen using a mouse. We manipulated common ground within the communicative task. In the privileged ground condition, the speaker saw additional competitor objects that were occluded from the listener's point of view. In order to communicate efficiently, the speaker had to ignore the occluded competitor objects. In the control conditions, all relevant objects were in common ground. The non-communicative task was identical to the communicative task, except that the speaker was instructed to describe the objects without the listener listening. When comparing the BOLD response during speech planning in the communicative and the non-communicative tasks, we found activations in the right medial prefrontal cortex and bilateral insula, brain areas involved in mentalizing and empathy. These results confirm previous neuroimaging research that found that speaking in a communicative context as compared to a non-communicative context activates brain areas that are involved in mentalizing (Sassa et al., 2007; Willems et al., 2010). We also contrasted brain activity in the privileged ground and control conditions within the communicative task to tap into the neural mechanisms that allow speakers to take common ground into account. We again found activity in brain regions involved in mentalizing and visual perspective-taking (the bilateral temporo-parietal junction and medial prefrontal cortex). In addition, we found a cluster in the dorsolateral prefrontal cortex, a brain area that has previously been proposed to support the inhibition of task-irrelevant perspectives (Ramsey et al., 2013). Interestingly, these clusters are located outside the traditional language network. Our results suggest that speakers engage in mentalizing and visual perspective-taking during speech planning in order to compute common ground rather than monitoring and adjusting their initial egocentric utterance plans.

D4 Behavioral and Neurophysiological Correlates of Communicative Intent in the Production of Pointing Gestures

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In everyday communication, index-finger pointing gestures are often used to establish triadic joint attention to a referent (Tomasello, 2008). Although such pointing is generally considered a joint action, it is unclear whether and how characteristics of the joint act shape the kinematic properties of the gesture. The present

study experimentally manipulated the gesturer's communicative intent as one possible factor influencing the kinematic properties of the pointing gesture, by varying the gestures' informativeness. In addition, a first step was undertaken towards understanding the neurophysiological mechanisms underlying the planning and production of referential pointing gestures. Twenty-four participants pointed for an addressee at one of four circles that lit up on a computer screen, while their three-dimensional hand movement kinematics and electroencephalograms were continuously recorded. The task of the addressee was to note down which circle lit up. The addressee looked at a corresponding screen placed back-to-back with the participant's screen and either saw the same circle light up or did not see a circle light up. This was mutually known by participant and addressee, rendering the participant's pointing gesture either redundant or informative. In the informative condition, participants significantly lowered the velocity of the gesture's stroke movement and significantly prolonged the duration of its post-stroke hold-phase. There was no behavioral difference in the duration of planning the gesture across conditions. However, response-locked event-related potentials (ERPs) time-locked to gesture onset showed a significant effect of informativeness in the 100-ms time-window before the onset of the gesture. In addition, stimulus-locked ERPs showed a P300 effect that reflected a significantly more negative ERP wave for informative compared to non-informative gestures. In line with findings on instrumental actions like reaching and grasping (Sartori et al., 2009), the kinematic form of a pointing gesture is influenced by the gesturer's communicative intent. The response-locked ERP results resembled the readiness potential with a slightly more anterior distribution. This suggests an interaction between planning the execution of a motor program and activation of the theory-of-mind network. Thus, the results of our study fit well with models of speech and gesture production that incorporate communicative intentions, such as the Sketch model (De Ruiter, 2000) and the Interface model (Kita & Özyürek, 2003). In addition, the P300 findings suggest that participants applied greater amounts of attentional resources in planning a more informative gesture (Polich, 2007). Thus, intentional and attentional networks may play an important role in the production of communicative gestures.

D5 Pointing kinematics: how communicative knowledge influences motor behavior *Anke Murillo Oosterwijk[1,2], Arjen Stolk[1], Miriam de Boer[1], Frank Hartmann[1,2], Ivan Toni[1], Lennart Verhagen[1,3]; [1]Radboud University Nijmegen, Donders Institute for Brain, Cognition and Behaviour, the Netherlands, [2]Erasmus University Rotterdam, Erasmus Research Institute of Management, Accounting, the Netherlands, [3]University of Oxford, Department of Experimental Psychology, United Kingdom*

HYPOTHESES: Pointing is a simple referential action that achieves the complex goal of changing the mental state of an addressee. Despite consensus on the use of communicative and motor domains for the planning of such actions, scholars disagree about the computational stage at which these domains interface. Here, we study pointing kinematics to dissociate and test two hypotheses. First, communicative and motor domains could operate in relative isolation, with communicative knowledge being integrated with sensorimotor computations only at a relatively late computational stage. In this view, pointing movements could be supplemented with a communicative tag, for example pointing ostensively long, while motor-control computations are left unaltered. Second, the domains might be integrated pervasively, allowing communicative knowledge to penetrate the visuomotor system and influence motor-control computations to govern joint motions in space. METHODS: We designed an online, interactive pointing game revolving around three tokens and played by a communicator and an addressee. We manipulated the contextual goal of pointing actions without altering the sensory input or social nature of the setup. In the communicative (mind-oriented) condition, the pointing action of the communicator directly informed the addressee about which target to select. In the instrumental (target-oriented) condition the communicator pointed to one of the tokens to evoke a corresponding computer-mediated consequence that informed the addressee. In addition, we manipulated the position of the addressee with respect to the communicator, either at the right-hand or the left-hand side, to study addressee specific adjustments of action guidance. We acquired finger and hand positions at high spatial and temporal resolutions and quantified the dynamics of the pointing trajectories with advanced kinematic analyses. This allowed us to isolate communicative specific adjustments in pointing actions and see how these adjustments depended on the spatial position of an addressee. RESULTS: Communicative and instrumental pointing movements differed in several respects. First, communicative pointing movements were supplemented with a clear extension of the holding phase near the target. Second, the trajectory planning of communicative pointing movements was influenced by the location of the addressee, over and above effects on spatial and temporal features of movement end-points. Importantly, these adjustments arose already very early during the pointing movement, suggesting a pervasive integration. Moreover, not only the end-location but also the direction of movement during transport was affected. In fact, effects of movement direction opposed those of end-location, indicating that these communicatively relevant adaptations were not target-oriented. SUMMARY: These findings show that communicative and motor domains of human cognition do not operate in isolation, nor interact only at a single computational stage. Instead, they are pervasively integrated allowing declarative pointing movements to be planned and controlled on the basis of communicative knowledge, rather than assembled by tagging instrumental movements with ostensive cues.

D6 Bidirectional syntactic priming: How much your conversation partner is primed by you determines how much you are primed by her *Lotte Schoot[1], Peter Hagoort[1,2],*

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In conversation, speakers mimic each other's (linguistic) behavior. For example, speakers are likely to repeat each other's sentence structures: a phenomenon known as syntactic priming. In a previous fMRI study (Schoot et al., 2014) we reported that the magnitude of priming effects is also mimicked between speakers. Here, we follow-up on that result. Specifically, we test the hypothesis that in a communicative context, the priming magnitude of your interlocutor can predict your own priming magnitude because you have adapted your individual susceptibility to priming to the other speaker. 40 participants were divided into 20 pairs who performed the experiment together. They were asked to describe photographs to each other. Photographs depicted two persons performing a transitive action (e.g. a man hugging a woman). Participants were instructed to describe the photographs with an active or a passive sentence depending on the color-coding of the photograph (stop light paradigm, Menenti et al., 2011). Syntactic priming effects were measured in speech onset latencies: a priming effect is found when speakers are faster to produce sentences with the same structure as the preceding sentence (i.e. two consecutive actives or passives) than to produce sentences with a different structure (active follows passive or vice versa). Before participants performed the communicative task, we ran a non-communicative pretest for each participant, to measure their individual priming effect without influence of the partner's priming effect. To test whether speakers influence each other's syntactic priming magnitude in conversation, we ran an rANCOVA with the syntactic priming effect of each participant's communicative partner as a covariate. Results showed that there was an interaction between this covariate and Syntactic Repetition ($F(1,38) = 435.93$, $p < 0.001$). The more your partner is primed by you, the more you are primed by your partner. In a second analysis, we found that the difference between paired speakers' individual syntactic priming effects (as measured in the pretest) predicted how much speakers adapt their syntactic priming effects when they are communicating with their partner in the communicative experiment ($ß = -0.467$, $p < 0.001$). That means that if your partner's individual susceptibility for syntactic priming is stronger than yours, you will increase your own priming magnitude in the communicative context. On the other hand, if your partner's individual susceptibility for syntactic priming is less strong, you will decrease your priming effect. Furthermore, the strength of the in-/decrease is proportional to how different you are from your speaker to begin with. We interpret the results as follows. Syntactic priming effects in conversation are said to result from speakers aligning their syntactic representations by mimicking sentence structure (Pickering & Garrod, 2004; Jaeger & Snider, 2013). Here we show that on top of that, the magnitude of syntactic priming effects is also mimicked between interlocutors. Future research should focus on further investigation of the neural correlates of this process, for example with fMRI hyper-scanning. Indeed, our findings stress the importance of studying language processing in real, communicative contexts, which is now also possible in neuroimaging paradigms.

Auditory Perception, Speech Perception, Audiovisual Integration

D7 Inside speech: neural correlates of audio-lingual speech perception

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One fundamental question is whether cross-modal speech interactions only depends on well-known auditory and visuo-facial modalities (i.e., lip movements) or, rather, might also be modulated by less familiar visual modalities (i.e., tongue movements, which we fell when produce speech but rarely see). In order to answer this question, we here investigated the neural correlates of both audio-viso-lingual and audio-visuo-labial speech perception using functional magnetic resonance imaging (fMRI). The stimuli consisted of individual /pa/, /ta/ and /ka/ syllables, recorded by one male and one female speakers in a sound-proof room, with the auditory track and the related labial and lingual movements simultaneously acquired by an ultrasound imaging system coupled with a video camera and a microphone. fMRI images were acquired with a 3T whole-body MR scanner with a sparse-sampling acquisition used to minimize scanner noise. Participants were instructed to passively listen to and/or watch the presented syllables in five different modalities: an auditory-only modality (A), two visual-only modalities related to either lip (VL) or tongue (VT) movements of a speaker, and two audio-visual modalities including either lip (AVL) or tongue (AVT) movements. fMRI data were preprocessed and analyzed using the SPM8 software package. A second-level random effect group analysis was carried-out with the modality (A, VL, VT, AVL, AVT) as the within-subjects variable and the subjects treated as a random factor. All contrasts were calculated with a significance level set at $p = 0.05$ family-wise-error (FWE) corrected at the voxel level. For both lip- and tongue-related stimuli, a conjunction analysis between the auditory, visual and audio-visual modalities showed common activation of the auditory, somatosensory and motor regions (notably including the Heschl'sgyrus, the posterior part of the superior temporal sulcus/gyrus, the superior parietal lobule, the primary sensorimotor and premotor cortices). Within this common neural network, more activation in the visual and auditory cortices was however observed during the perception of lip movements while, conversely, more activation was observed in motor and somatosensory areas during the perception of lingual movements. These results suggest a common network of audio-visuo-motor integration in relation to both labial

and lingual movements. Interestingly, greater activation of the somatosensory and motor cortices was observed during the perception of tongue movements. In this latter case, we hypothesize that a motor simulation of speech gesture was carried out by the participants, in relation with his/her own motor procedural knowledge of speech production and lingual speech movements.

D8 Putting the text in neural context: Short term experiential reorganization of language and the brain

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We have proposed that the brain routinely uses knowledge about context to predict and constrain interpretation of sounds. Because knowledge varies with individual experience, the "neural context" supporting language comprehension must be dynamically organizing. We tested this proposal by varying participants' experience with the visual context that accompanied sentences, either speech-associated mouth movements or printed text. Participants later listened to the same sentences without the accompanying context. We hypothesized that, if prior experience involved observing the actor's articulations, sensory-motor regions associated with processing those movements would be relatively stronger contributors to the neural context for processing the words in those sentences. Conversely, if prior experience involved print, brain regions associated with reading would be stronger contributors when processing those same words. Participants, unfamiliar with Basque, underwent 256-channel EEG. During Phase one (P1) participants saw and heard 40 unfamiliar video clips of an actor standing in front of a white board. In half the clips the actor faced the board and read aloud the English sentences printed on the board. In the other half she faced the participant and spoke English sentences and a "Basque translation" of those sentences was printed on the board. During Phase two (P2) participants heard audio-only versions of the 40 sentences from P1, created by removing the video track, and 40 previously unheard control sentences. All sentences ended in a target word matched for various stimulus properties. Ocular artifacts were removed from the resulting EEG data and then segmented into epochs time-locked to the onset of targets words. Epochs were bandpass filtered, average referenced, averaged, and source localized using Brainstorm software. All analyses corrected to $p < .05$. When target words heard in P2 could be read in P1 there was significantly greater bilateral activity in the angular gyrus, occipito-temporal cortex, and a large number of occipital lobe regions including the fusiform gyri when compared to controls or directly to target words that could not be read in P1. Conversely, there was significantly more activity bilaterally in the posterior superior temporal gyrus/sulcus, pars opercularis, and ventral aspects of the and pre-/central gyrus/sulcus for P2 target words when the actor's mouth could be seen producing those words in P1. Results suggest that hearing a word can be supported by different brain regions depending on our recent experience with that word. In particular, brain regions involved in the observation and production of mouth movements form part of the neural context associated with processing a word when prior experience includes seeing the person producing that word. Visual brain regions thought to support reading, including the putative visual word form area, comprise the neural context for that same word when prior experience with that word includes reading it. This pattern suggests that knowledge garnered from prior context is routinely used by the brain during language comprehension, even when that context is absent. This implies that the organization of language and the brain is not static but, rather, is dynamically organized around our prior and rapidly changing experience of the world.

D9 Listening to natural speech: effects of auditory stimulus rhythmicity and content on MEG power spectra

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Speech features rhythmicity (Port, 2003) which is manifested, for example, as the behavioral word and syllable production frequencies at 2-3Hz and 4-5Hz, respectively (Levelt, 1999). Speech rhythmicity has been suggested to be a determinant of how spoken language is processed in the brain. For instance, it has been shown that the coupling of cortical activation with peripheral signals preferentially occurs at behaviorally relevant frequencies in both speech production (Ruspantini et al., 2012) and speech perception (Peelle et al., 2013). However, in the case of speech perception, it remains unclear whether spontaneous cortical oscillations undergo power modulations as a function of speech rhythmicity. The present experiment aims to address this question. Cortical signals during perception of auditory stimuli were recorded with a whole-head MEG device (Elekta 306-channel neuromagnetometer) from 20 healthy Finnish-speaking participants (11 females; all right-handed; mean age 24.5). Four different types of auditory stimuli were used: natural speech at three different production rates (normal/spontaneous, slow, fast) as well as rhythmic noise. Speech stimuli consisted of the answers of a male speaker to questions drawn from six different thematic categories. In the case of the slow and fast production rates, the speaker was asked to aim for 50% and 150% of his normal speech production rate. Speech rate variations were carried out based on the subjective perception of the speaker; no external pacing device was used. In normal speech production, the word and syllable frequencies were 1.8 Hz and 4.6 Hz, respectively. In the slow speech condition, the frequencies were 58% (word) and 55% (syllable) of normal and in the fast speech were 148% (word) and 157% (syllable) of normal. Rhythmic noise consisted of amplitude-modulated white noise with the same envelope and spectral content as in the normal-rate speech stimuli. There were four stimulus blocks (normal, fast slow, noise) presented in pseudorandomized order, each consisting of six 40-second auditory segments. At the sensor-level,

paired t-tests were used to reveal differences in spectral power between conditions across all 306 MEG channels. Between-condition comparison of MEG sensor-level frequency spectra revealed decreased power in the left hemisphere for normal speech compared to both fast and slow speech ($p < 0.05$). The right hemisphere showed the opposite effect, that is, increased power at normal speech vs. fast and slow speech at frequencies below 30Hz. These effects were particularly pronounced over the temporal cortex in both hemispheres. Finally, when comparing normal speech to noise, MEG power in the 9-30Hz range was significantly greater ($p < 0.01$) for speech, especially in the right hemisphere. Based on the present initial sensor-level results, the auditory stimulus rate and content influence the power of spontaneous cortical oscillations, especially at frequencies below 30Hz. We did not detect a monotonical increase or decrease in oscillatory power as a function of auditory stimulus speed, but, instead, the normal speech rate stood out as a special case. Furthermore, these findings suggest a possible functional differentiation between the left and right hemispheres in speech comprehension.

D10 Chasing Language Through the Brain: Three Successive Parallel Networks *Vernon Leo Towle[1], G. Kavya Minama Reddy[1], Zhongtian Dai[1], Weili Zheng[1], David Brang[2], Scott Hunter[1], Michael H. Kohrman[1], Charles J. Marcuccilli[1], James X. Tao[1], Marvin A. Rossi[3], David M. Frim[1], Richard W. Byrne[3]; [1]The University of Chicago, [2]Northwestern University, [3]Rush University*

This neurophysiologic study addresses the precise timing of receptive and expressive linguistic processes in the brain. Although studies using fMRI and PET have thoroughly defined cortical areas involved in linguistic processes, and studies using DTI have provided complementary information about the anatomy of these networks, these measures of cerebral hemodynamics and anatomical connectivity have provided little information about the timing of linguistic processes in the brain. On the other hand, electrocorticographic (ECoG) recordings reflect neural information processing with millisecond resolution. We obtained ECoG recordings from chronically implanted subdural arrays of electrodes from six temporal lobe epilepsy surgery patients (four left, two right) while they performed three verbal tasks (word repetition, noun-verb generation, and cued recognition). The spatio-temporal dynamics of task-induced gamma activity (70-100 Hz) were studied, with emphasis placed on the onset, peak, and offset of event-related gamma band power recorded over each cortical gyrus. For each patient, the presurgical T1 MRI cortical surface was reconstructed in 3-D, with probabilistic identification of gyri determined by FreeSurfer. The patient's post-implantation CT image was co-registered to the preoperative MRI using SPM. Next, the subdural electrodes were registered to the reconstructed presurgical MRI surface using each individual electrode's geometric features, with open-source code developed in our laboratory. Reliable event-related gamma activations were observed to be widely distributed across the cortex, with their onsets, peaks and offsets clearly identified by visual inspection of the superimposed waveforms. Across all tasks and subjects, the onset of the earliest gamma activity after aural word onset (90 msec) was recorded over the posteriolateral and central superior temporal gyrus (dorsal pathway), peaking at 480 msec. Activity began in a second group of gyri (anterior STG, central and posterior ITG, temporal pole, orbital gyrus, and subcentral gyrus) at 330 msec. Finally, when the early posteriolateral STG activity peaked and began to decline, a third group of gyri (ventral pathway) became active at 610 msec (anterior MTG, inferior triangular gyrus, and para-hippocampal gyrus), the latter area with longer activation, lasting 1620 msec in duration. There were pre-stimulus decreases in gamma activity in the lateral frontal lobe in these repetitive verbal tasks. We interpret these as top-down executive decreases in frontal corollary discharges, allowing activation or gating of the subsequent semantic/lexical and memory/motoric networks. As this pattern of responses was observed consistently across our subjects and tasks, we interpret the succession of activations as three sequentially activated networks, each with increasingly widespread distributed processing, and occurring without regard to the nature of the task. These data are consistent with the idea that acoustic/phonetic processing occurs first, and is followed by semantic/lexical processing, and finally by motoric programming and memory updating. However, the data also demonstrate that there is little overlap between the peak of an earlier stage of processing and the onset of a later stage (only 150 msec for both acoustic-to-semantic and semantic-to-motoric). Consequently, this suggests that there is limited opportunity for top-down, analysis-by-synthesis feedback from later semantic processes to earlier perceptual processes in these experimental paradigms.

D11 Confronting functional and neural models of speech comprehension and production *Lou Boves[1], Mirjam Ernestus[1,2], Louis ten Bosch[1]; [1]Centre for Language Studies, Radboud University Nijmegen, [2]Max Planck Institute for Psycholinguistics, Nijmegen*

A central goal of research in neurobiology of language is to discover the neural underpinning of concepts such as "phoneme", "morpheme", "word", "lemma" and "phrase", conditions such as "agreement" and operations such as "wh-movement", which are defined in Linguistics. However, a large proportion of these concepts and operations originated as devices for meta-level discussions about sentences, ages before scientists started asking questions about the neural and cognitive processes that underlie the production and comprehension of utterances. At least some of the concepts may have no neural substance at all, even if they have been successfully invoked in explaining the results of psycholinguistic experiments. In the theory of speech comprehension it is hotly debated what the basic units of processing and representation are. The majority view still holds that the basic units are abstract phonemes or bundles of distinctive features, but there is increasing support for theories that take episodes or exemplars as the basic units. These antagonistic theories have in common that they remain extremely

vague about the details of the neural representations and the computations that are needed for a person to actually understand or produce a spoken utterance. If positions and claims are supported by computational models, it is virtually always so that those models operate on manually constructed discrete symbolic input representations, and the models make no claims about neurobiological plausibility. In the poster we will present the results of a large-scale behavioral experiment aimed at answering the question whether exemplars play a role in comprehension as well as in production. Participants were asked to shadow nonsense words of the form / CVVVVVV-CV-PV/ (Mitterer & Ernestus, 2008), where the vowel V in the central syllable could have normal or somewhat lengthened duration; also the voiceless plosive P that separates the second and third syllable can have normal duration or be lengthened. Native speakers of Dutch have several routes available for linking their perception to the ensuing articulation. At the perception side they may restrict processing to creating on-the-fly exemplars without a representation in the form of discrete units, they might create a representation in the form of discrete phonemic units, or they might access their mental lexicon to find the most similar word (Roelofs, 2004). For each of these routes we construct plausible neural computational procedures that could be used to control the speech production process in the shadowing task. Using end-to-end computational models (i.e., models that take acoustic speech signals as input and produce audible speech as output) we simulate the chronometric data and the accuracy with which the stimuli were shadowed, in an attempt to explain differences between participants in terms of different routes. We will use the result to discuss potential discrepancies between representations and processes implied in functional (psycho)linguistic models of speech comprehension and production on the one hand and a detailed account of what is currently known about the neural processes that support auditory processing of speech signals and the production of spoken utterances. Holger Mitterer and Mirjam Ernestus (2008) The link between speech perception and production is phonological and abstract: Evidence from the shadowing task, Cognition 109, 168–173. Ardi Roelofs (2004) Error Biases in Spoken Word Planning and Monitoring by Aphasic and Nonaphasic Speakers: Comment on Rapp and Goldrick (2000), Psychological Review Vol. 111, No. 2, 561–572.

D12 Is there a causal influence of motor cortex on comprehending single spoken words? Evidence from single-pulse TMS

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Introduction: The role of the left inferior frontal (LIF) language area and the adjacent articulatory motor cortex in language processing is under heavy dispute. Classic wisdom had been that this region serves a role in speech production but not in comprehending meaningful words. Meanwhile, mounting evidence from neuroimaging and patient research, and, most recently, TMS experiments, shows that LIF cortex is critical for classifying meaningless speech sounds into phonemic categories. However, whether such findings speak to the language comprehension issue is under heavy dispute, because comprehension does not require explicit phonemic classification. To assess the causality of LIF mechanisms in spoken language comprehension, the normal function of speech sounds in distinguishing between meaningful words must be investigated. Therefore, we here use an established comprehension paradigm, the word-to-picture matching (WPM) task, while applying transcranial magnetic stimulation (TMS) to LIF cortex. Methods: 13 right-handed native German speakers participated in the study. We used a standard psycholinguistic word comprehension task (the word-to-picture matching, WPM) while applying transcranial magnetic stimulation (TMS) to areas of motor cortex that control different articulators (lips vs. tongue). Critical word stimuli started with bilabial (lip-related) or alveolar (tongue-related) phonemes, yielding "lip words" and "tongue words". Stimuli were not embedded in noise but presented at a low sound level. In each trial, a spoken word was played via headphones, preceded by TMS pulses. Following this, two images were displayed. One image depicted the meaning of the target word and the other one the meaning of a minimal pair differing in the crucial initial phoneme (e.g., spoken "dear" vs. "beer"). Results: The analysis of reaction times in the single word comprehension task (word-to-picture matching) showed a significant interaction between word type (lip word vs. tongue word) and the location in motor cortex (lip vs. tongue) which had been stimulated with single TMS pulses. Conclusions: To our knowledge, this is the first evidence that the LIF cortex plays a causal role in the comprehension of meaningful spoken words, when phonemes serve their normal function as meaning-discriminating units. Furthermore, our results demonstrate the independence of such causal effects from stimulus degradation and response biases and rule out the option that additional features epiphenomenal to the comprehension process are reflected. Supported by the Deutsche Forschungsgemeinschaft (DFG)

D13 Finger-tracking in spoken language perception reveals phonological competition

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When listening to spoken language, multiple lexical representations sharing the same initial input ("cohorts") are partially activated and constantly updated as the speech signal unfolds over time. Arm movement trajectories to target words in the presence of word onset competitors have been shown to reflect this continuous word activation process (Spivey et al., 2005). Here, we tested this continuity assumption by tracking adult participants' finger movements on a touch screen. We expected trajectories to a target to be attracted by a distracting object that phonologically overlaps with the target compared to trajectories where target and distractor do not overlap in phonology.

Stimulus material consisted of 16 pairs of phonologically overlapping German nouns. Thirty monolingual native German speakers took part in this study. In each trial we presented them two colored images of objects simultaneously. In the distractor condition, the images referred to objects that overlapped in their initial phonemes (e.g., "Angel" and "Anker"; Engl., "fishing rod" and "anchor" respectively). In the control condition, objects held no phonological similarity (e.g., "Angel" and "Eimer"; Engl., "fishing rod" and "bucket"). The pictures were located on the upper left and upper right corner of a touch screen. Participants listened to a spoken word referring to the target object. We asked participants to move with their index finger on the screen from a start button on the bottom corner to the target object. Finger trajectories on the computer screen were recorded. Average finger trajectories differed for both conditions with trajectories travelling closer to the unselected alternative than to the target object in the distractor condition. Thus, finger trajectories reflect the continuous activation of phonological competitors and provide a feasible and cheap means for investigating spoken word access processes. References: Spivey, M. J., Grosjean, M., & Knoblich, G. (2005). Continuous attraction toward phonological competitors. Proc Natl Acad Sci U S A, 102(29), 10393-10398.

D14 Disrupted Functional Connectivity of Left Pars Opercularis During Viewing of Animated vs. Human Speech

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INTRODUCTION: Ecologically valid visual input accompanying speech facilitates comprehension and engages a frontoparietal network active during action observation and execution. Activation of this human mirror network may have beneficial effects on speech rehabilitation after stroke. Some experimental and commercial speech therapies for post-stroke aphasia use realistic avatars rather than human actors, which offer the option of flexible programming with a variety of voices. The biological differences between viewing the speech of animated characters and the more fluid and precise speech movements of a videotaped person are not known. METHODS: Twenty-four adults performed two tasks, observation and overt imitation of audiovisual syllables, during BOLD fMRI. One group viewed a human actor (N=11) while the other group viewed an animated actor presenting identical auditory stimuli. Following preprocessing, an average time series was extracted from the voxels in left pars opercularis (FreeSurfer parcellation). To assess functional connectivity, a whole brain correlation coefficient map (Pearson's r) was created with this average time series as the regressor of interest using 3dDeconvolve (AFNI). These maps were transformed into standard space and smoothed (5mm FWHM) to permit group analysis. A two factor ANOVA (human/avatar; observation/imitation) was performed. Results were FDR corrected for multiple comparisons. The same procedure was followed for left and right transverse temporal gyri (TTG), which served as control regions for the left IFG. RESULTS: The group viewing the avatar showed more widespread overall activation in response to both tasks compared to the group viewing the human. Across tasks, a large number of regions showed significantly greater correlation with left pars opercularis activation for those viewing the human actor compared to the avatar. At an FDR corrected significance level of q=.01, these regions included: on the left, anterior STG and hippocampus; on the right, the caudate, anterior cingulate, pars opercularis, posterior STS, intraparietal sulcus and cerebellum; and bilaterally, SMA, primary and secondary visual cortices, auditory cortices and posterior parietal cortices. No region demonstrated greater functional connectivity with left pars opercularis for the group viewing the avatar compared to the human (q=.01). Finally, functional connectivity of brain regions with TTG did not differ across the two groups. CONCLUSION: While overall brain activation is increased across a large set of regions when viewing an animation compared to a human actor, the neural coordination across these regions may be less efficient than that elicited by natural speech. Functional connectivity of left pars opercularis, a subdivision of Broca's area crucial in language and other tasks, and which is believed to be part of the human mirror system active for both observation and execution of speech, is disrupted for viewing an avatar compared to a human speaking. This may diminish the effectiveness of avatar observation in enhancing speech execution in human subjects with language impairment. As the field of telerehabilitation grows, this has significant ramifications for speech therapy programs and the manner in which stimuli are presented. The tradeoff between desired effects and flexible programming may favor use of a human talker in view of the present results.

D15 Abstract linguistic rules are detected early in processing

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The ability to extract abstract rules from the input has been claimed to be a fundamental mechanism for language acquisition. Behavioral studies have shown that this ability is present in both pre-lexical infants and adults. Nevertheless, it remains unclear the processing level at which abstract regularities are detected from the speech input. That is, whether they are detected in the early processing stages, or later, when syntactic patterns present in speech are more evident. The main goal of this experiment is thus to study the processing level at which the extraction of rules is taking place. We registered Event Related Potentials (ERP) using an oddball paradigm that has been proven to be effective for the study of the early stages in the detection of patterns. As standard stimuli, we created a series of trisyllabic CVCVCV nonsense words that followed an AAB rule. As deviant stimuli we created nonsense words following an ABC rule. In the experiment, participants were presented with the words in the auditory modality while they looked a silent film. ERP's were recorded during the presentation of the words. We observed a significant MMN component when we compared the ERPs following standard and deviant stimuli. This suggests the participants were

detecting the abstract pattern differentiating standard and deviant words as early as 200 ms. The present results add evidence to the idea that the MMN might be used as a tool for the study of the detection of abstract patterns implemented over linguistic stimuli. More importantly, because the MMN component reflects early stages of processing likely occurring at a pre-attentional level, the present results indicate that extraction of rules from speech takes place very rapidly and before higher syntactic stages of linguistic processing. These results are in line with rule learning models emphasizing the role of highly specialized mechanisms during the detection of patterns in the speech signal.

D16 Neural correlates of acoustic and linguistic contributions to listening effort during speech comprehension

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Understanding connected speech requires coordination between sensory and cognitive processes within a core speech system centered in bilateral temporal cortex and left inferior frontal gyrus. Although it has been shown that additional resources are recruited when dealing with syntactically complex speech, less is known about how the brain can successfully cope with acoustically challenging speech. We hypothesized that similar compensation mechanisms may be at play when processing degraded speech signals. Here we used interleaved silent steady-state (ISSS) functional magnetic resonance imaging (fMRI) to examine compensatory neural mechanisms that support processing of acoustically-degraded sentences that vary in their syntactic demands. Twelve healthy young adults (mean age=24 yrs) were presented with a series of spoken sentences. Each sentence comprised of six words (e.g., "Boys that kiss girls are happy"); subjects indicated the gender of the character performing the action via button press. Sentences were presented in the absence of acoustic scanner noise, after which we collected 10 seconds of data. The sentences were constructed in a 2 (subject-relative vs. object-relative embedded clause) x 2 (clear vs. degraded speech) factorial design. To degrade the speech we used a noise-vocoding algorithm with 24 channels that reduced spectral detail but preserved the overall amplitude envelope of the signal. Behavioral testing in a separate group of 20 young adults confirmed that this manipulation preserved intelligibility, but reduced perceptual clarity, $t(19) = 5.84$, $p<.001$. In the fMRI study, accuracy was high (mean > 94%) and did not differ as a function of acoustic clarity. Our results revealed that the left frontotemporal areas were more activated by increasing the syntactic demand. Importantly, this network also showed increased activity to successfully process acoustically degraded speech. Lastly, a part of the left inferior frontal area yielded activity when processing sentences requiring most listening effort (e.g., degraded speech with object-relative embedded clause). Together, our data suggest that compensation mechanisms are required when processing spoken language signals for both linguistic and acoustic challenges along the frontotemporal speech network.

D17 Musical consonance modulates rule learning

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Music and language are systems that present parallels; their perception and production share neural resources and are abilities unique to our species. Several studies have reported that musical training influences other cognitive domains including linguistic, reading, mathematical and spatio-temporal abilities. Consonance, a salient perceptual aspect in music associated with pleasantness, seems to be deeply rooted in how we experience music. The objective of the present work was to explore if consonance perception affects rule learning mechanisms that have been shown to be fundamental for language acquisition. In four experiments we explored the role that consonance might play in the extraction of abstract rules. In Experiment 1 we implemented simple AAB rules over consonant chords. In Experiment 2 the rules were implemented over dissonant chords, while in Experiment 3 rules were implemented over both consonant (A category) and dissonant chords (B category). To control for any effect of variability in the stimuli, in Experiment 4, the A and B categories in the AAB sequences included both consonant and dissonant chords. Stimuli were sequences of three two-note chords that either followed an AAB (target) or an ABC rule (non-target). The experiments consisted of a training phase followed by a test phase. During the training phase, participants were acoustically presented with target and non-target sequences and instructed to respond (pressing a key) only after target stimuli. During the test phase, participants were presented with new sequences not presented during training and asked to choose the ones more similar to the target sequences heard before. Results show participants learn the rule better when rules were implemented over consonant chords (Experiment 1) than over dissonant chords (Experiment 2). Moreover, performance increased dramatically when there was a mapping between categories in the stimuli and consonant and dissonant chords (Experiment 3). The enhancement observed in Experiment 3 was not due to stimuli variability, so when there was no mapping between categories and consonance, no improvement was observed (Experiment 4). The results show that consonance modulates the extraction and generalization of simple rules. They also provide evidence that consonance and dissonance act as categorical anchors that help listeners structure the signal. Together with previous results, this study suggests that musical primitives might affect the operation of structure extraction mechanisms that have been shown to be fundamental in the early processing of grammar learning. This opens the door to further studies exploring the interaction of neural resources dedicated to language and music.

D18 Prosody provides cues to morphosyntactic structure: an EEG-fMRI study of neural networks subserving Swedish word tone processing

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Introduction Cues in spoken language are constantly used in order to predict upcoming linguistic information. In Swedish, tonal patterns associated with word stems have been found to help listeners predict which suffix a word will have. All words carry one of two "stem tones", either so-called 'Accent 1' (low tone) or 'Accent 2' (high tone) which are associated with particular suffixes, e.g. Accent 1 + singular suffix, Accent 2 + plural suffix. Using EEG and fMRI, the present study investigated the neural networks responsible for the prediction of suffixes based on stem tone form. EEG recordings allowed for measurements of the timeline of brain responses to tones and suffixes, while fMRI was used to locate the neural networks spatially. Methods EEG and fMRI recordings were conducted separately, with identical paradigms and the same subjects. Participants listened to complex (stem+suffix) words - either singular or plural nouns - embedded in carrier sentences. Combinations of stems and suffixes were cross-spliced in order to create critical stimulus words in which the suffix either matched the stem tone or not, thus creating matching (valid) and mismatching (invalid) conditions. Two tasks were used in different blocks to modulate the depth of grammatical processing: 1. Participants pressed a button as quickly as possible to indicate whether the word was in the singular or plural. 2. Participants pressed a button as soon as the sentence had ended. Results Response time (RT) data showed that Accent 1 is a stronger predictor for its suffixes, as processing slowed down for Accent 1 words with invalid suffixes. This effect was not found for Accent 2. In the EEG data, there was an increased negativity for Accent 1, which is probably due to the greater predictive power of Accent 1 as compared to Accent 2. Furthermore, this negativity correlated with the Accent 1 RT advantage for valid over invalid suffixes. The negativity was stronger in Task 1, in which it was more meaningful for participants to predict the suffix. Accent 1 gave rise to left hemisphere activations in primary auditory cortex (A1), the superior and middle temporal gyri, the temporal pole and the inferior frontal gyrus (IFG). The A1 BOLD activation correlated with activation in the EEG data and also with the RT advantage for validly cued Accent 1 suffixes. Furthermore, a comparison between valid and invalid Accent 1 words revealed increased activity in the left inferior parietal lobe (IPL). This correlated with a P600 effect in the EEG, which was found for invalid Accent 1 words. Conclusion The combined EEG-fMRI data from the present study suggest a course of events in which stem tones are distinguished in the auditory cortices shortly after tone onset. This is immediately followed by the activation of a phonological representation in the superior temporal gyrus and a representation of the suffix involving the IFG, and followed by later reanalysis and repair processes, possibly subserved by the IPL.

Motor Control, Speech Production, Sensorimotor Integration

D19 Exploring Neural Networks Associated with Silent and Overt Reading: A Graphical Model Approach

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Introduction: The neural regions involved in silent reading and those involved in overt speech production have been well described (Guenther & Vladusich, 2012; Price, 2012), whereas the neural networks associated with each of these processes are not well understood. Moreover, the integration of silent reading and overt speech production models is limited even though these processes rely on highly interconnected systems. Building a model that characterizes the integrated neural networks associated with silent and overt reading will advance our understanding of these particular processes in the context of typical and atypical function. To this end, we examined the usefulness of graphical models in providing further specificity of the silent and overt networks in a proof-of-concept framework. Methods: In the present study, functional magnetic resonance imaging (fMRI) was used to investigate the pattern of functional connectivity in 30 individuals who took part in one of two tasks: 1) covert reading of highly familiar words and 2) overt reading of highly familiar words. Using the graphical lasso (Friedman, Hastie, Tibshirani, 2007), we explored the relationship between the time-series (i.e., partial correlation) extracted from a set of nodes that included: cerebellum, precentral gyrus, supplementary motor association cortex (regions involved in overt speech production), visual word form area (VWFA), supramarginal gyrus, and posterior inferior frontal gyrus (regions involved in silent reading). The graphical lasso assumes the functional connectivity network between the brain regions is sparse and has been shown to perform very well in an fMRI context (Cribben et al., 2012). Results: Both tasks produced very similar mean activation maps; however, the connections between the active regions extracted from the graphical models were markedly different as a function of task. The functional network associated with covert reading including the VWFA as a key node that was connected to: cerebellum (motor planning), supplementary motor association cortex (articulatory planning), and precentral gyrus (covert articulation). The functional network associated with overt reading also included connections between VWFA and motor planning regions; however, additional connections were identified for the overt reading task including those associated with phonological processing/ decoding (supramarginal gyrus, posterior inferior frontal gyrus) nodes. Overall, these results provide evidence that both silent and overt reading rely on regions involved in speech production; however, overt tasks involve a more extensively connected network that includes

phonological processing regions. Our results demonstrate the benefit of using graphical models to provide further specificity of the silent and overt reading neural networks and validate its use in fostering a comprehensive model of reading. The use of graphical models as a viable tool for further exploring these complex language networks is indicated with the results of these two preliminary applications.

D20 Dynamics of response planning in word typing : Evidence for inhibition

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Typing is a pervasive phenomenon in our modern information societies, yet its cortical dynamics remain poorly understood. We sought to characterise the underlying processes leading to typed response production using EEG recordings. Data were acquired while expert typists performed a typed version of a picture-naming task. To focus on motor preparation, we studied activity time-locked to the first keystroke of a word. We observed clear positive and negative waves developing respectively over motor cortices ipsilateral and contralateral prior to the first keystroke. This characteristic pattern is very similar to the one observed in simpler two-alternative choice-reaction time tasks; it can be interpreted in terms of activation of the contralateral primary motor area involved in the movement of the typing hand, accompanied by inhibition of the ipsilateral primary motor area, involved in the movement of the other hand. These data constitute interesting electrophysiological evidence that could constrain behavioural models of typing previously proposed (Rumelhart, D. E., & Norman, D. A. (1982). Simulating a skilled typist: A study of skilled cognitive-motor performance. Cognitive Science, 6(1), 1–36.; Logan, G. D., & Crump, M. J. (2011). Hierarchical Control of Cognitive Processes: The Case for Skilled Typewriting. Psychology of Learning and Motivation-Advances in Research and Theory, 54, 1.).

D21 Two distinct auditory-motor circuits for monitoring speech production as revealed by content-specific suppression of auditory cortex

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Speech production, both overt and covert, down-regulates the activation of auditory cortex. This is thought to be due to forward prediction of the sensory consequences of speech, providing a feedback control mechanism for speech production. Critically, however, these regulatory effects should be specific to speech content to enable accurate monitoring of speech. To determine the extent to which such forward prediction is content-specific, we recorded the brain's neuromagnetic responses to heard multi-syllabic pseudowords during covert rehearsal in working memory, contrasted with a control task. Both tasks were performed under identical stimulation with simultaneous auditory and visual stimuli. The auditory stimuli consisted of 30 pseudowords with CVCVCCV structure. The visual stimuli included black square, circle, triangle, or diamond on gray background. In the rehearsal task, participants (N=24) memorized the first auditory pseudoword of a trial, covertly rehearsed it while distractor and probe pseudowords were presented, and pronounced it aloud at the end of each trial. The probe stimuli matched the rehearsed pseudowords fully, partially, or not at all. In the control task, participants counted the number of times the visual symbol presented first in that trial occurred and said aloud the result at the end of the trial (i.e., the task was not related to the auditory pseudowords). According to the results, the cortical processing of auditory target syllables was significantly suppressed during rehearsal compared to control, but only when the stimuli matched the rehearsed items. This critical specificity to speech content enables accurate speech monitoring by forward prediction, as proposed by current models of speech production. The one-to-one phonological motor-to-auditory mappings also appear to serve rehearsal in phonological working memory. Further findings of right-hemisphere suppression in the case of whole-item matches and left-hemisphere enhancement for last-syllable mismatches suggests that speech production is monitored by two auditory-motor circuits operating on different timescales: finer-grain in the left vs. coarser-grain in the right hemisphere. Together, our findings provide hemisphere-specific evidence of the interface between inner and heard speech.

D22 Time course of phonological encoding in Cantonese di-syllabic word production: An ERP study

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To investigate the phonological encoding processes in spoken word production, the Picture-Word Interference (PWI) task has frequently been employed where participants were asked to name individually presented pictures and ignore a word distractor. Participants' naming responses were found faster if the target and distractor shared similar phonological contents relative to an unrelated control. Such phonological facilitation has been argued to be originated at phonological encoding. However, previous research mostly conducted with alphabetic languages where phonology and orthography were closely associated. The present study was therefore conducted with Cantonese-speaking participants using the PWI task. The grapheme-to-phoneme correspondence is exceptionally low in logographic Chinese, hence the effects of phonology could be studied without orthographic confound. Furthermore, ERP recordings were conducted to investigate the time course of phonological encoding in Cantonese di-syllabic word production. Nineteen native Cantonese-speaking participants were recruited from the Chinese University

of Hong Kong. Fifty line-drawings each depicts an object with a di-syllabic Cantonese name were used. Participants were asked to name the picture and ignore a concurrently presented visual distractor (single Chinese character) on each trial. The distractor overlapped with the target's word-initial syllable, word-final syllable, or was unrelated to the target. Meanwhile, ERP recordings were taken throughout the experiment. A separate group of 20 Cantonese speakers were recruited to participate in a pilot study for behavioral data. Participants' naming responses (mean: 704 ±75ms) were faster, relative to the unrelated control, in both word-initial related ($t(19) = 5.7$, $p < .001$) and word-final related conditions ($t(19) = 3.1$, $p < .01$). ERP data were recorded by a 64-channel Neuroscan system (version 4.3). ERPs were computed for each participant over an epoch from 100ms pre- to 600ms post-target. Mean amplitude values in each successive bin of 50-ms window were obtained. ANOVAs with Target-Distractor Relatedness (related vs. unrelated), Hemisphere (left vs. right), and Region (anterior, middle, and posterior) as three within-subjects variables were conducted for each 50ms window. Word-initial related condition: A significant Relatedness x Hemisphere interaction was observed in the 300-350ms window ($F = 6.6$, $p = .019$). Follow-up comparisons suggest that the ERP waves in the Related condition were more negative-going than the Unrelated condition but the effect was restricted to the left hemisphere ($t(18) = 2.24$, $p = .038$). A significant main effect of Relatedness ($F = 4.6$, $p = .046$) and a reliable Relatedness x Hemisphere interaction ($F = 6.45$, $p = .021$) were found in the 450-500ms window. Further comparisons indicate that the waves in the Related condition were more positive-going than the Unrelated condition but the effect was restricted to the right hemisphere ($t(18) = 2.77$, $p = .013$). Word-final related condition: A significant main effect of Relatedness was found in the 500-550ms window ($F = 4.61$, $p = .046$) indicating that the waves in the Related condition were more positive-going than the Unrelated condition. The early ERP effect (300-350ms) might reflect the serial rightward prosodification stage during phonological encoding, whereas the late ERP effect (450-550ms) reflects the retrieval of syllables from mental syllabary. Implications of the present findings to the existing theories of language production will be discussed.

D23 Mapping the cortical representation of speech sounds during syllable repetition

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The transformation of speech sounds between auditory and motor representations underlies the ability of speakers to repeat words and phrases. Theoretical models have begun to flesh out the importance of a so-called "dorsal stream," which links superior temporal and inferior parietal cortical regions with inferior frontal regions to map between input phonological representations (activated by auditory inputs) and output representations used in production. Still, traditional fMRI methods have generally been unable to clearly distinguish between brain areas that are explicitly used for representing speech sounds and those that become engaged during speech tasks but do not contain speech-specific representations. Multi-voxel pattern analysis (MVPA) allows the study of representations using the quality of statistical models as an indicator of local information content. Here we utilized this approach to assess phonetic/phonological information related to consonant-vowel-consonant (CVC) syllables that subjects heard, maintained over a short delay period, then produced. 13 healthy, adult speakers participated in the experiment. CVC syllables were constructed from all combinations of three consonants and three vowels, yielding 18 stimuli, which were recorded multiple times by four different speakers and RMS normalized for use in this experiment. A trial began with auditory presentation of a syllable, and, after a ~8s delay, overt repetition was cued visually. The task thus required participants to perceive a syllable, encode it in short-term memory, and construct and execute a speech plan. During each trial, two whole-brain EPI volumes were collected – one timed to the peak of the hemodynamic response to stimulus onset and the other to the peak response for speech production. Cortical surfaces were reconstructed, and surface-based MVPA searchlight analyses were used to create information maps (based on cross-validation accuracy of support vector machine classifiers compared with empirical chance distributions) that estimate the degree to which local cortical regions contain information about a discrete stimulus feature. Such maps were created for the onset, vowel, and coda of each syllable and the identity of each complete syllable, separately based on the perception and production responses. An additional analysis was conducted to determine how strongly each local region predicted the variability in vowel acoustics (i.e., phonetic variability). Group-level results demonstrated a left-lateralized region in the mid-superior temporal sulcus (STS), as well as inferior parietal and ventral inferior frontal gyrus (IFG) clusters that significantly predicted vowel identity for perception events. For production events, a more anterior STS region was identified, along with a more dorsal IFG region at the junction of the inferior frontal sulcus; furthermore, a new cluster at the posterior extent of the left Sylvian fissure (i.e., Area Spt) was observed, and vowel-level information was strongly left-lateralized for production classifiers. Prediction of consonant identity during production was mainly localized to bilateral sensorimotor cortex, suggesting a basis in articulatory planning and/or somatosensory feedback. Prediction of whole syllables based on either perception or production events highlighted a network of temporal, parietal, and frontal regions. These syllable-level maps were compared to prediction accuracies from constituent phonemes to determine regional preferences for phonemic vs. whole-syllable information.

D24 Sequence Processing In A Covert Speech Repetition Network

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Generating words, phrases, and sentences requires grouping syllables into a correct order. Previous functional MRI studies of syllable sequencing have revealed a network of motor-related cortical and sub-cortical speech regions. In this study, we first identify the sensorimotor network involved in covert speech repetition and then investigate the network's involvement in syllable sequencing comparing tightly matched sequence and non-sequence conditions. Each subject participated in two sessions: a training session in which overt repetition of unfamiliar sequences of 4 CV syllables were trained and tested outside the MRI scanner, and an fMRI scanning session in which BOLD signals were obtained when the participant performed the tasks covertly. We used two repetition conditions. In one, subjects listened to the set of 4 CV syllables (presented in a 2s period at 2Hz) and then repeated back the set during the subsequent 2s (Repeat Sequence; RS). In the second, syllables were presented at a slower rate (1 Hz) over a period of 4s and subjects immediately repeated each syllable right after presentation of the cue (Repeat Units; RU). Thus, in the 4s activation blocks, subjects heard and produced the same syllables, the difference being only whether they were repeating a sequence (RS) or individually (RU). Regions of interest (ROIs) were identified in a separate localizer scan, which had four conditions: (1) listen + covert rehearsal of speech cues; (2) listen + rest; (3) passive listening; and (4) rest. Conjunction analyses involving the contrasts [listen+rehearsal vs. rest] and [passive listening vs. rest] identified eleven cortical and subcortical ROIs representing the network. Within this broad network, sub-groups of regions were identified based on their response properties in the localizer scans. One group (IFG, SMA, BG) responded during the listen+rehearsal condition but did not respond to passive listening; this network also showed greater activity in both [listen+rehearsal vs. listen+rest] and [RS vs. RU] contrasts. A second group (PMC, Spt, IPL, cerebellum) responded during listen+rehearsal and passive listening. Within this group, ROIs in Spt, PMC, and right cerebellum could differentiate listen+rehearsal from listen+rest conditions, but did not show significant difference between RS and RU conditions; by contrast, the ROI in left IPL could differentiate RS from RU without demonstrating significant difference between listen+rehearsal and listen+rest conditions. A third group (bilateral STG) responded during passive listening but not during listen+rehearsal. They were not sensitive to the RS vs. RU manipulation. These findings suggest a particular role of traditional motor-speech areas (IFG, SMA, and BG) in syllable sequencing. Furthermore, although not all components in the network were identified activating differentially to the RS and RU conditions, functional connectivity between nodes in the network were correlated with sequencing error rates as measured behaviorally outside the scanner, indicating that speech sequencing involves a complex sensori-motor network composed of interacting cortical and sub-cortical regions.

D25 Mapping left hemisphere language networks by navigated TMS: a psycholinguistic parametric modulation approach

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Navigated transcranial magnetic stimulation (nTMS) during the object-naming task has been used to map cortical areas causally related to language functions in the preoperative context. So far, conforming to intraopertive DCS mapping, object naming performance was assessed categorially by classifying errors into no-response, semantic, phonological and performance errors. Specific language functions were localized based on the error types. Hesitation or longer reaction times (RTs) have been considered uninterpretable and remained unanalyzed despite their more frequent occurrences. In contrast, non-virtual-lesion fMRI studies in basic research (e.g., Graves_et_al_2007; Wilson_et_al_2009) utilized the well-established effects of psycholinguistic parameters on RTs to localize specific language functions: negative correlation between concept familiarity and RTs for conceptual preparation in the inferior temporal lobe, negative correlation between word frequency and RTs for whole-word phonological code retrieval in the posterior superior temporal gyrus (pSTG), positive correlation between word length (number of syllables or of phonemes) and RTs for articulatory motor planning in the pars opercularis (opIFG) and the ventral premotor area. Conceptually applying this psycholinguistic parametric modulation approach to data analysis, the present nTMS study investigated functional subdivisions of the STG and the inferior parietal lobe (IPL), which are lower in mapping accuracy by categorial error analysis, in connection with the IFG. Data from 7 right-handed, English-speaking, healthy adults were analyzed. Participants were asked to name 151 familiar objects presented on a computer screen. Only the correctly responded pictures without nTMS were presented in the nTMS condition. For each trial, a 5-Hz 10-pulse train started at the picture presentation onset. RT for each trial was measured from the onset of the first pulse to the onset of the first phoneme of the object name. At each of the 29 stimulation sites pre-defined along the gyri in IFG, STG, and IPL, three trials were given, the regression slope of the RTs on each of the 4 psycholinguistic parameters was computed, and the ratio of the participants whose slope directions indicated functional disruption was calculated for each psycholinguistic parameter. The resulting 29 x 4 matrix was submitted to a hierarchical clustering analysis to group stimulation sites with similar functional profiles in a dendrogram. Each stimulation site typically received a high disruption score for one of the 4 psycholinguistic parameters. The effect of concept familiarity was disrupted most at the dorsal anG stimulation site, which was clustered with the ventral anterior opIFG stimulation site. The effect of word frequency was disrupted most at the posterior mSTG stimulation site. The effect of the number of syllables was disrupted most at the dorsal posterior opIFG site, which

was clustered with the posterior mSTG stimulation site. The effect of the number of phonemes was disrupted most at the dorsal anterior opIFG site, which was clustered with the dorsal posterior SMG stimulation site. The middle posterior opIFG stimulation site, ventral to the site where the syllable effect was disrupted, preserved the effect of the psycholinguistic parameters. These results support the models that postulate hierarchical phonological representations with the fronto-temporal syllable network and the front-parietal phoneme network.

D26 EEG Pattern Classification of Semantic and Syntactic Influences on Subject-Verb Agreement in Production

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Subject-verb agreement is one of the most common grammatical encoding operations in language production. In many languages, morphological inflection on verbs code for the number of the head noun of a subject phrase (e.g., The key to the cabinets is rusty). Despite the relative ease with which subject-verb agreement is accomplished, people sometimes make agreement errors (e.g., The key to the cabinets are rusty). Such errors offer a window into the early stages of production planning. Agreement errors are influenced by both syntactic and semantic factors, and are more likely to occur when a sentence contains either conceptual or syntactic number mismatches. Little is known about the timecourse of these influences, however, and some controversy exists as to whether they are independent. The current study was designed to address these two issues using EEG. Semantic and syntactic factors influencing number mismatch were factorially-manipulated in a forced-choice sentence completion paradigm. To avoid EEG artifact associated with speaking, participants (N=20) were presented with a noun-phrase, and pressed a button to indicate which version of the verb 'to be' (is/are) should continue the sentence. Semantic number was manipulated using preambles that were semantically-integrated or unintegrated. Semantic integration refers to the semantic relationship between nouns in a noun-phrase, with integrated items promoting conceptual-singularity. The syntactic manipulation was the number (singular/plural) of the local noun preceding the decision. This led to preambles such as "The pizza with the yummy topping(s)... " (integated) vs. "The pizza with the tasty bevarage(s)..." (unintegrated). Behavioral results showed effects of both Local Noun Number and Semantic Integration, with more errors and longer reaction times occurring in the mismatching conditions (i.e., plural local nouns; unintegrated subject phrases). Classic ERP analyses locked to the local noun (0-700 ms) and to the time preceding the response (-600 to 0 ms) showed no systematic differences between conditions. Despite this result, we assessed whether difference might emerge using multivariate pattern analysis (MVPA). Using the same epochs as above, support-vector machines with a radial basis function were trained on the single-trial level to classify the difference between Local Noun Number and Semantic Integration conditions across time and channels. Results revealed that both conditions could be reliably classified at the single subject level, and that classification accuracy was strongest in the epoch preceding the response. Classification accuracy was at chance when a classifier trained to dissociate Local Noun Number was used to predict Semantic Integration (and vice versa), providing some evidence of the independence of the two effects. Significant inter-subject variability was present in the channels and time-points that were critical for classification, but earlier timepoints were more often important for classifying Local Noun Number than Semantic Integration. One result of this variability is classification performed across subjects was at chance, which may explain the failure to find standard ERP effects. This study thus provides an important first test of semantic and syntactic influences on subject-verb agreement with EEG, and demonstrates that where classic ERP analyses fail, MVPA can reliably distinguish differences at the neurophysiological level.

Language Development, Plasticity, Multilingualism

D27 Advancing the understanding of neural substrates of language learning success using ERP and DTI data

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In this two-step study we aimed at investigating the neural correlates of Language Analytic Ability (LAA) employing two neuroimaging techniques: event-related potentials (ERPs) and magnetic resonance diffusion tensor imaging (MR-DTI). LAA is one of the components of language aptitude, defined within the field of Second Language Acquisition (SLA) as a specific ability for learning languages. It is considered to be one of the most robust predictors of language learning success. In this study we investigated how, in terms of functional and structural neural correlates, highly skilled analytical learners differ from the average ones. In our first experiment we examined the role of LAA in feedback processing during acquisition of a novel language. We investigated whether the neural basis of feedback processing during an artificial grammar learning (AGL) task differs between populations of highly and moderately skilled second language learners. Two groups (high vs. moderate LAA) of 10 participants each were formed on the basis of a test measuring LAA in a large group of participants (N=200). Participants performed an AGL task that consisted of learning and test phases. Event-related potentials (ERPs) evoked by feedback provided after participants' grammaticality judgement on test items were analysed. Behavioural data showed learning effects in both groups, with a steeper learning curve for the highly skilled learners. Between-group analyses with group as the independent variable revealed a larger decrease of Feedback Related Positivity (FRP) in time among the highly skilled learners in agreement

with previous literature (Opitz, Ferdinand, & Mecklinger, 2011). In the second experiment, using MR-DTI, the white matter connectivity was assessed in two groups (high vs. moderate LAA), with 15 participants in each group. Tract-based spatial statistics (TBSS) using mean fractional anisotropy values revealed no significant differences between groups of highly and moderately skilled learners. The study provides evidence that successful and efficient SLA is modulated by neural mechanisms responsible for processing of feedback. TBSS analyses suggest that language analytical ability may not be modulated by individual variability of white matter. The experiments will yield more detailed information about the functional and structural substrates of LAA and may aid the efforts to understand the neurophysiology of individual differences in SLA. Opitz, B., Ferdinand, N. K., & Mecklinger, A. (2011). Timing matters: the impact of immediate and delayed feedback on artificial language learning. Front Hum Neurosci, 5, 8.

D28 Bilingualism at the core of the brain. Plasticity effects of language experience on subcortical structures

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Brain structure is susceptible to morphological changes as a consequence of learning and experience. A particularly interesting case of brain plasticity can be observed when comparing simultaneous bilinguals and monolinguals, an approach that allows to unveil how language naturally shapes the human brain through a long-lasting learning and practice process. Here we focused for the first time on how bilingualism affects subcortical structures that are germane for a number of language functions, including monitoring of speech production and language control –two processes especially solicited by bilinguals. We acquired structural magnetic resonance images (sMRI) for a carefully selected sample of 46 monolingual Spanish speakers (26 females; mean age = 21.85 years, SD = 4.13) and 42 simultaneous Catalan-Spanish bilinguals (22 females; mean age = 21.64 years, SD = 2.17). All participants were students at the University Jaume I of Castellón de la Plana, a bilingual region of Spain, and differed only in their language experience from birth. sMRI were processed by means of a shape analysis algorithm (Patenaude et al., 2011) that performed a fully automatic segmentation and surface reconstruction of the caudate nucleus, accumbens, putamen, globus pallidus and thalamus. After careful quality control, we computed the perpendicular vertex displacements with respect to a sample-specific average surface, representing individual relative surface expansions or contractions vertexwise that were analyzed at the group level. We observed that bilinguals displayed bilateral expansion of putamen and thalamus with respect to monolinguals, as well as of the left globus pallidus and right caudate (all $P < 0.05$, corrected for multiple comparisons). No other significant effects were observed for any other structure. Similarly, no significant expansions were observed for monolinguals with respect to bilinguals. Putaminal effects were distributed in the left structure, with expansions observed along the anteroposterior axis, both in the external (lateral) and internal (medial) surface, as well as in the anterior pole. Conversely, the significant effect found for the right putamen was well localized in the anterior section of the external surface. With regard to the thalamus, the greater expansion observed in the bilinguals group was distributed across its surface bilaterally, suggesting a global effect rather than a regional one. The pallidal expansion, solely observed in the left hemisphere, took place in a well defined area of its anteromedial surface. Finally, for the right caudate nucleus, a small cluster in its dorsolateral surface was found to be expanded in bilinguals compared to monolinguals. Given the characteristics of the sample, our findings point to a causal effect of language experience over subcortical morphology. The topography of the observed putaminal effects suggests that a more complex phonological system in bilinguals may lead to a greater development of a subcortical brain network involved in monitoring articulatory processes, whereas thalamic, pallidal and posterior caudate expansions could be consequence of greater requirements in lexical decision and speech production processes.

D29 Age effects in L2 grammar processing and how (not) to study them

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Introduction: Many attempts have been made to characterize the conditions which are necessary for a learner to achieve native-like processing in a second language (L2). In this study we investigate the effect of one of these factors, age of acquisition (AoA), on the brain responses of L2 learners. AoA has played a central role in theorizing about the critical period and its relation to second language learning. The general expectation is that the earlier the onset of L2 acquisition, the more native-like the speaker's performance. However, most studies are somewhat problematic in that they create discrete groups on the basis of continuous variables such as AoA, rather than taking into account the full range of variability amongst learners (i.e. by using the numerical value itself). The goal of the current study was to remedy this situation for AoA. Methods: 67 Slavic advanced learners of German, with AoAs ranging from 7-36 years, took part in an Event-Related Potential (ERP) experiment containing auditorily presented German sentences with correct and incorrect use of grammatical gender and verb finiteness agreement. We use the strength of the P600 effect as an indication of native-like processing. Results: In a generalized additive mixed-effects regression model (GAM) of the waveforms elicited by correct and incorrect sentences, we show that the ERP signal depends on the AoA of the learner. The gender errors elicit a positive wave that begins at about 500 ms and peaks around 900 ms. While the onset of the positivity increases with AoA, the second language speakers' waveform is reasonably similar to that of the native speakers overall. However, the learners with the latest AoA instead show a clear negative deflection, and thus a qualitatively different

response to the violation in gender agreement. In the verb finiteness condition, the positive deflection is preceded by a negative deflection and continues positively for an extended period of time. AoA analyses reveal that only early onset learners show the early negative deflection, while late onset learners are primarily characterized by a later peak in their positivity. Conclusions: Although AoA leads to clear differences in processing strategy for both finiteness and gender agreement, the onset of these age effects is not as clear cut as generally assumed in the literature: we do not find a clear turning point around the end of puberty as assumed by the Critical Period Hypothesis (CPH), neither is there a linear decrease as proposed by models arguing against the CPH and in favour of more general cognitive developmental factors and competition from L1. Taken together, the non-linearity and difference between structures argue against any account of AoA that predicts a single, relatively simple effect. Uncovering these differences requires a statistical approach that takes into account the full range of non-linear response patterns and continuous predictors, and does not resort to traditional group averaging. We therefore argue in favour of using regression based models, explicitly taking into account the non-linear pattern over time.

D30 Assessing language lateralisation in preschoolers using functional transcranial Doppler sonography

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The experiential and maturational factors involved in the typical pattern of left hemisphere dominance for language have received renewed attention in recent years (Toga & Thompson, 2003; Bishop, 2013). Of primary interest is the developmental trajectory of lateralisation during childhood, when language abilities increase dramatically. However, research focusing on language dominance in children has been hampered by the strict movement constraints of many neuroimaging techniques. Consequently, many studies of child language take place with neonates using passive speech perception tasks (Dehaene-Lambertz et al., 2006; Mingawa-Kawai et al., 2011). Those studies using higher order language tasks requiring comprehension and production of language most often take place after children have begun school (Szaflarski et al., 2012; Groen et al., 2012). These studies suggest a progression of typically left-lateralised activity which develops with age (Szaflarski et al., 2012) and proficiency (Groen et al., 2012). However, given that it has been suggested that the acquisition of literacy affects the neurobiology of oral language processing (e.g. Dehaene et al., 2010) a question which remains is whether these early leftward asymmetries in higher order language processing tasks relate to proficiency before the onset of literacy. Functional transcranial Doppler sonography (fTCD) is a fast and non-invasive way of establishing hemispheric dominance during cognitive tasks (Deppe et al., 2004). The technique measures event related changes in blood flow velocities in left and right middle cerebral arteries and shows high concordance with other methods of measuring functional lateralisation, such as the Wada test (Knecht et al., 2001) and fMRI (Somers et al., 2011). The technique is quick to administer, cheaper than most other imaging modalities, and is portable – allowing testing of special populations and children. It is also possible to collect behavioural data alongside that of the blood flow response, given the technique's tolerance for movement. In the current study we used fTCD to examine lateralisation of language processing in 17 preschool children (Mean age = 3.5 years (range 3.2 – 4.1)). Children completed an animation description task (Bishop et al., 2009) whilst bilateral blood flow speed recordings were made using fTCD. The children also took part in a battery of standardized and experimental language assessments including handedness, BAS-III verbal and nonverbal assessment, rapid automatized naming, digit span and a test of lipreading skill. As a group the children showed left lateralisation (Laterality Index mean = 1.83 (s.d 3.7) range (-8 to 7.2) which approached significance (i.e. when contrasted with zero) ($t(16) = 2.03$, $p = .059$). Eleven of the children were significantly left lateralised, 1 was significantly right lateralised, and the 5 remaining children showed low lateralisation. Relationships between the strength of lateralised responses during language production and offline behavioural language measures will be discussed. These data form the first part of a three year longitudinal study to assess the development of language lateralisation using fTCD, which has the potential to offer unique insights into individual variability of functional lateralisation and its relationship to language and literacy gains made in the early years.

D31 Temporal Dynamics of EEG Topographic Similarity during Successful Language Learning

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Adults vary widely in their language learning capability. Successful and not so successful learners have distinct cognitive profiles even when measured prior to attempting to learn a new language (Linck et al., 2013). Moreover, the neural signatures underlying the retrieval and usage of a newly-learned language are more native-like in the successful learners (Osterhout et al., 2008). These results suggest that successful and not so successful learners may use different learning strategies. However, the temporal dynamics of the neural substrate underlying successful learning is largely unknown. The current study used electroencephalography (EEG) measured during implicit learning of an artificial language to investigate the moment-to-moment dynamics that contribute to successful learning. Thirty-four native English speakers participated in a 45-minute training session of an artificial language, while EEG was recorded from 32 scalp channels at the sampling rate of 512 Hz. During the training session, learners watched a short video depicting a basic scene (such as a doctor eating an apple). While the scene played, it was accompanied by a narration describing the scene in a novel artificial language. The training session contained 360 scenes

and the novel language was comprised of 4 transitive verbs and 30 nouns embedded in a subject-object-verb structure. Learners' knowledge of the vocabulary was tested after the training session in a picture-sound matching paradigm. The EEG data were divided into twelve 30-trial blocks, preprocessed, and averaged across trials within each block. The topographic similarity for each time point was calculated as spearman correlation across 32 scalp channels between each block and the 12th block. The slope of similarity growth from the 1st to the 11th learning blocks, representing the amount of learning at each time point, were then entered into multiple linear regression models with learning outcome as the dependent variable. Participants' performance in the vocabulary task after training was 57% in average, significantly higher than 25% chance level (Wilcoxon signed rank test, $p < .001$). However, the inter-subject variability (33% - 100%) suggested a wide range of learning efficacy. EEG analysis showed the growth of topographic similarity across learning blocks that started to accelerate 100 ms after the movie onset across all participants. The slope of similarity growth at 160 – 170 ms (ranging from 0.06 to 0.12) was strongly correlated with participants' vocabulary score (Spearman's Rho's > 0.48, p's < 0.05, FDR-corrected). Participants who performed better on the vocabulary task showed more rapid learning over the blocks, suggesting that the cognitive process during this time window contributed substantially to successful vocabulary learning. The fact that crucial learning was observed even before the onset of the sentence implied successful learners might have pre-activated the newly-learned words during the scene and their chance of accurate anticipation increased over the course of learning. Our findings suggest that the temporal dynamics of the topographic similarity between each learning stage and the final learning stage were sensitive representations of learning with great potential in revealing the fine-grained cognitive mechanism during language learning process.

D32 The role of expertise in simultaneous interpreting: an fMRI study

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Introduction: Several neuroimaging studies have examined the neural dynamics or experience-related plasticity of various fields such as motor skills and language. In the language domain, the neural mechanisms involved in the cognitive control system among bilingual people who have lifelong experience in using two languages have been reported to be anatomically and functionally different from those of monolingual people (Abutalebi et al., 2012, Cerebral Cortex). However, little is known about training-related neural plasticity in language experts such as professional simultaneous interpreters. Simultaneous interpretation (SI) is a demanding task, as several cognitive processes must be performed simultaneously. Various cognitive resources are required to retain information while coordinating the different mental operations that co-occur during simultaneous interpretation. The present study used functional magnetic resonance imaging (fMRI) to compare the neural mechanisms mediating SI in professional interpreters and non-experts. Methods: The non-expert group comprised 18 right-handed native speakers of Japanese. The expert group comprised 12 professional interpreters recruited from interpreter agencies in Japan. The mean number of years as a professional interpreter was 12.98 (SD: 4.51). All participants studied English as a second language (L2) primarily in a classroom setting. Using auditory sentences, we prepared (a) two SI conditions, English to Japanese (EJ) and Japanese to English (JE), and (b) two shadowing conditions, English to English (EE) and Japanese to Japanese (JJ). Brain activity was measured using fMRI as subjects performed a SI or Shadowing to control for speech articulation. All utterances during the fMRI experiment were recorded using a dual-channel noise-canceling microphone. Statistical analyses were performed with SPM5, using a random effects model. We performed two-sample t-tests on the SI-shadowing contrast (i.e., [EJ+JE] - [EE+JJ]) to identify distinct patterns of brain activity during interpretation in the non-expert and expert groups ($p < 0.001$ uncorrected, but > 50 voxels). Finally, in order to examine how the SI experience mediated the brain difference, we performed correlation analyses between the intensity of brain activation in observed areas and the SI career of each professional interpreter. This study was approved by the Institutional Review Board at the Graduate School of Medicine, Tohoku University, Japan. Results and Discussion: Double dissociation of training-dependent neural plasticity was observed between experts and non-experts during simultaneous interpreting. Compared with the non-experts, the experts showed lower activity in the anterior cingulate cortex, the left middle and superior frontal area, the left parietal lobule, and the left precuneus, all of which are associated with cognitive control and attention. As extensive training in interpreting reduces control demands, activation in the experts' control area was lower. In contrast, premotor area activation was increased in the experts. Supportively, activation in this area was positively correlated with amount of the SI experience in the expert group ($r = 0.71$, $p < 0.05$). The premotor area activation observed in the expert interpreters is likely to be related to the development of automaticity in the working memory system.

D33 Optimizing word learning via sensorimotor information

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The grounded cognition framework states that sensorimotor experiences play a functional role in knowledge representations (Barsalou, 2008). This suggests that there could be a cognitive benefit to observing as well as producing bodily movements or gestures while learning new information. In fact, considerable evidence suggests that producing congruent

gestures with speech can improve certain types of learning, such as problem solving. Across two behavioral and one EEG experiment we examine the effect of observing dynamic movement on word learning in children and adults. First we look at native language word learning when children (7-8 years old) simply observe a dynamic animation containing either meaning congruent or incongruent movements. In this case, the children did not make any movements themselves. In a second experiment, we look at native language word learning when the words are paired either with: 1) Observing a congruent dynamic animation, but making no movement themselves; 2) Observing a congruent dynamic animation and performing a gesture related to the dynamic animation or 3) observing a congruent dynamic animation and performing an unrelated, but goal-directed movement. Finally in an EEG experiment we explore second language word learning in adults. The aim of the EEG experiment was to explore the oscillatory signature during training when word learning was successful at test. Furthermore, we compare the oscillatory and ERP signature for learned versus not learned words at test. Overall our results suggest that simply observing meaning congruent movement as well as producing movement aids word learning. Combining the previous results on congruent gesture or physical engagement on cognitive tasks and our current results, we propose that word learning can be optimized by providing an opportunity for a person to make a congruent link from the to-be-learned information to their own experiences via the sensorimotor system.

D34 Inhibitory control mechanisms of bilinguals in language production

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The present study investigated inhibitory control mechanisms in bilingual language processing. Given that words from both languages are always active during speaking (e.g., Costa, Caramazza, & Sebastian-Galles, 2000), it is important to understand how bilinguals control this activation to eventually achieve language selective production, without intrusions from the unintended language. According to the Inhibitory Control Model of Green (1998), an inhibitory control mechanism suppresses representations in the non-target language to allow production in the target language. In Van Assche, Duyck, and Gollan (2013), we investigated the scope of language control differentiating between whole-language control involving control of an entire lexicon specific to one language, and item-specific control involving only a restricted set of lexical representations. We investigated these mechanisms using a letter fluency task in L1 and L2. To examine whether bilinguals use control to inhibit the non-target language as a whole, we asked speakers to complete different letter/phoneme categories across language blocks (e.g., Dutch-English bilinguals produced words that begin with B only when tested in Dutch, and words that begin with M only when tested in English). To investigate whether bilinguals use more item-specific control, they completed the same letter/phoneme categories across language blocks. Dutch-English and Chinese-English bilinguals showed reduced dominant language fluency after producing words starting with the same letter/phoneme in the non-dominant language. Chinese-English, but not Dutch-English showed similar testing order effects when different letters/phonemes were tested across language blocks. These results indicate that both groups of bilinguals rely on item-specific control mechanisms but that only Chinese-English bilingual rely on a whole-language control process. In the present study, we investigated the processing requirements and testing conditions that lead bilinguals to sometimes also rely on whole-language suppression to achieve language control. We specifically tested how the similarity of the languages spoken and proficiency in L2, may influence language control mechanisms. The participants were 60 early, balanced Turkish-Dutch bilinguals and 60 late, unbalanced Dutch-English French trilinguals. The latter group was tested in L1 Dutch and L3 French. As in Van Assche et al. (2013), they performed a letter fluency task in L1 and L2 or L3 for repeated and non-repeated letters. The results revealed that balanced Turkish-Dutch bilinguals showed evidence of item-specific control processes in both languages. They produced fewer Turkish responses when the same letters were tested after a Dutch testing block and they produced fewer Dutch responses when the same letters were tested after a Turkish testing block. For the Dutch-English-French trilinguals, no clear language of testing order effects emerged. The results from these different bilingual groups indicate the importance of factors such as language proficiency and language similarity for the use of whole-language and item-specific control mechanisms. The results of the different subject groups are interpreted within current accounts of bilingual language production (e.g., Green, 1998).

D35 Vedic Pandits dedicated to oral memorization/ recitation of Sanskrit texts show anatomical reorganization of language, memory and visual systems

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While spoken language is primarily a spontaneous communication device, preliterate cultures rely on oral tradition for recording and maintaining their cultural heritage. The brain organization that supports oral culture transmission is unknown because populations studied with neuroimaging are typically sampled from highly literate cultures where oral knowledge is de-emphasized. The Vedic Sanskrit Pandits of the Indian subcontinent, however, maintain a rigorously formalized oral tradition. Pandits train for ~10 years from youth to orally memorize and recite 3000 year old Vedic Sanskrit texts containing 40,000+ words, preserving exact pronunciation and invariant content. Professionally qualified Pandits, who are also fluent in Sanskrit, spend several hours daily reciting in groups and individually. Our work examines the potential impact on brain organization of extremely specialized repetitive

speech production with massive oral memorization. We examined changes in cortical thickness (CT) and gray matter density (GM) in a group of 21 Pandits and 21 controls, matched for gender, age, handedness, eye-dominance, and multilingualism. We acquired two T1-weighted structural images per participant on a 3T scanner at India's NBRC. These were processed via FSL's Voxel-Based Morphometry (VBM) pipeline for GM, and FreeSurfer's pipeline for calculation of CT. We manually edited the automatically generated skull-stripped brains to ensure accurate brain inclusion and non-brain exclusion. Pandits showed increased CT in right lateral and anteroventral temporal cortex, and in left medial prefrontal/anterior cingulate regions (ACC). CT in the left superior temporal gyrus correlated with Pandits' years of practice. The GM results were consistent with the CT analysis but more extensive, and included, among other regions, bilateral visual cortices and bilateral cerebellum. Increased GM was found in right Transverse Temporal Gyrus and Planum Polare, but not on the left, suggesting practice-induced changes in regions implicated in tracking syllable-level input. Pandits showed less GM in most subcortical structures, which is surprising given recent work suggesting these structures are linked to rote recital (Bridges et al., 2013). We also found a pattern of GM changes in medial temporal lobe (MTL) structures closely matching those previously reported for spatial navigation expertise (Maguire et al., 2000). Our data suggest that long term, intensive recitation and memorization of oral language content, phonology and prosody results in widespread changes in both GM and CT. The changes in lateral temporal cortices may indicate plasticity related to specialization in precise language production, and close monitoring of and synchrony with others' production. Changes in visual-system may indicate cross-modal plasticity, as previously documented in clinical populations, with Pandits adapting parts of their visual cortices for high-volume processing of oral text. Changes in MTL and ACC regions likely indicate use of these systems for memory store and access, with continuous short term processing in the MTL coordinated with long-term ACC storage and retrieval.

Orthographic Processing, Writing, Spelling

D36 Another Sub-lexical Unit of Representation in Reading Chinese? The Logographeme Number Effect

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Studies of Chinese character recognition have demonstrated widely that complex characters are automatically decomposed into sub-lexical components referred to as radicals during reading and writing in Chinese. Yet, an issue raised by Yang et al., (2009) was that it is unclear how the orthographic sub-system in during character recognition is able to differentiate when the sublexical unit "□" in characters such as □ should be activated as a radical for the left side unit, but not for the right radical □ which also embeds a □ within the radical. Studies of writing errors of Chinese children and aphasic patients argue that logographemes, a smaller sub-lexical unit than the radical, are one of the core units of representation within a character (e.g., Han & Bi, 2009; Law & Leung, 2000). Logographemes refer to a series of stroke patterns that are productive (i.e. exist in many characters) and appear to be smaller sub-lexical units than the radicals. For example, the character presented earlier consists of three logographemes of which two are □ and one is □. However, the generalizability of such claims remains inconclusive given the small sample size and observations being limited to spelling tasks per se. Using a lexical decision task, we investigated to whether logographeme units influence character recognition with behavioural measures and event-related potentials (ERPs). Real characters varied in a factorial design by character frequency (high vs. low) and the number of logographemes within a character (3 vs. 6), whilst matching for stroke number, and controlling for phonogram regularity and semantic transparency. Stroke-matched pseudo characters served as filler trials, and were constructed by randomly rearranging the radicals of the real characters. Behavioural findings showed main effects of frequency and logographeme number, where high frequency characters or characters with three logographemes were faster to identify than ones of low frequency or with six logographemes. Electrophysiological results revealed that logographeme number modulations occurred at the P100 component, whereby characters with many logographemes evoked a larger P100 component. At the N170 component, the logographeme number effect was constrained to low frequency characters, where characters with few logographemes elicited a greater negativity. No effects were found at the frontal P200 or central parietal N400 components suggesting that the number of logographemes in a character does not facilitate phonological or lexical-semantic retrieval. Relative to radical activation, the findings suggest that logographemes differ to its time course of activation, such that they are accessed earlier than radicals and only during early visual-orthographic processing stages of Chinese character recognition. More importantly, the findings challenge Chinese character recognition models such as the Lexical Constituency model (Perfetti & Liu, 2006; Perfetti, Liu & Tan, 2005) and the Multilevel Interactive-Activation framework (Taft, 2006; Taft & Zhu, 1997; Taft, Zhu, & Peng, 1999), which do not assume a logographeme representational level.

Language Development, Plasticity, Multilingualism

D37 Assimilation and accommodation in non-native reading networks: Evidence from Korean-Chinese-English multilinguals

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INTRODUCTION: There has been evidence supporting the assimilation hypothesis that the brain network for learning non-native language (NNL) is largely shared

by that for processing learners' native language (NL). Recent neuroimaging studies with Chinese learners of English (e.g. Cao et al. 2013; Tan et al. 2003) consistently supported the assimilation hypothesis, showing that the reading network for English (NNL) is very similar to that for Chinese (NL). In contrast, the accommodation hypothesis predicts that learning NNL may require the brain network not involved in the target NL's reading network. Several studies on English learners of Chinese have supported this hypothesis (Nelson et al. 2009; Liu et al. 2007). Therefore, it is of great interest to examine what are the factors that influence the balance between assimilation and accommodation. The current study, on native Korean speakers who learned both English and Chinese as NNLs, attempted to test the hypothesis that if the NNL is alphabetic or has a more regular mapping between orthography and phonology than the NL (e.g. Chinese-English bilinguals), there will be assimilation, while if the NNL is logographic or has a more arbitrary mapping between orthography and phonology than the NL (e.g., English-Chinese bilinguals), there will be accommodation. According to the hypothesis, when Korean speakers process English, we would expect assimilation because both NL and NNL are semi-regular alphabetic system, whereas when Korean speakers process Chinese, we would expect accommodation because NNL is logographic and the alphabetic NL network is not sufficient for processing the NNL. METHOD: During functional magnetic resonance imaging (fMRI) scanning, Korean adult learners of Chinese and English performed a visual rhyming task with three languages (Korean: KK, English: KE, Chinese: KC) where participants had to indicate whether subsequently presented word pairs rhymed (e.g., late-hate) or did not rhyme (e.g., pint-mint). The proficiency on the two NNLs was matched. To test the assimilation and accommodation hypotheses, brain activation from the KC was compared to a native Chinese group's task (CC) and KK, and the data from KE was compared to a native English group's task (EE) and KK, respectively. RESULTS: The brain activation for KC was similar to that for CC, but was different from that for KK, showing more activation in bilateral medial frontal gyrus, middle occipital gyrus, and left cuneus and lingual gyrus, supporting the accommodation hypothesis. In contrast, the brain network for KE was similar to that for KK, but was different from the EE network, showing more activation in right superior frontal gyrus, middle frontal gyrus, inferior/superior parietal lobule, postcentral gyrus, and left supramargnial gyrus, supporting the assimilation hypothesis. CONCLUSION: The current study suggests that the nature of the mapping principle determine whether the brain network for NNLs shows assimilation or accommodation. While similarities between NL (Korean) and NNL (English) as alphabetic languages contribute to the assimilation patterns in NNL network, dissimilarity in writing system between Korean (alphabetic) and Chinese (logographic) elicits the accommodation patterns in NNL network.

D38 Reading in the brain of children and adults: a meta-analysis of 40 functional magnetic resonance imaging studies

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Introduction: We used coordinate-based meta-analysis to objectively quantify and compare the brain activation patterns of children and adults in response to reading or reading-related tasks during functional magnetic resonance imaging (fMRI). Specifically, we computed separate meta-analytic maps for children and adults in order to synthesize the brain activation for each group separately and to identify regions of overlapping activation. In addition, we computed a difference map in order to search for statistically significant differences in reading-related brain activation between children and adults. Methods: Twenty published fMRI studies with adults were matched to 20 studies with children in terms of reading task, stimuli, and native language. A total number of 676 participants, 395 children (age means: 7-12 years) and 281 adults (age means: 23-34 years) were included in the 40 studies. All of the 40 studies reported foci of reading-related brain activation, resulting in a total number of 506 foci entering the meta-analysis (179 for children and 327 for adults). For meta-analytic quantification of the distribution of these foci, Signed Differential Mapping (SDM) version 2.41 was used. The resulting meta-analytic maps were thresholded using a voxel-level (height) threshold of $p < .001$ (uncorrected), and a cluster-level (extent) threshold of 10 voxels. Results: The separate meta-analyses for children and adults identified a common pattern of reading-related activation in left anterior and ventral posterior brain regions. Specifically, we found overlapping activation in a widespread network of left occipito-temporal (OT), left inferior frontal, left middle frontal, and bilateral superior frontal regions. Higher meta-analytic convergence of activation for studies with children was found in the bilateral superior frontal cortex, whereas higher meta-analytic convergence of activation for studies with adults was found in the left posterior ventral OT cortex and in the left dorsal precentral gyrus. Conclusion: The present results speak for engagement of a core network including left ventral OT and left frontal cortex early on in reading development. In addition, the higher activation in bilateral superior frontal regions in children reflects involvement of domain-general attention or control processes in beginning readers. For skilled adult readers, the finding of extended left posterior ventral OT activation together with higher left dorsal precentral activation indicates progressive interactive specialization among the regions of the reading network. We speculate that the development of skilled reading relies on increased functional integration (in terms of structural, functional, and effective connectivity) of early visual cortex with left inferior frontal and precentral language regions.

D39 Masked language switch cost effects: now you see them, now you don´t *Aina Casaponsa[1], Eneko Antón[1], Manuel Carreiras[1,2,3], Jon Andoni Duñabeitia[1]; [1]Basque Centre on Cognition, Brain and Language, [2]Ikerbasque, Basque Foundation for Science, [3]University of the Basque Country EHU/UPV*

How do bilinguals detect the language of a word that they are reading? Recent electrophysiological research has shown that bilingual readers identify a word's language already 200 milliseconds after the word has been displayed, as shown by masked priming experiments testing the switch cost effect (namely, the effect of processing a word in a given language right after subliminally perceiving a different word in the same language vs. in a different language). The main goal of this study is to understand the underlying mechanisms of switch cost effects, investigating the extent to which language detection is modulated by the sub-lexical orthographic regularities of the words. In a first ERP experiment, we manipulated the bigrams of the words in the second language (Basque) as a function of their legality in the first language (Spanish). Spanish targets were preceded by unrelated words either in Spanish or Basque. Unrelated Basque words could contain bigram combinations that were either legal or illegal in the target language. Results showed a long-lasting switch cost effect in the N250 component followed by an N400 effect only for Spanish words preceded by Basque primes containing Spanish-illegal bigrams, and a clear lack of such effects for Basque words whose bigrams did also exist in Spanish. These results suggest that bilingual visual word recognition is mediated by a language detection mechanism sensitive to statistical orthotactic regularities between languages at early stages of word processing. A follow-up control experiment using the same set of materials with Spanish monolinguals with no knowledge of Basque showed significant switch cost effects also in the N250 for Spanish words preceded by Basque primes containing Spanish-illegal and Spanish-legal bigram combinations, with larger switch cost effects for words preceded by Basque words containing Spanish-illegal bigram combinations. Furthermore, larger negativities were found in the N400 epoch for both types of Basque primes as compared to Spanish primes, showing generalized switch cost effects for Basque words regardless of the legality of their bigrams in Spanish. These results demonstrate that bilingual readers process orthographically marked words differently from orthographically unmarked words and that language detection mechanisms in bilinguals are based on statistical orthographic regularities. Besides, the lack of masked language switch cost priming effects found in bilinguals for Basque words that followed the orthotactic regularities of the target language (Spanish), as opposed to the significant switch cost effects found for monolinguals in the same condition, suggest that orthographically unmarked words were lexically processed by bilinguals. In light of these results, we tentatively conclude that bilinguals process language-unmarked words faster than language-marked words, and that bilingual lexical access highly depends on the cross-language orthotactic regularities of the words.

D40 Neural Systems for Reading Chinese Character: A Multiparametric Approach *Jianfeng Yang[1], Xiaojuan Wang[1], Hua Shu[2], Jason D. Zevin[3]; [1]School of Psychology, Shaanxi Normal University, Xi'an, China, [2]State Key laboratory of Cognitive Neuroscience and Learning, Beijing Normal University, Beijing, China, [3]University of Southern California, Los Angeles, CA, USA*

Background: Reading in both Chinese, as in alphabetic languages involves the computation of the spoken forms of words and their meanings from print. How the brain network for reading Chinese differs from the network for reading other languages is a matter of debate. Here we examine the relationship between brain activity during a lexical decision task and statistical properties of Chinese characters in order to study the response properties of regions associated with visual, phonological, and lexical processes. Methods: We adapted multi-parametric approach to analyze the data of a Chinese fMRI study, in which participants were asked to perform lexical decision on 90 real characters and 150 pseudo characters. The reading network was identified by correlating the BOLD signal with reaction time and stimulus properties of real characters, including frequency, orthography-phonology consistency and number of strokes. To further test the function of the regions in neural systems of reading aloud, nine ROIs in the left hemisphere were identified from the conjunction map of regions where activity is correlated with the three stimulus variables. The mean β value of voxels in each ROI was computed and compared across four types of pseudo characters: Those with both Phonological and Semantic (PS) cues, Only Semantic (OS) cues, Only Orthographic (OO) cues, and non-characters produced by Reversing the typical position of Radicals (RR). Results: The multi-parametric approach revealed a distributed neural systems in left hemisphere for Chinese characters reading, including visual cortex at MOG and SPL, as well as two routes sensitive to different quantity of stimuli properties. One route for easy stimuli (high frequency or consistent characters) including middle MTG, tempo-parietal junction regions, including posterior SMG and AG, and another route for difficult stimuli (low frequency or inconsistent characters) including frontal cortex (pre-central gyrus/MFG and IFG) and the insula. Further ROI analysis revealed that regions related to easy characters are also activated more strongly for OS than PS, OO or RR conditions, indicating those regions are sensitive to sub-lexical semantic information, relative to orthographical or phonological processing. In contrast, regions for difficult stimuli showed weaker activation for the RR condition, and stronger activation for PS than OS or OO condition, indicating those regions are sensitive to orthographical and phonological, but not semantic processing. Moreover, activation patterns revealed distinct function of sub-regions at frontal cortex: pre-central/MFG and Insular are more sensitive to general processing modulated by items difficulty, but IFG is specified for sub-lexical phonological processing. Conclusion: The current findings suggest that high

frequency Chinese characters are processed by regions associated with semantic processing, such as the MTG, posterior SMG and AG. Frontal regions and the insula appear to be related instead to task difficulty, rather than specific stimulus parameters. These results are broadly consistent with findings from alphabetic orthographies.

D41 Cross-language difference of the Neural Systems for Reading at word and story level

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Background: Increasing interest has focused on cross-language studies asking whether the neural circuits for reading vary across writing systems. In the literature on word reading, both universal and specific brain regions have been identified for Chinese and English reading. However, recent finding revealed brain regions in reading network are driven by the interaction between task demands and stimulus properties. In a study with monolingual Chinese and English readers, we previously observed very different patterns of language effects in story reading and lexical decision. Here we compare these two tasks in native Chinese readers who are proficient in English. Methods: Eighteen university students (8 females) participated in the experiment. Each participant performed lexical decision and naturalistic story reading tasks for two language versions. For lexical decision task, fast event related design was adapted. The materials comprised 45 real and 45 pseudo (words in English, characters in Chinese) words designed to manipulate wordlikeness parametrically (Wang, et al., 2011; Yang et al., 2012). For naturalistic reading task, block design was adapted. The materials were four fairy tales (by Hans Christian Anderson), two in Chinese and two in English. Each full story was split into 5 blocks for each run. Each block lasted about 40s, with a following period of 20s of rest. All participants performed naturalistic reading after the LD task. Half of them performed Chinese tasks first and half performed English tasks first. Results: For the lexical decision tasks, common reading networks were involved both for Chinese and English including bilateral frontal cortex at pre-central, inferior frontal gyrus; bilateral parietal cortex at superior/inferior parietal lobule; and bilateral visual cortex at occipital gyrus and fusiform gyrus; robust activity was also observed in the insula. Cross-language comparison revealed more activation for Chinese than English at bilateral superior parietal lobule, fusiform gyrus and post-central gyrus, whereas more activation for English than Chinese at bilateral lingual gyrus and left angular gyrus. For the story reading task, Chinese and English reading activated very similar brain regions including frontal cortex at pre-central/inferior frontal cortex, a large temporal area along superior temporal sulcus, and visual cortex at occipital, lingual and fusiform gyrus. The cross-language comparison revealed more activation for Chinese than English stories at bilateral angular gyrus, anterior superior/middle temporal gyrus, and superior frontal gyrus, indicating more semantic processing was carried out when reading Chinese. English activated more than Chinese at bilateral insula, pre-central/inferior frontal gyrus, and inferior temporal gyrus, potentially related to greater processing difficulty. Conclusion: Our results suggested that for Chinese readers, largely the same systems are engaged by Chinese and English in both Lexical Decision and Naturalistic Reading tasks. Language differences were driven by the processing required for specific tasks. In particular, language differences in Lexical Decision were driven by differential demands on spatial and attention processing. In contrast, the differences in naturalistic reading seem to be dominated by differences in areas related to lexical and discourse comprehension.

D42 Brain activation during novel word encoding predicts lexical integration

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Acquisition of a novel word involves the integration of a newly formed representation into the mental lexicon, a process which is thought to benefit from offline consolidation. Brain activity during post-learning sleep has been shown to relate to behavioural measures of lexicalisation (Tamminen et al., 2010; 2013), suggesting that the outcome of acquisition is indeed at least partly determined after encoding. It is however unknown to what degree the neural response during the learning phase itself influences successful lexicalisation. A consistent body of evidence indicates that activation in medial temporal, parietal and frontal areas during encoding predicts subsequent memory strength (Kim, 2011), suggesting that encoding-related factors may also affect offline integration processes. In the present study we combined and extended these two lines of research and asked whether encoding-related neural activity is related to subsequent lexical integration as well as explicit memory. Specifically, we hypothesised that immediate orthographic and semantic integration during the first few encounters with novel words predicts their later ability to interact with existing words. Participants studied 40 novel printed words, each paired with a picture of a common object illustrating its meaning, while their neural responses were measured using functional magnetic resonance imaging. A primed visual lexical decision task was administered approximately 24 hours after encoding. In this task, participants made lexical decisions to existing and pseudo-word targets, which were each preceded by a briefly presented novel word that was either semantically related or unrelated to the target. Faster response times to related versus unrelated pairs suggest that links have been formed between the novel-word representations and their semantic associates. Priming effects can therefore be considered a strong indication that novel words have been lexically integrated. Following the priming task, cued and free recall tasks probed explicit memory for the learned

novel words. A significant priming effect was observed, suggesting that those novel words that had been encoded successfully were sufficiently lexicalised to influence recognition of their existing semantic associates. In line with previous findings, words that were correctly recalled in the test session elicited enhanced activation in the left inferior frontal gyrus (IFG) during encoding. Similarly, words that subsequently produced priming effects showed enhanced IFG activation compared to words that had no facilitating effect. Crucially, a set of additional clusters predicted subsequent priming but not memory persistence. These were found in left temporal-parietal regions involved in semantic processing, as well as in a posterior portion of the left fusiform gyrus known as the visual word form area (VWFA). These data suggest that increased orthographic and semantic processing during encoding facilitates lexicalisation. We argue that enhanced VWFA activation during encoding reflects the formation and integration of a stable orthographic representation. This enables rapid lexical access to the novel word, which in turn facilitates retrieval of related words and hence boosts their recognition. In conclusion, successful lexicalisation is determined in part by the engagement of encoding mechanisms that stimulate memory integration, above and beyond those supporting memory formation.

D43 Neural Correlates of Emerging Readers in L2: A Bi-directional Approach Using Hebrew and English *Daniel Sharoh[1], W. Einar Mencl[1,2], Jay Reuckl[1,3], Peter J. Molfese[1], Steve Frost[1], Ram Frost[4], Julie Van Dyke[1], Kenneth R. Pugh[1,2,3]; [1]Haskins Laboratories, [2]Yale University, [3]University of Connecticut, [4]Hebrew University*

Second language learners vary considerably in fluency attainment of their L2. A significant barrier to attaining proficiency in L2 is the degree of similarity between L1 and L2. To date, a large proportion of work on L2 acquisition has investigated intra-family L1/L2. This project bi-directionally investigates the neurocognitive parameters that affect young adults' (14-26) acquisition of L2, and specifically, their ability to read in L2 using a highly contrasting L1/L2 pair (English and Hebrew). Previous work conducted at Haskins Laboratories (Frost et al., 2009), has demonstrated important differences in neurocognitive organization of reading circuits for English and Hebrew L1 readers. Namely, Hebrew relies relatively more on lexical/semantic processing, whereas English on orthographic and phonological relatedness. In a two site, longitudinal design, cohorts were recruited in both the U.S and Israel with, at most, basic L2 reading ability. Data were acquired in the L2 environment -- Israel (Hebrew University) or New York (New York University) -- with Hebrew L1s scanned in New York and English L1s in Israel. Participants in both cohorts continued to be immersed in their L2 environments. In addition to multiple standardized assessments to index L2 proficiency, functional MRI data were acquired twice over 36 months. Initial MRI sessions (reported here) included a 2(Auditory, Visual) x 2(Word, Pseudoword) x 2(English, Hebrew) semantic judgment task. Within each run, alternating sets of English and Hebrew stimuli were presented, and participants made made animacy judgments. Standard analyses of fMRI data were performed in AFNI (Cox, 1996) for an event-related design. English L1 participants (n=33), reading English activated the well-documented reading circuit (Pugh et al., 2012), including IFG, OT, inferior parietal, and STG/MTG. In contrast, when reading Hebrew, activation levels in OT (bilateral fusiform), extrastriate and IFG were significantly increased. For Hebrew L1 participants (n=26), similar findings were found; Hebrew activated the typical reading circuit, and readers experienced increases in parahippocampal, bilateral fusiform, IFG and STG/MTG. The data indicate that reading activates the typical reading circuits in both L1 and L2, but activate more so for L2. Additional results including brain-behavior correlations are targeted at understanding the role of individual differences as they pertain to identifying statistical regularities and linguistic structure in L2 acquisition. We believe these data will provide insight into the contrast configurations of linguistic knowledge where the division of labor between phonologic, orthographic, semantic and morphologic knowledge differ considerably by language and transition from early fluency and literacy to proficient speaking and reading. Results will be further discussed in terms of neural assimilation or accommodation as a function of increased proficiency.

D44 Intrinsic Connectivity to the Visual Word Form Area and the Putative Visual Number Area *Tanya Evans[1], John Kochalka[1], Vinod Menon[1]; [1]Stanford University*

The ventral-occipital-temporal cortex is thought to contain neuronal populations specialized for distinct perceptual categories, and the visual word form area (VWFA) in the left hemisphere, in particular, has specificity been linked to word recognition. Recent work has suggested that a putative visual number area (pVNA) serves a similar role in the visual recognition of numerical digits. Here we examine the domain specificity of the VWFA and the pVNA from a developmental perspective by characterizing their functional networks in children and adults. Using resting-state functional MRI data, we examine the intrinsic functional connectivity of the VWFA and the pVNA in children (n = 17) and adults (n = 18) matched for intelligence-quotient, reading and math abilities. Children showed greater VWFA connectivity with bilateral inferior frontal, and inferior, middle and superior temporal gyri when compared to the right pVNA. Adults showed a similar pattern but also showed greater VWFA connectivity with bilateral posterior parietal cortices (specifically in the intraparietal sulci, a region typically implicated in quantity processing) relative to the right pVNA. Children also showed stronger connectivity of the VWFA with bilateral inferior and middle frontal, and inferior, middle and superior temporal gyri when compared to the left pVNA. Adults showed greater connectivity of the VWFA with left inferior temporal gyri and posterior parietal cortex relative to the left pVNA. These results are consistent

with the VWFA being part of network of regions supporting skilled reading, but suggest that the pVNA may not play a circumscribed role in number processing.

Lexical Semantics

D45 Learning the meaning of words: a neurocomputational account of semantic category-specificity and semantic hubs

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Experimental evidence indicates that language comprehension processes involve and rely upon both modality-specific (primary and secondary) sensorimotor cortices as well as multi-modal higher-order association areas. Whereas the former are frequently seen as the home of category-specific semantic processes, the latter are sometimes described as general "hubs" processing all types of semantic information. No explanation so far exists as to why different cortical areas specialise in category-specific and general semantic processes. We use a neurocomputational model of the language cortex and additional sensorimotor and multimodal areas that incorporates a range of realistic brain-anatomical and physiological features to simulate semantic grounding of symbols in action and perception. Surprisingly, we find that the model explains both category-specificity and hub-character of local cortical areas. The neurocomputational model extends a previously implemented model of the language cortex which simulated six perisylvian areas (three in superior temporal and three in the inferior frontal gyrus) relevant for speech perception and production. Six new areas were added here to model the ventral visual system (early visual, temporo-occipital and anterior-temproal areas) and the dorso-lateral hand-motor system (primary-motor, premotor and adjacent prefrontal cortex). Known features of within- and between-area cortical connectivity were implemented, as were nonlinear activation summation, neuronal adaptation, correlation (Hebbian) learning, and mechanisms mediating cortical processes of inhibition and competition. The model was used to imitate the learning of word-object and word-action contingencies. This was done by simultaneously activating, for each "object word", a specific pattern of neuronal units in the articulatory primary motor, primary auditory and primary visual cortices of the model; for action words, correlated activation was delivered to primary articulatory-motor, auditory and hand-motor "areas". 3,000 learning episodes were simulated for each of 12 novel words (6 action- and 6 object-related). As a result of such correlated primary activations, cell assemblies spontaneously emerged across the network. These distributed circuits included subsets of the specific "neurons" that were activated in primary "areas" during learning, larger numbers in secondary, and substantially larger amounts of "cells" in the higher-order association model areas, where neuronal activity coming from sensory and motor systems converged. Cell assemblies for action words exhibited significantly larger numbers of "neurons" in the network's hand-motor primary and secondary areas compared with those for object words. The reverse was found in early visual "cortices". Numerous cells in both dorsolateral prefrontal and anterior-temporal network areas belonged to circuits of either word type, without significant differences between semantic types. These results reconcile and integrate the known category-specific role of primary and secondary modality-preferential areas of the real cortex with the involvement of anterior-temporal and prefrontal cortices in general semantic processes, explaining both. Our simulations demonstrate that category-specificity as well as across-the-board character of semantic processing as they are found in the brain can emerge spontaneously, as a result of learning word-object and word-action associations, in a network incorporating basic features of cortical anatomy and function. The existence of such a neurocomputational explanatory account, relying solely on realistic brain features, lends strong support to an action-perception theory of cognitive cortical function.

D47 The Effects of Age of Acquisition and Familiarity on Semantic Memory

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A word's age of acquisition is an important factor in ease of semantic processing. Earlier learned words are processed faster and more accurately than those learned later in life, even when controlling for possible confounding factors such as cumulative frequency. These effects are mitigated by semantic connectedness, however, such that high familiarity with a later acquired concept boosts semantic processing. Studies of the interaction between age of acquisition and semantic connectedness typically do not extend to very recently acquired words. The current study examined narratives for words and people whose names emerged at specific points over the last five decades (e.g., slinky was invented in the 70s), including words acquired in the last 10 years. Twenty older adults (μ=64 yrs) defined randomly, orthographically presented popular objects (e.g., slinky, smurf) (N=44) and famous people (e.g., Elvis Presley, Bill Clinton) (N=50). Stimuli represented decade blocks from 1960-2000s. Three independent raters coded narratives offline for accuracy and content information units (CIUs). Results of a repeated measures analysis of variance indicate a significant main effect of familiarity for both people and objects ($p < .001$), such that high familiarity words were more robustly described than low familiarity words. For famous people, there was a significant linear main effect of age of acquisition: participants described temporally remote items better than more recent items ($p < .05$). There was not a significant effect of decade for objects ($p > .05$). Thus, an age of acquisition effect that extends to very recently learned items is evident in people but not objects. There was no evidence of an age of acquisition by familiarity interaction, suggesting that semantic connectedness is not differentially more important for concepts learned at different points in time. We address implications of these results for theories of age-of-acquisition and the neurobiology of aging.

D48 The contribution of posterior middle temporal gyrus in semantic development: evidence from a longitudinal study

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A longitudinal study was used to explore the developmental changes in neural correlates of semantic processing using functional magnetic resonance imaging (fMRI). We followed 30 normally developing children and adolescents ranging from age 8 to 15 for two years. Participants were scanned on entering the study (time 1) and a follow-up period of 2 years (time 2). They were asked to decide if character pairs were related in meaning. Character pairs were arranged in a continuous variable according to association strength. This parametric manipulation allows for a more precise examination of the brain regions crucial for reading development. Previous research has demonstrated that processing weaker association pairs produced greater activation in posterior middle temporal gyrus for children, indicating that this region may engage a more extensive access to semantic representations in order to identify the distant relationships (Booth et al., 2007; Chou et al., 2009). The aim of this study was to further elucidate whether there were different developmental trajectories from time 1 to time 2 between adolescents and children in the weaker association pairs. Our results demonstrated that processing weaker association pairs elicited greater activation in posterior middle temporal gyrus (BA 21) in both age groups. Moreover, the developmental increase between time 1 and time 2 was larger for the children (aged 8-11) as compared to that for the adolescents (aged 12-15). Posterior middle temporal gyrus is often being suggested as a repository site for semantic knowledge (Binder et al., 2009). Greater developmental increases in this region indicate that children demonstrate greater improvements of accessing semantic knowledge via enhanced interconnections between these representations for weaker association pairs.

D49 Measures of white matter integrity explain age-related differences in non-verbal fluid intelligence

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Aging is characterized by neural, behavioral, and cognitive changes. For example, there are well documented age-related declines in brain structure, and within the domain of language, age-related differences have been observed in language production. However, fewer differences have been reported for semantic abilities, and the relationships between structural and cognitive factors are still emerging. Moreover, the extent to which specific age-related structural differences can be isolated from general age-related effects is unclear. Here we investigated the relations among age, white matter (WM) integrity, and cognition. We used diffusion tensor tractography to measure fractional anisotropy (FA) and a neuropsychological battery to assess cognition in 27 older and 34 younger adults. We examined 1) age-related differences in WM integrity, and 2) how WM integrity related to cognitive abilities. We Consistent with previous findings, we found age-related differences in FA (older < younger). We incorporated separate hierarchical cluster analyses of FA and cognition (as evaluated through a battery of neuropsychological and psychometric tests) to extract components. The FA analysis revealed two components: the first included genu, splenium, bilateral superior and inferior longitudinal fasciculi, and bilateral optic radiations, while the second included bilateral uncinate fasciculi. The cluster analysis of the neuropsychological variables yielded three oblique components: one cluster comprised speed, recall, and non-verbal executive function measures, the second cluster comprised verbal fluency measures, and the third cluster comprised vocabulary and recall. There were significant relations between age and each FA cluster, and significant relations with age and the first cognitive cluster ($r = 0.75$, $p < .0001$) and the second cognitive cluster ($r = -0.30$, $p < .05$), but not with the vocabulary/recall cluster. Additionally, there were significant relations between FA and the speed/non-verbal executive function cluster (FA1: $r = -0.48$, FA2: $r = -0.34$) and between the uncinate fasciculi and verbal fluency clusters ($r = 0.25$, $p < .05$). A step-wise regression revealed that inclusion of FA measures substantially reduced age-related variance in cognitive cluster 1 (speed, recall, and non-verbal executive function) from 57% to 34%, a reduction of 40%. However, clusters 2 and 3 (verbal fluency and vocabulary) were not affected by including FA measures in the regression model. These findings suggest that WM integrity strongly reduced age-related variance in neuropsychological measures of speed, memory, and non-verbal executive function but not measures of language suggesting age-related differences in white matter most strongly influence nonverbal fluid intelligence.

D50 Individual variability in a cortical semantic hub

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Semantic memory underlies the representation of meaning in language. The neural system for lexical-semantic memory is often assumed to be highly similar across healthy individuals. Here we challenge this assumption in a series of experiments, which demonstrate that individual variability in the anatomy of a cortical semantic hub relates to lexical-semantic performance, functional activation, and the shared anatomic properties of the lexical-semantic network. We examined fMRI activation and cortical thickness in healthy young adults performing a word-recognition task. A cortical hub in the left angular gyrus was strongly activated during word recognition ($p<.05$, corrected). We next identified critical structure-behavior and structure-function relationships in this region, demonstrating that increased cortical thickness accounts for both faster performance and greater semantic activation (all $p<.05$, corrected). Furthermore, we found that this region covaries with the structural properties in a broad network of lexical-semantic regions ($p<.05$, corrected). Altogether,

these findings illustrate the fundamental biological link between structural neuroanatomy and the functional, behavioral, and network properties of the lexical-semantic system.

D51 Theta and beta changes related to learning new words from linguistic context

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Introduction. Adults acquire most of their vocabulary via learning from context, or using linguistic information to identify a word's meaning. This incremental process requires one to isolate the novel word, identify potential meanings, store these meanings in memory and then inhibit any candidate meaning that does not match subsequent exposures. We know little about the neural mechanisms underlying these processes over multiple exposures to a new word. This study used time frequency analysis of the EEG to examine the role of semantic retrieval (theta), working memory (alpha), and semantic binding (upper beta) during learning from context. Methods. Twenty participants read sentence triplets presented word-by-word followed by a test question. In all sentences, the target novel word appeared in the sentence-final position. In the Meaning Plus (M+) condition the sentence triplets increasingly supported the novel word's meaning with the last sentence providing a great deal of support (e.g., "Pour some water in my zat"). The Meaning Minus (M-) condition also contained sentence triplets but each sentence provided little semantic context so as not to provide enough information to determine the novel word's meaning. After each sentence triplet, participants were asked to identify the novel word's meaning, if possible. Analysis. EEG data were epoched in a -500 - 1500 msec range around the target word. Time frequency analysis was used to quantify event-related spectral perturbations. Epoched data were Fourier-transformed, magnitude-squared, and normalized to obtain the power spectral density. Data were averaged across trials and subjects, and computed using the log power values minus the baseline (Delorme & Makeig, 2004). Using EEGLAB, we computed p-values for both the time and frequency points for each comparison of interest using random permutation statistical analysis. The study design was a 2 (M+ and M-) x 3 (Presentation 1, 2, and 3) ANOVA in the theta (4-8 Hz), alpha (8-12 Hz) and upper beta (20-30 Hz) frequency ranges between 350-550 msec. Results. The analysis revealed similarities and differences between the M+ and M- conditions in theta, alpha and upper beta engagement across the three exposures. The first presentation of the novel word resulted in theta and alpha synchrony for both conditions, indicating similar efforts at meaning identification and storing potential meanings in working memory. Both conditions showed similar alpha increases at the second presentation, suggesting a continued reliance on working memory. Also at the second presentation, the M+ condition exhibited a strong upper beta synchrony increase, interpreted as the semantic binding effect noted by Hart et al. (2013), and M- revealed increased theta synchrony, attributed to continued attempts at word meaning identification. An upper beta synchrony increase at the third presentation for M- may represent attempts at semantic binding, even when a meaning was not available. Conclusions. These data provide a window into the incremental process of word learning from context highlighting the importance of the synchronization of alpha, related to working memory, theta, related to a semantic search and upper beta, related to semantic binding.

D52 The impact of acute, moderate-intensity exercise on new word learning in healthy older adults: An exploratory investigation

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Meta-analyses have revealed that acute aerobic exercise can have positive effects on memory and executive function (McMorris & Hale, 2012; Lambourne & Tomporowski, 2010); however, little is known about its effect on language function in older adults. This line of inquiry is important given the changes in cognition and language observed in healthy older adults and those with neurologic disease. The aim of this study was to investigate the effect of acute, moderate-intensity aerobic exercise on novel word learning in healthy older adults. A within-subjects crossover design was used to compare novel word learning following moderate-intensity aerobic exercise (AE) vs. stretching (ST). Order of conditions was counterbalanced across participants. Ten monolingual English speakers (3 male, 7 female), aged 55-74 years (mean= 66.2) were recruited for participation. They fell within the normal range on the Montreal Cognitive Assessment (Nasreddine et al., 2005) and the Beck Depression Inventory (Beck et al, 1961), did not consume >6 cups of coffee/day, >2 standard alcoholic drinks/day or >10 cigarettes/day, had no history of neurologic disease or psychiatric illness, no conditions with exercise contraindications and were not taking hormone replacements or dopaminergic, anti-depressant, anti-psychotic, or illicit drugs. The study comprised 10 sessions over 5 weeks. Week 1: Baseline; Weeks 2 and 4: Training and testing on Monday, Wednesday and Friday; Weeks 3 and 5: One week post-training testing on Friday. A sub-maximal graded exercise test (ACSM, 2006) was administered at baseline to estimate maximal oxygen uptake (VO2max) and set the target training zone for the AE condition (50-75% of maximum heart rate). During training, participants engaged in 30 minutes of AE or ST followed by a novel word learning task in which they viewed randomly presented familiar (n=30) and unfamiliar (n=30) objects paired with a two-syllable nonword. Unfamiliar objects were ancient farm tools (Laine & Salmelin, 2010). Two sets of balanced stimuli were used. Testing was administered immediately following each of the three training sessions and one week post-training. Participants typed the nonword name of each randomly-presented object (recall) and indicated as quickly and accurately as possible which of three objects matched the nonword that appeared below (recognition). To assess maintenance of learned

words, change scores were calculated for two time points: (#correct at third session – #correct at first session) and (#correct at one week post-training – #correct at first session). Analyses were conducted for all objects, unfamiliar objects, and familiar objects. A repeated measures ANOVA was conducted with Condition and Time Point as two-level within subjects factors and Condition Order and Set Order as two-level between subjects factors. A significant main effect of Condition ($p = .030$) revealed better performance in the AE condition for recognition of familiar objects, suggesting a beneficial effect of exercise on maintenance of learned words. The results of this exploratory study suggest that acute, moderate-intensity aerobic exercise may have a positive impact on language learning in healthy older adults. Further research with a larger sample size is warranted. Findings may have implications for improving language re-learning individuals with neurologic disease.

D53 Shaving bridges & tuning kitaraa: How code-switching affects semantic integration (N400) in second-language learners

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When learning a new language, do we store new words in the same lexicon as used for our first language (L1), or do we create a separate lexicon for the words belonging to a second language (L2)? Despite being extensively studied, this question remains largely unanswered. This event-related potential (ERP) study aims to clarify this matter, using a unique combination of semantic processing and code-switching. We presented L2 learners of different proficiency levels (low/high) with congruent and incongruent L2 stimuli (The man is shaving his beard/bridge* every morning) and with stimuli containing a code-switch back to L1 in combination with congruent and incongruent target words (The boy is tuning kitaraa/aurinkoa* ennen konserttia). Our goal was to investigate how the N400 component was affected by code-switches. Our findings indicated that the amplitude and latency of the N400 for high-proficient L2 speakers were similar to the control group of English native speakers in the monolingual condition. However, the low-proficient L2 speakers showed reduced and delayed N400 effects, the latter result thereby replicating previous studies (cf. Weber-Fox and Neville, 1996). Interestingly, the code-switches elicited an additive N400 effect alongside the N400 effect found for the incongruent code-switched stimuli in both groups of L2 speakers. Additionally, switching back to L1 resulted in earlier and enhanced peaks of the N400, pointing towards earlier semantic access in L1. This ERP pattern suggests that second-language learners move through different stages of second-language learning; whereas the underlying concepts of L2 words seem to be accessed via L1 at earlier stages of language acquisition, stages of high proficiency can be characterized by a shift towards more direct links between word concepts and L2 words. Our results therefore provide neural evidence for psycholinguistic models such as the Revised Hierarchical Model (Kroll and Stewart, 1994) and offer important new insights into the cortical organisation of the bilingual mental lexicon.

D54 Default-mode network connectivity predicts response to semantic therapy in cases of anomia

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One in four stroke survivors experiences language deficits such as aphasia. From a neurofunctional perspective, stroke affects the integrity of neural networks contributing to language processing. Specifically, the canonical language network (CLN), including Broca and Wernicke areas, is often altered after a stroke. More recently, our team documented poor integration within the default mode network (DMN), in patients with chronic aphasia (PWA), and improved connectivity after targeted anomia therapy with SFA (Semantic Feature Analysis). The purpose of this work is to examine pre-therapy markers that characterize a good response to SFA in participants with aphasia. Given that two different subnetworks within the DMN have beeen documented, the anterior and the posterior subnetworks, their respective contribution to aphasia recovery was studied. Nine PWA with moderate to severe anomia, secondary to a left-hemisphere stroke (between 4 and 25 years post-stroke) benefited from SFA therapy, to facilitate production of nouns and verbs. Functional connectivity markers of good response to therapy were gathered within the DMN and the CLN, correlated with the overall naming improvement. Measures were collected in healthy controls and PWA during two fMRI sessions, prior- and post SFA therapy. Functional connectivity was quantified via integration measures, reflecting how synchronously different brain areas were engaged during a given task, by reference to their anterior and posterior portions. Significant improvement in noun and verb naming was observed in all PWA, and it was highly correlated. No significant differences in CLN integration were observed before and after therapy. Conversely, integration within the DMN increased significantly in conjunction with behavioral improvement, and no significant gap between integration values in healthy and language impaired subjects was observed following SFA, both with noun and verb SFA therapy. Specifically, this normalization of DMN integration was mostly accounted for by improvement in posterior sub-network connectivity. Furthermore, there was a positive correlation between DMN connectivity prior to therapy and naming recovery after therapy. This study presents an innovative approach to the clinical management of post-stroke aphasia. Specifically, the documented correlation between DMN integration prior to therapy and reactivity to SFA shows that DMN status before therapy can be predictive of response to specific language therapy. Moreover, DMN functional connectivity was mostly accounted for by posterior

subnetwork improved integration, a fact that may be related to the well-documented contribution of posterior DMN areas to semantic processing. In other words, it is possible that the semantic nature of the approach used contributed to increased engagement of the posterior DMN subnetwork. Altogether, these results show that functional integration measures of the DMN have prognosis value in that they can be predictive of brain reactivity to specific aphasia therapy.

D55 Investigating Broca's and Wernicke's area involvement in metaphor processing: A tDCS study

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It is widely accepted that the left hemisphere of the brain is specialised and dominant for language comprehension and production and that patients with left hemisphere damage often display profound language disruption. In contrast, following right hemisphere damage, disruption to language is less perceptible to the casual observer. Current research acknowledges a critical role for the right hemisphere in processing inferred or implied information by maintaining relevant facts and/or suppressing irrelevant ones but the exact role of the right hemisphere and its coordination with the left is still under investigation. The present study investigated the role of Broca's and Wernicke's areas in the left hemisphere and their homologues in the right hemisphere in the processing of metaphorical language by studying the processing abilities of individuals with depressed unilateral brain function produced by transcranial direct current stimulation (tDCS). The study employed an auditory sentence priming paradigm using both novel and conventional metaphors as well as literal sentences, and young healthy participants (N=24) were asked to make semantic judgements. Cathodal or sham stimulation was applied to electrodes F7/F8 and CP5/CP6 known to tap onto Broca's and Wernicke's areas and their homologues in the right hemisphere respectively. Significantly reduced processing abilities for both novel and conventional metaphors were observed only after cathodal (i.e., inhibitory) stimulation of the homologue of Broca's area in the right hemisphere, while stimulation of Wernicke's homologue in the right hemisphere did not produce any statistically significant results. The present findings corroborate previous lesion and neuroimaging research in underlining the importance of the right hemisphere in processing metaphorical language.

D59 Evidence for the causal role of left motor areas for processing abstract and concrete words – a dual case study on brain tumor patients

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In the past decade, a range of neurostimulation approaches, as well as studies performed on neurological patients (e.g. Pulvermüller et al. 2005, 2010) were able to show the functional involvement of motor- and sensory cortices for the processing of concrete words. At the same time, evidence for an embodiment of their abstract counterparts, which lack transparent sensorimotor semantics, remains under discussion (Kiefer & Pulvermüller, 2012). Based on recent fMRI findings, which indicate an involvement of the left motor cortex in the processing of abstract emotional words, like "Love" (Moseley et al. 2012), the current study investigated word processing in two brain tumor patients, MR and CA. MR was suffering from a lesion in left frontocentral cortices, including motor areas, while CA's lesion in addition covered the left supplementary motor area (SMA). A speeded lexical decision task (LDT) as well as naming-, repetition-, and comprehension subtests of a standardized aphasia test (Aachener Apahsie Test, AAT) were administered. In the LDT, nouns and verbs from five different semantic categories (abstract-emotional, hand- and face-action related nouns and verbs, leg-action related verbs and animal name nouns) were presented, together with an equal number of pseudowords. All stimuli were meticulously rated by healthy native speakers regarding their semantic features and equated within verbs and nouns for psycholinguistic features lemma frequency, word length, number of syllables, average bi- and trigram frequency and number of orthographic neighbors. AAT results for both patients failed to document clinically manifest impairments of language or executive functions, which also matched the neurological assessment. LDT accuracies for semantic categories showed significant impairments of task accuracy specifically for abstract emotional words in both patients. For verbs, patient CA showed an increased error rate across semantic verb categories. These results point to a causal role of the motor cortex for the processing of abstract emotional words and therefore suggest that the motor areas found active during abstract emotion word processing in the fMRI study by Moseley et al. indeed serve a crucial function in abstract word recognition. Furthermore, previous findings on the functional role of motor areas for processing concrete words, in this case action related verbs, could be replicated. Our results are therefore difficult to reconcile with the idea that sensorimotor systems are somehow peripheral and epiphenomenal to meaning and concept processing. References: Kiefer, M., & Pulvermüller, F. (2012). Conceptual representations in mind and brain: theoretical developments, current evidence and future directions. Cortex, 48(7), 805-825. Moseley, R., Carota, F., Hauk, O., Mohr, B., & Pulvermüller, F. (2012). A role for the motor system in binding abstract emotional meaning. Cerebral cortex, 22(7), 1634-1647. Pulvermüller, F., Cooper-Pye, E., Dine, C., Hauk, O., Nestor, P. J., & Patterson, K. (2010). The word processing deficit in semantic dementia: all categories are equal, but some categories are more equal than others. Journal of Cognitive Neuroscience, 22(9), 2027-2041. Pulvermüller, F., Hauk, O., Nikulin, V. V., & Ilmoniemi, R. J. (2005). Functional links between motor and language systems. European Journal of Neuroscience, 21(3), 793-797

D60 Constructing the white matter networks of semantic processing with healthy and patient populations

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Semantic memory stores the general knowledge of objects, people, and facts and is central to a wide range of cognitive processes. Decades of research have investigated the cortical regions (Binder et al, 2009) and major white matter (WM) tracts that support semantic memory (Han et al., 2013). An important gap between these two lines of research is that their correspondence is elusive given that the major white matter tracts identified connected numerous cortical regions. In this study, we construct a first whole-brain white matter "network" for semantic processing by directly tracking WM connections among all cortical regions (as nodes) in healthy populations and testing the effects of observed WM connections (edges) in semantic processing in patients. In a first step, we build a whole brain white matter connectivity network by conducting tractography using diffusion imaging data by 48 healthy participants, rendering a network contained 688 white matter "edges" across 90 cortical and subcortical "nodes". We then tested the relationship between the integrity of the obtained WM edges and semantic performance across 80 brain damaged patients. Semantic performance was obtained by performing principal component analyses in 8 semantic and nonsemantic tasks. Edge integrity was measured both by lesion percentage (structural imaging) and mean fractional anisotropy (diffusion imaging). For semantic processing, we obtained 42 WM edges for lesion percentage analysis and 37 ones for mean fractional anisotropy analysis, with the cortical nodes they connect elucidated. The majority of the semantic edges landed on left inferior fronto-occipital fasciculus, left anterior thalamic radiation, and left uncinated fasciculus. Using graph analyses we identified five hubs nodes with top degree (number of connections) and betweenness, including orbital part of inferior frontal gyrus, orbital part of middle frontal gyrus, insula, and thalamus and hippocampus. The results highlight the critical roles of distributed white matter connections among specific temporal and frontal regions in semantic processing. Reference: Binder, J. R., Desai, R. H., Graves, W. W., & Conant, L. L. (2009). Where Is the Semantic System? A Critical Review and Meta-Analysis of 120 Functional Neuroimaging Studies. Cerebral Cortex, 19(12), 2767-2796. Han, Z., Ma, Y., Gong, G., He, Y., Caramazza, A., & Bi, Y. (2013). White matter structural connectivity underlying semantic processing: Evidence from brain damaged patients. Brain, 136(10), 2952-2965.

Discourse, Combinatorial Semantics

D61 Neural correlates of speech preparation in interactive turn-taking: An early start?

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In psycholinguistic experiments on language processing, researchers have traditionally focused on either comprehension or production. However, real-life, communicative language use happens most often in an interactive setting, involving rapid turn-taking between interlocutors. In such a setting, listening to a turn probably overlaps with preparing an answer to this turn. In the current EEG experiment, participants answered quiz questions, asked by the experimenter. Unknowingly to participants, these questions were pre-recorded, while the experimenter gave live feedback on participants' answers. Questions appeared in two different conditions. Participants could confidently guess the answer to the question either halfway through the question (e.g., "Which character, also known as James Bond, appears in the famous movies?"), or only when they heard the last word(s) (e.g., "Which character, who appears in the famous movies, is also known as James Bond?"). Participants took longer to respond to the latter than the former question type, indicating that they start response preparation already during the question if they can, but leaving open when exactly production planning starts. ERP results showed a small N400 effect (Kutas & Hillyard, 1984), followed by a large positivity time-locked to the moment within the question that the answer started to become apparent (the critical point), relative to an equivalent position in the other condition. The N400 effect likely reflects the comprehension of the question, caused by a difference in the predictability of the words. In contrast, the positivity is more likely to be triggered by production processes, which was supported by source localisations of this effect in language production areas (e.g., Broca's area and the temporal lobe, Indefrey & Levelt, 2004). In the frequency domain, less power in the alpha/mu band was found, starting within 500 milliseconds after the critical point. A follow-up control-experiment in which participants only listened to the questions and tried to remember them, was necessary to determine to what extent the positivity in the ERPs and the alpha/mu decrease indeed reflected production processes. Such a control-experiment showed a qualitatively similar pattern in the ERPs. However, the N400 was larger and the positivity was smaller and not localized in production areas, in contrast to the positivity in the main experiment. The effect in the alpha/mu band was absent or at least very much reduced. In combination with the localisations from the main experiment, we tentatively interpret the relative decrease in alpha/mu power as a signal of a shift of attention from comprehension to production-related processing. In all, both this effect and the positivity in the ERPs suggest that response preparation in interactive turn-taking situations starts quickly (within half a second) after an appropriate response can be retrieved. References Indefrey, P., & Levelt, W. J. (2004). The spatial and temporal signatures of word production components. Cognition, 92, 101-144. Kutas, M., & Hillyard, S. A. (1984). Brain potentials during reading reflect word expectancy and semantic association. Nature, 307, 161–163.

D62 Overlap between Language processing areas and sensory-motor maps

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The last two decades of neuroimaging research have pointed toward a significant role for sensory-motor maps in language processing. However, we lack a definitive estimate of overlap between areas involved in processing language and areas containing sensory-motor maps. Here we more accurately determine these overlaps using the latest surface-based auditory, somatomotor, and visual mapping methods, and a naturalistic reading comprehension task in the same group of subjects. 19 right-handed native English speakers took part in an experiment consisting of 4-5 fMRI sessions including: (1) language comprehension, (2) retinotopic, (3) somatomotor, and (4) tonotopic mapping, and (5) structural scans. The language experiment consisted of a naturalistic reading task, where comprehension blocks contained a short narrative passage in English (64 words total, average rate 4 words/sec, word duration a function of word length, one word visible at a time, other words greyed rectangles). Control conditions were meaningless (to the subjects) Hindi character strings or a large dot to control for the effects of low level visual processing (same fixation durations, rectangles). Finally, there was central fixation OFF (32 blocks/run, 4 runs). To control attentional variations across conditions, a secondary task was to detect colour changes of the text/dot/central-fixation. Comprehension for each unrelated English passage was measured afterwards. Retinotopic mapping and auditory mapping experiments followed previous work (Sereno et al., 2013, Dick et al., 2012). For somatomotor mapping, participants gently bilaterally moved body parts on auditory cue. Eight 64s cycles consisted of moving 11 body parts from tongue to toe. Four runs alternated movement cycle direction. Data was acquired on a 1.5T Tim Avanto System with a 32 channel head coil using standard EPI (24 slices, 3.2x3.2x3.8mm, flip=90°, TE=39ms, TR=2sec) and multi-band sequences (40 slices, 3.2x3.2x3.2mm, flip=75°, TE=54.8ms, TR=1sec, accel=4). Two T1-weighted MPRAGE images were acquired for surface reconstruction (Freesurfer 5.3). Each subject's mapping data was analyzed using Fourier based methods on their cortical surface followed by a group analysis in a common icosahedral coordinate system (cross subject complex-valued statistics described in Hagler et al., 2007). Language data was analysed with a GLM in FSL followed by surface-based group analysis with mri_glmfit and multiple comparison correction with mri_glmfit-sim (Freesurfer). To illustrate the all-maps/language overlap, we rendered English vs. Hindi, then overlaid visual, auditory, and somatomotor maps as transparent labels. Note that for an area to be activated by the phase-encoded mapping stimuli, it must respond better to one retinal location/frequency band/body part, than to any other (mere visual, auditory, or somatosensory responses are 'subtracted out'). A large portion of the cortex contains unimodal receptotopic maps. The regions of explicit multisensory map overlap are much smaller. The language activations in occipital/inferior temporal /parietal lobe completely overlap with visual maps. There is a partial (separate) overlap with both visual and tonotopy maps in superior temporal lobe (bilateral for tonotopy, unilateral for visual) and a partial overlap with all three maps (partially overlapping) in the left frontal cortex.

D63 The storyteller's brain: Patterns of activation and deactivation during the creation of narrative fiction differentially modulate narrative structure and predict audience engagement

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We used fMRI to explore the relationships between activity in the brains of storytellers during the process of creating fiction, the nature of the work that is produced and the impact of this work on an audience. Thirty five subjects produced novel stories and retold overlearned stories while being scanned; stories were recorded, transcribed and used to assess levels of engagement by independent readers. Transcripts were also coded to derive measures of narrative complexity that conformed to the principal dimensions of a situation model. Imaging artifacts associated with continuous overt speech were removed with an automated denoising method based on spatial independent component analysis. When contrasted with retelling overlearned stories, spontaneous production of novel stories resulted in characteristic patterns of activations and deactivations distributed throughout the brain. These included activation of a set of regions that constitute the default-mode network (including medial prefrontal, posterior cingulate/retrosplenial cortices, inferior parietal lobule, hippocampal formation, and anterior superior temporal sulcus) as well as the left inferior frontal gyrus. In contrast, significant deactivations were found in regions related to executive control (including dorsolateral prefrontal cortex, intraparietal sulcus and dorsal precuneus) and self-awareness (anterior insula cortex and the dorsal anterior cingulate cortex). Activity in regions that comprise the DMN was positively correlated with measures of narrative structure – indices of causality, shifts in time, spatial relationships and sociality. These associations demonstrated regional specificity and a marked anterior to posterior gradient: activity in frontal regions was more closely associated with action, cause and effect, movement in time; activity in poster and lateral regions more closely associated with depictions of space and social detail. When levels of activity were correlated with measures of audience engagement, a significant association was found not with the DMN, but with the array of regions that had been deactivated in above contrast. These correlations were negative, suggesting that audience engagement becomes stronger as executive control is suspended and a sense agency is attenuated during the generation of fiction. Together

these results suggest unique roles for two distinct but interrelated systems in storytellers' brains during the act of creation. Activation within the DMN appears to be related to narrative elements of the stories themselves that are used to construct a situation model. In contrast, the degree of deactivation in regions that play a role in cognitive control, self-awareness and conscious self-monitoring is associated with the stories' quality as assessed by their impact on an audience.

D65 What does it take to tell a good story? The relation between narrative skills and neuropsychological factors in 3rd graders

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Narrative skills refer to the ability to construct a written or oral text that describes a sequence of events. Such skills are central to children's academic performance, as seen in the emphasis on producing and evaluating narratives in most school curriculums. There is also mounting evidence that narrative abilities are compromised in language impairment. In fact, some studies of children with early language impairment have found that narrative skills may be more resistant to improvement than other language abilities such as vocabulary and grammar (Fey et al. 2004). Despite the increased awareness that narrative skills are central to school achievement and to our understanding of language impairment, few studies have attempted to assess the background variables that influence children's narrative competence. The purpose of the present study was to assess to what extent selected background variables can explain variability in narrative skills during emergent literacy. A total of 43 typically developing Norwegian children participated in the present study (26 males; 17 females; mean age 8.2 years). Each child produced three narratives: oral and written narratives elicited by picture stimuli and a free written narrative. Key stroke logging was used during the written tasks. In addition to the narratives, children were tested with standardized tests measuring neurocognitive skills (digit span, rapid naming, visuo-spatial skills), language abilities (vocabulary, grammar, linguistic abstraction), reading abilities and creativity (product improvement). Thus, as opposed to many studies of unimpaired children where group or class tests are used, there was extensive individual testing in the present study. In addition to the tests, parents completed questionnaires assessing communication skills and risk factors for language impairment. The test administration took place at school and lasted about 2 1/2 hours for each child. Quality of narrative macrostructure was scored according to the Narrative Scoring Scheme (Heilmann et al. 2010), and tests were scored according to their respective manuals. Correlation analyses were performed to select the best predictor variables for the three different narrative tasks. In subsequent stepwise regression analyses, short term memory was entered first and explained 14.3% of the variance in oral story quality (F (1, 39) = 6.34, p = 0.016) and 10,3% of the variance in written free narrative (F (1, 40) = 4.53, p = 0.04). For written picture stories, receptive vocabulary was entered first and explained 17.2% of the variance (F (1, 39) = 7.91, p = 0.008). In sum, results from the study show that short term memory and vocabulary are the most important factors that explain overall narrative quality. However, the relative contribution of these two predictors depends on the type of narrative task. References Fey, M. E., Catts, H. W., Proctor-Williams, K., Tomblin, J. B., & Zhang, X. (2004). Oral and written story composition skills of children with language impairment. Journal of Speech, Language, and Hearing Research, 47(6), 1301. Heilmann, J., Miller, J. F., Nockerts, A., & Dunaway, C. (2010). Properties of the narrative scoring scheme using narrative retells in young school-age children. American Journal of Speech-Language Pathology, 19(2), 154-166.

Syntax, Morphology

D66 Priming of transparent derived verbs in L2 speakers: An fMRI study

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In this fMRI long-lag priming study, we investigated the processing of Dutch semantically transparent, morphologically complex derived verbs. In such words, the meaning of the word as a whole can be deduced from the meanings of its parts, e.g. wegleggen 'put aside'. Native (L1) speakers have been found to decompose transparent complex words in many behavioral and some fMRI studies [1,2]. The brain region usually implicated in morphological decomposition is the left inferior frontal gyrus (LIFG). In a previous fMRI long-lag priming study, this region was found to be deactivated upon presentation of the primed word of a morphologically related word pair [2]. In non-native (L2) speakers, the processing of transparent derived words has hardly been investigated, especially in fMRI studies, and results are contradictory: Some behavioral studies have found more reliance on holistic processing by L2 speakers [3]; some have found no difference between L1 and L2 speakers [4]. In this study, we wanted to find out whether Dutch transparent derived verbs are decomposed or processed holistically by L2 speakers and a control group of L1 speakers. Half of the derived verbs (e.g. omvallen 'fall down') were preceded by their stem (e.g. vallen 'fall') with a lag of 4 to 6 words ('Primed'); the other half (e.g. inslapen 'fall asleep') were not ('Unprimed'). Eighteen Dutch L1 speakers and 21 German L2 speakers of Dutch made lexical decisions on these visually presented verbs. A ROI analysis over both groups showed that there was significant deactivation for Primed compared to Unprimed derived verbs in the LIFG. Even though the interaction between Priming and Language Group was not significant, a closer look at the data showed that this effect was large and statistically significant for the L2 group alone, but not for L1 speakers alone (although they did show the same pattern descriptively). The results of the ROI analyses were confirmed in a

whole-brain analysis. Thus, L2 speakers show a clear priming effect in the LIFG, whereas the evidence for a priming effect in L1 speakers is less clear. As mentioned before, the LIFG has been associated with morphological decomposition. Our finding of LIFG deactivation in L2 speakers is consistent with the idea that L2 speakers decompose morphologically complex verbs rather than processing them holistically. Results will be discussed in the context of the available behavioral and neuroimaging data on the processing of morphologically complex words in L1 and L2 speakers. References: [1] Marslen-Wilson, W. D., Tyler, L. K., Waksler, R., & Older, L. (1994). Morphology and meaning in the English mental lexicon. Psychological Review, 101(1), 3-33. [2] Bozic, M., Marslen-Wilson, W.D., Stamatakis, E.A., Davis, M.H., & Tyler, L. (2007). Differentiating morphology, form, and meaning: Neural correlates of morphological complexity. Journal of Cognitive Neuroscience, 19(9), 1464-1475. [3] Clahsen, H., & Neubauer, K. (2010). Morphology, frequency, and the processing of derived words in native and non-native speakers. Lingua, 120(11), 2627-2637. [4] Portin, M., & Laine, M. (2001). Processing cost associated with inflectional morphology in bilingual speakers. Bilingualism: Language and Cognition, 4(1), 55-62.

D67 Activation modulation in the left inferior frontal gyrus caused by scrambled word orders: An fMRI study in Kaqchikel Maya

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In our previous study with functional magnetic resonance imaging (fMRI), we have reported that activations in the left inferior frontal gyrus (L. IFG) were more enhanced for noncanonical scrambled sentences than canonical sentences (Hum. Brain Mapp. 29, 1015–1027). Scrambling is mainly observed in dependent-marking languages, in which subjects and objects are marked. In the present study, we examined whether such an effect of scrambling can be observed in Kaqchikel, a Mayan language spoken in Guatemala, in which subjects and objects are unmarked for this head-marking language. The order of morphemes in the verb is [Aspect-Absolutive-Ergative-Verb stem], where person (1st, 2nd, and 3rd) and number (singular and plural) agreement for both objects and subjects are obligatorily expressed on a transitive verb in this order. It has been suggested that Kaqchikel allows various scrambled word orders, such as SVO, VSO, and OVS, which are all grammatical. Among these word orders, OVS requires more movement operations than SVO and VSO (J. Coon, Lingua 120, 354–378). We hypothesize that activations in the L. IFG are more enhanced for OVS than SVO, as well as for VSO than SVO. Since Kaqchikel is typologically differed significantly from other well-studied languages, this study would be ideal to examine the universal role of the L. IFG in syntactic processing. We recruited eight right-handed native Kaqchikel speakers (six males, 31 ± 4.7 years old), whose linguistic knowledge included the agreement markers on the verb, as confirmed by a discrimination test. We used a picture-sentence matching task, in which the participants listened to a sentence [e.g., Ri säq xeroyoj ri taq käq, "The white (person) called the red (persons)"] and judged whether the action depicted in a picture matched the meaning of the sentence. In each sentence, one of two persons in the picture was always singular, while the other was plural. We used 3.0 T MRI system (Signa HDxt, GE Healthcare), and analyzed the fMRI data using SPM8 software with fixed effects analyses. Behavioral data of the task showed that the accuracy for OVS were significantly lower than that for the other word orders, and that the reaction times for OVS and VSO were significantly longer than that for SVO (corrected $p < 0.05$). These results indicate that OVS and VSO were more demanding word orders. To exclude any general effects due to task difficulty, the accuracy was used as a nuisance variable for the fMRI analyses. To examine the effect of scrambling between word orders with a verb in the middle position (i.e., OVS and SVO), we tested the OVS − SVO contrast, which resulted in localized activation in the L. IFG and lateral premotor cortex (L. LPMC) (corrected $p < 0.05$). Moreover, we tested the most stringent contrast of VSO − SVO. We found clearly localized activation in the L. IFG, suggesting that VSO has more complex syntactic structures than SVO. The modulation of activations in the L. IFG and the L. LPMC thus indicates a sensitive indicator of word orders in any natural languages.

D68 First language effects on second language processing of grammatical gender: An ERP-study

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Learning the grammar of a foreign language later in life is a big challenge. The present study examines whether the processing of grammatical properties in a second language (L2) is affected by how similar or different these properties are in the first (L1) and second language. One aspect of grammar that is particularly difficult to master for late L2 learners of Dutch is grammatical gender. This classification system divides Dutch nouns into a common and a neuter gender category. Definite articles have to agree in gender with the noun they refer to. That is, common nouns receive the definite article 'de' and neuter nouns 'het'. Although Polish and Russian have a gender system, they lack articles and mark gender on different elements referring to the noun. In contrast, Turkish and Persian do not have a grammatical gender system at all. How do the learners from these different language backgrounds process grammatical gender in L2 Dutch? Is the processing of grammatical gender modulated by the presence of a gender system in the L1? If so, does this facilitate or hinder processing? Highly proficient L2 learners of Dutch from gendered (N=30) as well as non-gendered language backgrounds (N=27) participated in this study. They listened to Dutch sentences containing noun phrases in which gender agreement between the definite article and the noun was either correct (het huis; the[neu] house[neu]) or incorrect (*de huis; the[com] house[neu]). In addition, gender manipulations were either between adjacent or non-adjacent elements (*de/het grote huis; the big house), the latter noun phrase structure containing an

intervening adjective, unmarked for gender, between the article and the noun. The corresponding Event-Related Potentials were measured and compared to a control group of Dutch native speakers (N=27). The results revealed a typical P600-effect for the control group of Dutch native speakers in response to both types of gender manipulations. Importantly, there was an interaction between the distance and the correctness of agreement: for non-adjacent gender violations the P600-effect was larger than for adjacent gender violations. Both L2 groups showed atypical behavior in response to the gender violations. The L2 speakers coming from a non-gendered background showed no sensitivity to either type of gender mismatch. The results for the L2 learners with a gendered L1 also revealed an interaction between the distance and correctness of agreement. Whereas these learners showed no sensitivity for the adjacent gender violations, they revealed a positivity in the P600 time window for non-adjacent gender mismatches. The results suggest that L2 processing of grammatical gender is modulated by the presence of a gender system in the L1. Having a L1 gender system facilitates processing of gender agreement in the L2, even though the elements that are marked for gender are different from the L2. Moreover, the distance of agreement influenced the sensitivity to the gender violations for both the Dutch control group and the L2 learners from a gendered background. The additional time of the intervening adjective might allow for more in-depth processing of the gender marking on the article.

D69 "Right now, Sophie *swims in the pool?!" processing of grammatical aspect in native and second language readers

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Event-Related brain Potentials (ERPs) of semantic and grammatical processing have been investigated extensively, prototypically showing N400 modulations for semantic violations, and modulations of the P600 (or LPC) for certain grammar violations (e.g., agreement errors). Here, we focus on the processing of grammatical aspect, a core grammatical category with a strong meaning component, representing an interface between semantics and grammar. Progressive aspect in English marks an event as temporally 'in progress', and use depends on semantic constraints related to the temporal frame of reference introduced by discourse context (cf. Dahl 2000) (e.g., discourse contexts "What are you up to right now?" or "What are you up to every Monday?", with respective grammatical answer sentences "I am working at home" or "I work at home). Given its complexity, aspect is interesting for the investigation of second language (L2) processing. Here, we investigate whether native and highly proficient second language readers of English (Dutch as native language) are sensitive to aspect violations (a mismatch of discourse context and verbal aspect), and whether ERPs of aspect processing reflect semantic or grammar processing (Experiment 1). In Experiment 2, we obtained acceptability ratings of sentences containing semantic, grammar and aspect violations from the same participants. Participants (N=20 each group) read questions that set up a temporal-aspectual context (i.e., either "What is Sophie doing in the pool right now?" progressive context or "What does Sophie do in the pool every Monday?" habitual context), followed by answer sentences (presented word by word). ERPs were time-locked to verb phrases in four conditions (40 trials each), e.g., progressive context followed by one of four sentences "Right now, Sophie… (a) is swimming (Control condition); (b) *is cooking (Semantic violation); (c) *are swimming (Grammar violation); (d) *swims (Aspect violation) …in the pool" (same verb phrases rendered different conditions in habitual contexts). Both groups showed typical N400 effects for semantic violations, and P600 modulations for grammar violations. Aspect violations elicited a posteriorly distributed N400 effect in the second language group. In native readers we found an early, short-peaking Anterior Negativity (peak 250-300ms), and no N400 effect. Besides the native language - second language comparison, we will present results showing individual differences in judgments of aspect violations and ERPs of aspect processing in both groups. Overall, findings are discussed in relation to studies identifying early Anterior Negativities as markers of predictive processing (Martin et al. 2013), reflecting a mismatch with expectations related to the temporal-aspectual reference frame generated by discourse context, potentially based on expectations at the level of orthography or form (cf. Holcomb & Grainger 2006).

D70 How does the old support the new? The role of memory consolidation in learning novel morphological forms

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The English past tense has had a long history as a major psycholinguistic battleground between opposing views of language processing and cognitive structure (McClelland & Patterson, 2002; Pinker & Ullman, 2002). In the current study we seek to open a new dimension in this debate by focusing on the role of memory systems in learning novel morphological forms. We examine the predictions of a Complementary Learning Systems approach (McClelland et al. 1994) which suggests that the similarity between newly acquired information and existing knowledge crucially determines the relative involvement of the hippocampal vs. neocortical memory systems in acquiring new knowledge. In particular, high levels of similarity between the newly learned and existing memories should allow swift integration in the long-term neocortical stores, whereas low levels of similarity will require greater hippocampal involvement and thus be subject to a stronger influence of memory consolidation. We designed a set of novel verbs that were phonologically similar to existing English verbs: half of the items were similar to neighborhoods of existing verbs with predominantly regular past-tense forms (e.g. PLARE; cf. share-shared, stare-stared), and half to neighborhoods of existing verbs with predominantly irregular past tenses (e.g. FLEEP; cf. sleep-slept, keep-kept). Participants (native English speakers) were first trained on the present tenses of the novel verbs (PLARE,

FLEEP) using word repetition in a sentential context, and sentence completion. A week later they were trained on the past-tense forms of the novel verbs: these were either consistent (e.g. plared, flept) or inconsistent (e.g. plore, fleeped) with the existing neighborhoods. Participants were trained on the past-tense forms in the morning or in the evening and were tested 12 hours later using past tense generation, recall and recognition. When tested immediately after learning, the generation of the novel past-tense forms was influenced by both the regularity of the existing neighborhood and whether the given past tense was consistent with the properties of the neighborhood, as well as the regularity x consistency interaction. Specifically, participants in both groups were better at generating the novel past-tense forms when they were supported by the predominant pattern in the language (plared, fleeped > plore, flept; flept > plore). Crucially, there was a significant difference between sleep and wake in the performance at the delayed test: unlike the participants who slept between training and test whose memory for all novel forms was preserved, for the participants tested after a wake delay only the memory for the forms consistent with the existing predominant pattern was preserved (plared, fleeped), whereas the memory for the inconsistent forms was significantly impaired (plore, flept). These findings provide clear evidence in support of the hypothesis that new linguistic forms consistent with the existing knowledge can be rapidly acquired via the support from the long-term neocortical knowledge (McClelland, 2013). New forms inconsistent with the existing knowledge are subject to a stronger influence of memory consolidation due to an increased involvement of the hippocampal system. More broadly, these findings suggest a role for domain-general memory mechanisms in learning novel morphological forms.

D71 Linguistic Rule Representation in the Bilingual Brain

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Language is one of the most complex rule-based behaviors that humans are capable of. In bilinguals, the complexity is increased by the fact that individuals must "keep track of" multiple ways of representing information and multiple rules for manipulating them. Little is known about how bilinguals represent and control these multiple rule systems, but at least three possibilities exist: (1) target language is represented hierarchically, with all other sub-rules (e.g., how verbs tense) being organized categorically according to target language; (2) linguistic functions (e.g., verb tense) contain a parameter that specifies how to execute for a given language; or (3) rules are represented according to the features they share, irrespective of target language. To examine these hypotheses, we adapted a Rapid Learning Instructed Task (RITL) paradigm (Stocco et al., 2012), in which participants received different linguistic instructions on each trial before receiving the variables (words) on which to apply them. Each trial began with a code indicating whether the target language was English or Spanish. Subsequently, one of 4 linguistic codes instructed participants to pluralize a noun, provide the pronoun, translate a verb to the past tense, or translate a verb to the future tense. After rules were presented, a variable (word) was presented in the target language of interest. Participants pressed a button after having mentally transformed the variable according to the given rule. Afterward participants indicated whether a probe was correct or incorrect based on the given stimulus-rule pair. Capitalizing on the fact that the considerable similarities between linguistic and non-linguistic rule-based behaviors (Buchweitz & Prat, 2014) such as the shared involvement of the dorsolateral prefrontal cortex (DLPFC) and the striatum, we predicted that if bilingual rule representations are organized hierarchically according to target language (1), then more anterior DLPFC regions should activate when participants encode target language than when they encode linguistic rules. If, instead, rules are represented according to linguistic function (2), then patterns of activation should vary as a function of the rule itself irrespective of the target language the rule is being encoded in. Finally, if rules are represented according to shared features or functions (option 3) then we should see closer overlap in patterns of activation for rules that have similar features across language (e.g., to pluralize you add "s" to the end of a noun in both Spanish and English) than for rules that do not (e.g., future verb tense in Spanish vs. English). We have collected data from 5 English-Spanish bilinguals to date who acquired both languages before 7 and are highly proficient in both languages. Preliminary results suggest that, consistent with option 1, more anterior regions of the DLPFC activate when participants encode information about target language than when they encode information about linguistic rules. Additionally, more posterior inferior frontal gyrus activation was observed when individuals encoded linguistic rules than when they encoded target language. These results suggest that target language is represented as a hierarchical rule in the bilingual brain which organizes subsequent linguistic rule structures.

D73 The processing of regular and irregular verbs at early stages of L2 development: an ERP study

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The present study examines the role of the native language in the processing of regular and irregular verbs in Spanish and English-speaking learners of Brazilian Portuguese as a second language, examining their development at two points during their first semester of classes in an immersion context. Partly based on Fiorentino et al. (2012), we tested learners after two months and six months of exposure. Participants read series of regular and irregular verb inflection including present tense and past tense embedded in syntactic contexts. Results for the 10 Brazilian Portuguese native controls showed P600s for violations of regular verb inflection and N400s for violations of irregular verb

inflection in both present and past tense. For the learners of Brazilian Portuguese as L2 (10 native speakers of Spanish and 10 native speakers of English) no effects were found in session 1, but in session 2, violations of the two types of verb inflection elicited N400s for the native speakers of Spanish but not for the native speakers of English. These findings suggest an effect of the native language on the processing of inflectional morphology by late L2 learners at early stages of development and are discussed in the light of dual-route models of morphological processing (Marslen-Wilson & Tyler, 2007; Ullman, 2001; Pinker, 1991; Pinker & Price, 1988).

Language Disorders

D74 COMMUNICATIVE STRATEGIES AND DISCOURSE PROCESSING IN ALZHEIMER'S DISEASE

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Language impairment is a prominent symptom of the progression of Alzheimer's Disease (AD). Although a number of studies has reported that discourse is impaired in AD, there is a lack of studies analyzing both production and comprehension of discourse with comparable tasks. The participant of this case study is a 78-year-old man diagnosed with mild AD by a neurologist; he has had 16 years of formal education and lives in a rest home in the city of Porto Alegre. His results were compared to a matched control ones. A linguistic battery was administered, composed by two narratives in which the participants were asked to read aloud, retell their stories and answer open comprehension questions. Psycholinguist criteria were observed for the development of the texts. Moreover, four tasks involving oral production were administered. Two of them were narratives: in the first, participants were asked to talk about an important event of their life, while in the second, participants were asked to tell a story based on a sequence of scenes. The two other tasks approached procedural discourse: participants were asked to explain the procedures to change a flat tire and to prepare a sandwich. In this description, they had to include the ingredients and the preparation steps. A health condition survey and a reading and writing habit questionnaire were also administered. The patient's results indicated impaired reading comprehension ability in all levels, although the participant presented fluent reading. He also showed deficits in the comprehension of instructions. In the production tasks, despite of showing large knowledge of vocabulary due to intense reading habits in the past, results indicated a very repetitive discourse with very low informativeness, when compared to the control's performance. In the production based on scenes, the participant was successful in naming the elements of each figure; however, he could not relate the different scenes in order to build a narrative. Thus, he did not infer that the main character was the same in all the scenes. In the procedural discourse, he presented anomia, when phonological clues were not helpful; the procedural discourse presented very few details and many circumlocutions in order to explain both procedures. Overall, we observed the use of compensatory communicative strategies during the performance of the linguistic tasks; they were circumlocutions, questions, paraphrases, irony and generalizations. Thus, results indicate that there may be a considerable decline in the discourse processing in probable AD, concerning mainly comprehension processes. This result may be associated to the difficulty of AD patients in creating a situational model appropriate for the discourse. Such difficulty may be related to deficits in the retaining main ideas and supporting details of a text, and their consequent retrieval. These findings may offer important evidence for a differential diagnosis of AD, once conversational interaction is fundamental for the functionality of AD patients.

D75 A dual-route account of object knowledge deficits in primary progressive aphasia

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Language disorders caused by neurodegenerative disease are known as primary progressive aphasias (PPA). Several variants of PPA are now recognized, including an agrammatic variant (PPA-G) with predominately frontal atrophy, a logopenic variant (PPA-L) characterized by posterior temporoparietal atrophy, and a semantic variant (PPA-S) with prominent atrophy in the anterior temporal lobe (ATL). The latter diagnosis may overlap with the syndrome of semantic dementia, where ATL atrophy (usually bilateral) results in a mixture of language and object recognition impairments. This has led to differing accounts of ATL functioning, with some claiming the region is amodal and therefore contributing equally to verbal and nonverbal impairments when lesioned. In the current study we administered a series of object processing tasks to PPA patients (overall N = 55; PPA-G & PPA-L = 39, PPA-S = 16) and age-matched healthy controls (N = 35), with the goal of discovering a) whether patients would show difficulty in object judgments and b) whether such difficulties are related to atrophy in ATL and/or other regions. Participants were given three tasks, designed to place increasing conceptual demands on the object recognition system. In the shape task participants judged whether pairs of rudimentary symbols (e.g. hearts, diamonds) were the same of different. In the category task, participants judged whether pairs of real-world objects belonged in the same taxonomic category (e.g. dog and cat). In the context task, participants judged whether pairs of objects shared a thematic association (e.g. dog and leash). Performance on these tasks were compared between healthy controls, PPA-S patients, and the combined PPA-G and PPA-L patients, who served as a "patient control" group where object processing was predicted to be relatively unimpaired. PPA-S patients, healthy controls, and patient controls all showed relatively high levels of accuracy on the shape and category tasks (mean accuracy > 90%). On the context task, however, PPA-S patients were less accurate (mean of 85%) and more variable compared to healthy and patient controls. PPA-S patients were then split into those performing above and

below the group average on the context task. Cortical thickness analysis showed that whereas both good and poor performers showed atrophy in left ATL, only the poor performers showed atrophy in the right ATL as well. Both groups were extremely impaired in object naming. These results are consistent with a dual-route account of ATL functionality, according to which the left ATL is selectively specialized for verbal representations of object concepts while non-verbal representations are mediated predominantly by the right ATL or collectively by the ATLs in both hemispheres. This account predicts that truly amodal deficits emerge only with bilateral ATL damage.

D76 The predictability effect on N400 reflects aging and the severity of reading comprehension deficits in aphasics

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This study aimed to examine how healthy elders and aphasic patients make use of the contextual information to afford rapid and successful sentence comprehension by using the N400 components of the event-related potential. In the literature, the N400 has been used to index the semantic integration or retrieval. By manipulating the contextual predictability (cloze probability of the final word embedded in the sentence), a lot of studies have repeated found the N400 amplitude was inversely correlated with the predictability, the higher predictability of the final word, the less negative N400 was found (Kutas and Hillyard, 1984). Studies also suggested that, for healthy elders, the cloze probability effect on N400 showed typical central-parietal distribution, but reduced in amplitude and slightly delayed in latency (DeLong, Groppe, Urbach, & Kutas, 2012). Aphasic patients often show large variations in their reading comprehension ability. However, it remains to see whether the predictability effect on N400 could be used to index the comprehension ability in Aphasic patient. In the experiments, participants were asked to read a set of sentences for comprehension. We manipulated the predictability (high versus low cloze probability) of the final word in the sentences and measured the N400 elicited by the final words. The results for the aphasic patients (n = 10) were analyzed according to the severity of their comprehension deficit and compared to a group of 10 neurologically unimpaired age-matched elders, as well as a group of 16 undergraduate students. The aphasic patients were subdivided into high and low comprehension ability groups by their scores of reading comprehension subtest in Chinese Concise Aphasia Test (CCAT). The healthy young controls revealed a typical centro-parietal distributed predictability effect on N400. Although the healthy elders also revealed a significant predictability effect on N400, such an effect was slightly prolonged in latency and reduced in amplitude. For the aphasic group, we found the severity of reading comprehension would modulate their predictability effect on N400 in both latency and topographic distribution. Compared with the age-matched elders, the aphasics with minor reading comprehension deficit exhibited a reduced predictability effect on N400 with more central distribution, and the aphasics with severe reading comprehension deficit exhibited a much prolonged and reduced predictability effect on N400 in frontal electrodes. Our findings suggest the N400 could reflect the severity of reading comprehension deficit. Furthermore, the different topographic distributions in two groups of aphasic patients may imply that they utilize different mechanisms for semantic access and integration for reading comprehension.

D77 The Effect of Semantic Constraint and Cloze Probability on Chinese Classifier-Noun Agreement in Aphasia

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This event-related potentials (ERPs) study aim to investigate whether aphasic patients with comprehension deficits are capable of using top-down information to predict or integrate upcoming words by utilizing the characteristics of Chinese classifier-noun agreement. In Mandarin Chinese, whenever a number or a demonstrative precedes a noun, a classifier must come in between. Most importantly, the usage of Chinese classifiers in modern Mandarin is semantically motivated, although not fully predictable. Thus, we could present participants a set of Chinese classifier-noun pairs that were manipulated to have two levels of classifier constraint strength (strong and weak) and three levels of cloze probability for the pairing noun (high, low, implausible). Participants were first read a classifier and then a paring noun on the center of screen and they were asked to perform an acceptability judgment for the classifier-noun pair. Analyses focused on the N400 component elicited the paring nouns respectively, since the N400 has been used to reflect the semantic integration and retrieval. The aphasic patients (n=18) were subdivided into high and low reading comprehension groups, based on their scores on the comprehension subtest of the Chinese Concise Aphasia Test (CCAT). A group of 9 neurologically unimpaired age-matched elders were served as the control group. For the control group, ERPs elicited by the pairing nouns showed a significant cloze probability effect on the N400. No matter the nouns following the strongly or weakly constrained classifiers, both unexpected nouns (low cloze probability and implausible nouns) elicited a greater N400 than expected nouns did. However, there was no difference between low cloze probability and implausible nouns (implausible = low cloze > high cloze). Compared with control group, the aphasic patients with high reading ability revealed a much reduced cloze probability effect on the N400 for the nouns following the strongly constrained classifiers (implausible = low cloze > high cloze). However, there was no cloze probability effect for nouns following the weakly constrained classifiers on the N400. For the aphasic patients with low reading ability, their ERP data

showed a clear reduction of amplitude on N1 and P2 when compared to both control and high reading ability groups and show no typical pattern on N400. Overall, the patients with high reading ability may preserve the ability to make use the contextual information of strong constraining classifiers to predict the upcoming words. The N400 could be used to index the ability of making use of contextual information and the severity of comprehension deficit.

D78 Resting connectivity within the right Broca's homolog relates to poor word reading in aphasic patients with left-hemisphere stroke *Laura Skipper[1], Elizabeth H. Lacey[1,2], Shihui Xing[1], Alexa Desko[1], Mackenzie Fama[1], Xiong Jiang[1], Peter E. Turkeltaub[1,2]; [1]Georgetown University Medical Center, [2]MedStar National Rehabilitation Hospital*

The role of the right hemisphere in aphasia recovery has been debated for over a century. Some argue that the right hemisphere plays a compensatory role, aiding recovery (e.g., Basso et al., 1989), while others posit that right hemisphere activity interferes with recovery (e.g., Barwood et al., 2011). Recently, research has shifted to examining connectivity, rather than activation levels, in order to better understand neural patterns that explain aphasia symptoms and recovery (Bonilha et al., 2014). This approach is critical because some differences in task-related activity in aphasia may relate to differences in the effort required for task performance rather than actual reorganization of language networks. This experiment examined the relationship between resting state connectivity within the right hemisphere Broca's homolog (BA 44 and 45) and performance on a range of language tasks. We focused here on BA 44 and 45 because in the left hemisphere these areas are highly functionally interconnected and play important roles in language in healthy controls (Bokde et al., 2001). Further, prior functional imaging studies on aphasia have found increased activity in right BA 44 and 45 (Turkeltaub et al., 2011), but the specific roles of these areas in aphasia recovery remain controversial. Twenty participants with left hemisphere lesions and aphasia diagnosis participated in the study. The participants underwent a 7 minute T2* weighted resting state MRI scan, as well as a high-resolution structural scan. Participants also underwent a battery of language and other cognitive tests. Regions of interest were the right Brodmann area (BA) 44 and right Brodmann area 45. First, the time course in right BA 44 was extracted for each participant. The model used the time course in right BA 44 as the predictor, and included motion parameters as covariates. Finally, parameter estimates were extracted for each participant from the second ROI, right BA 45. These parameter estimates quantify the degree to which right BA 45 activity correlates with the right BA 44 time course. The results revealed that right BA 44/45 connectivity was marginally positively correlated with left hemisphere lesion size, and was unrelated to lesion location in a voxel-based lesion symptom mapping analysis. Partial correlations were then carried out, using the parameter estimate for each participant, the score on specific behavioral measures, and lesion size. Connectivity between right BA 44 and right BA 45 correlated negatively, controlling for lesion size, with several measures of oral reading accuracy for real, single words, including a short-word reading task, concrete word reading, and abstract word reading. However, there was no relationship between right BA 44/45 connectivity and single nonword reading. These results suggest that engagement of the right hemisphere Broca's homolog, as measured by intra-regional connectivity, is inversely related to word reading in people with aphasia. The relationship between right intra-Broca's connectivity and lesion volume suggests that the connectivity relates to post-stroke reorganization, but further investigation will be needed to determine the nature of this reorganization and to examine other relationships between right hemisphere connectivity and aphasia recovery.

D79 Neural circuitries underlying distinct types of verb naming errors in aphasia *Maria Ivanova[1], Olga Dragoy[1], Rosa Vlasova[1], Elena Kozintseva[1,2], Yulia Akinina[1], Svetlana Malyutina[3], Alexey Petrushevsky[2], Oksana Fedina[2], Eugene Gutyrchik[4]; [1]National Research University Higher School of Economics, [2]Center for Speech Pathology and Neurorehabilitation, [3]University of South Carolina, [4]Ludwig Maximilian University of Munich*

Verb naming errors in aphasia can be of different types (Kemmerer & Tranel, 2000). Persons with aphasia (PWA) can produce semantic paraphasias (i.e., semantically closely related verbs) or grammatical class errors (i.e., nomination of objects involved in the target action). This first pattern is more characteristic of fluent aphasia, and the later of individuals with agrammatic aphasia. In the current study we investigated whether different neural activation patterns underlie these distinct behavioral responses. Nineteen healthy individuals and six chronic patients with aphasia due to left hemisphere damage were tested using an overt picture naming task in a block-design fMRI paradigm. In the experimental condition, participants were required to name an action picture with a single verb. In the baseline condition, they uttered a constant pseudo-verb in response to abstract pictures constructed by digital distortion of real drawings. Behavioral profiles of patients were assessed in a separate action naming test outside the scanner. Neuroimaging data were processed using SPM 8. All activation clusters reported here for PWA were significant at q = .001, FDR-corrected. In the control group action naming contrasted to the baseline condition elicited specific activation in the left inferior frontal cortex and precentral gyrus, providing support for their critical role in verb production. All PWA had lesions involving the left temporal lobe with partial involvement of the frontal lobe. Behaviorally PWA demonstrated either predominance of noun responses or verb semantic paraphasias. These two profiles of error patterns corresponded to distinct patterns of neural activation. Two patients who primarily produced nouns instead of verbs demonstrated activation in the inferior frontal lobe, supplementary motor cortex and precentral gyrus. In contrast, four patients with abundance of semantic paraphasic responses demonstrated similar extensive activation in the frontal areas (inferior frontal lobe, supplementary motor cortex, precentral gyrus)

and in addition in the temporal cortex extending to inferior parietal areas. Thus, cumulatively our data speak against verb naming being solely dependent on the frontal semantic network. The results are consistent with previous findings where verb-naming deficits stemmed from temporal lesions (Luzzatti, et al., 2006) and favor the interpretation that successful verb naming depends on intact and efficient interaction between the general temporal-parietal semantic system and frontal motor semantic system. Reported data add to the long-lasting debate of separate semantic systems for actions and objects and further emphasize the need to look into error patterns when neural correlates of anomia are under investigation. Acknowledgments: this research was supported by the Russian Foundation for Basic Research (grant 13-06-00651).

D80 Neural Correlates of Verbal Memory and Lexical Retrieval in Logopenic Variant of Primary Progressive Aphasia

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Background/Motivation: Logopenic variant of primary progressive aphasia (lvPPA) is characterized by poor repetition of phrases and sentences, and limited word-finding. Recently, Flanagan et al. 2014 showed verbal memory impairment in lvPPA but the basis for this impairment is unclear. One possibility is related to discrete atrophy in medial temporal lobe (MTL) substructures. Much research in lvPPA, using whole-brain voxel-based morphometry, has shown posterior perisylvian cortical atrophy but no MTL atrophy. lvPPA is often associated with Alzheimer's disease (AD) pathology, a condition associated with MTL atrophy. MTL is not a uniform structure, but is comprised of substructures: Cornu Ammonis (CA1), dentate gyrus (DG), subiculum (SUB), entorhinal cortex (ERC), Brodmann areas (BA) 35 and 36. Even if there is not overall MTL atrophy, substructures within MTL might be differentially affected, and traditional T1 Magnetic Resonance Imaging (MRI) of whole-brain grey matter (GM) may not be sensitive enough to detect atrophy of MTL substructures that are associated with verbal episodic memory difficulty. A second possibility is that lvPPA patients may have impaired lexical retrieval that interferes with episodic memory free recall, and a more reliable assessment of episodic memory may require a recognition testing. Here, we related verbal episodic memory recall and recognition as well as lexical retrieval in lvPPA to MTL subfields using a specialized T2-weighted MRI sequence, and to whole-brain GM atrophy using T1 MRI. Methods: Both lvPPA (n=11) and elderly controls (n=22) were matched in age, gender, education, and intracranial volume. All subjects underwent T1 MRI as well as a high resolution T2 MRI (0.4x0.4mm in-plane) sequence, which maximizes visualization of the dark band that separates CA from DG. A multi-atlas algorithm was applied to automatically label CA1, DG, SUB, ERC, BA35 and BA36. We used Philadelphia Verbal Learning Test (PVLT), a serial list-learning task, to assess verbal episodic memory and Boston Naming Test (BNT) to measure lexical retrieval. Regression analyses were performed. Results: Compared to controls, lvPPA patients performed poorly on forward digit span ($p<0.001$) and BNT ($p<0.025$). Though lvPPA patients displayed poor performance on delayed recall of PVLT ($p<0.008$), their recognition memory was intact ($p>0.5$). Significant atrophy of MTL substructures was found in bilateral CA1, bilateral SUB, and right BA35 in lvPPA compared to controls. Regression analyses showed that only PVLT recall, but not BNT, is associated with left CA1 atrophy ($r=0.69$, $p=0.019$). Whole-brain GM analyses showed significant GM atrophy in lvPPA relative to controls in temporal-parietal areas, including middle and inferior temporal, and superior parietal gryi. Regression analyses related BNT deficits to left superior-parietal atrophy, area involved in visual processing of stimuli presented, while PVLT was associated with left posterior-inferior temporal atrophy, areas involved in lexical-retrieval and depth of processing effect on successful episodic encoding of words. Conclusion: We found that specific MTL subfields and temporal-parietal areas are both affected in lvPPA, and regression analyses suggest that impaired lexical retrieval contributes significantly to episodic memory deficits in lvPPA.

D81 Lexico-semantic dissociations in patients with brain tumors in the posterior temporal lobe

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Introduction: Cortical and subcortical structures of the posterior portion of the temporal lobe have been linked to meaning selection and phonological word form retrieval (Hickok, 2009). Since objects and actions differ both at the semantic and the lexical level, they can be used to examine this relationship further. Objects and actions are represented in at least partly separable substrates as evidenced by dissociations of performance in the presence of temporal lobe damage (Vigliocco et al., 2011). In addition, examining naming performance of subsets of objects and actions which vary in their properties may help to refine behavioral and anatomical accounts of these and other dissociations. For example, deficits in object naming and irregular verbs may coexist in the case of dual processes for verb processing, as these rely on lexical processes for which the left temporal lobe vs more anterior areas plays a relevant role (Ullman et al., 1997). Methods: Two Italian speakers with a high-grade glioma in the posterior part of the temporal lobe, and a third subject with a posterior temporal lesion that extended to the parietal lobe, participated in this study (2 men, 1 woman; aged 59-65 years; >17 years of education). Diffusion tensor imaging revealed deviation and infiltration of the Arcuate Fasciculus (AF) and of the Inferior Fronto-Occipital Fasciculus (IFOF). Two standardized object and action (finite verb) picture-naming tasks were administered before and

within a week after surgery; 30 non-brain-damaged controls were tested only once. We compared patient performance to that of controls, and between subsets for objects vs actions and regular vs irregular verbs. Each subset was matched for name agreement, frequency of usage, imageability, age of acquisition, word length, and manipulability. Results: A double dissociation was documented in naming objects vs actions. Subject 1, whose lesion affected the posterior segment of the AF and deviated the IFOF superiorly, named objects significantly worse than actions before surgery. He also fared worse on regular than irregular verbs. Subject 2, whose lesion affected, mildly, the posterior segment of the AF, was worse at naming objects only after surgery. Subject 3, whose lesion extended to the parietal lobe and affected the middle segment of the AF and deviated the IFOF inferiorly, was worse at naming actions only after surgery. Conclusion: These data support the hypothesis that the posterior part of the temporal lobe is engaged in lexico-semantic processing. Subjects 1 and 2, with damage to the posterior segment of the AF, named objects more poorly than actions. This is presumably because this AF segment is located in the temporal lobe. Subject 3, with mild damage to the parietal lobe and to the middle AF segment was worse at producing actions, presumably because this AF segment connects to more anterior areas. A trend in the data does not support the hypothesis of a dual process for verb processing, as in subject 1 deficits in object naming coexisted with poorer performance on regular than irregular verbs.

D82 Bilateral Temporal Lobe Damage Distinguishes Patients' Anomia Type

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When semantic deficits occur following brain damage, the subjects generally show anomia as well as deficits on semantic matching tasks such as the Camels and Cactus test. Such individuals can be further characterized as demonstrating either a semantic control deficit or a storage deficit (Jeffries & Lambon Ralph, 2006). Semantic control subjects show improved performance when responses are constrained, but storage subjects do not. In the present study, we categorized 17 subjects with neurodegenerative diseases – Alzheimer's disease and Primary Progressive Aphasia - as Semantic Storage or Semantic Control patterns of deficit, based on their performance on three semantic tasks—Naming, Cued Naming, and Word-to-Picture Matching. This was done independent of both the subject's localization of brain damage and clinical diagnosis. Subjects who demonstrated impaired performance on the Naming task, but showed normal performance on Cued Naming and Word-to-Picture Matching, were classified as showing a control deficit (N = 8), while subjects who were impaired on all three semantic tasks were classified as anomic subjects with a storage deficit (N = 9). Despite only using these three semantic tasks, the identified sub-groups demonstrated different patterns of semantic knowledge consistent with either a control deficit or a storage deficit. The identified sub-groups, for example, were comparable for letter fluency, but subjects with a storage deficit were significantly worse for animal fluency. Accessing subjects' semantic knowledge with the word and picture versions of the Camels and Cactus test, we also found that storage deficit subjects' performance was equally poor on both versions compared to normal elderly participants, whereas control deficit subjects were relatively impaired only in the word version. Finally, comparing FDG PET scans for these subjects, we noted storage deficit subjects typically had bilateral temporal damage—all but one participant—whereas control deficit subjects' temporal lobe damage was more severe in the left hemisphere and typically unilateral. Therefore, these results suggest our three tasks were sufficient for differentiating anomic subjects with either a control deficit or a storage deficit. Furthermore, these hemisphere results suggest that anomia is more likely restricted to naming impairments when brain damage is less severe and more isolated to the left temporal lobe. Bilateral temporal damage may be necessary for producing storage deficits across modalities in anomic patients (Gainotti, 2014).

D83 Surface dyslexia is more prominent in semantic variant primary progressive aphasia with left-predominant than with right-predominant temporal lobe atrophy

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Surface dyslexia is one of the hallmark features of the semantic variant primary progressive aphasia (svPPA). Surface dyslexia is characterized as a selective impairment in reading words with exceptional spelling-to-sound correspondences (irregular words), where they are 'over-generalized' and pronounced as they are spelled (e.g., 'sew' pronounced 'sue'). The impairments in svPPA are coupled with atrophy of the anterior temporal lobes (ATLs). While usually bilateral, atrophy is asymmetric and two variants are observed, one with predominantly left (L-svPPA) and the other with predominantly right atrophy (R-svPPA). Prior studies report some differences in the neuropsychological profile of these subgroups, most notably a more profound naming impairment in L-svPPA and a greater deficit in retrieving person-specific information in R-svPPA. We report the first comparison of reading performance. We investigated single word reading in 21 svPPA patients with left-predominant ATL atrophy, 12 with right-predominant atrophy and 14 healthy participants. Reading was assessed using the 'Regularity' and 'Nonwords' reading subtests of the Psycholinguistic Assessments of Language Processing in Aphasia battery (30 regular and 30 irregular words matched for frequency, imageability and word length, and 24 nonwords) or the Arizona Battery for Reading and Spelling (40 regular, 40 irregular words and 20 nonwords matched for word length). Object naming, repetition, syntax comprehension, pyramids and palm trees (PPT) test performance and visuospatial and executive function were also evaluated. Voxel-based morphometry was used to map differences in the distribution of ATL atrophy and identify a more precise locus of the grey matter correlate

of exception word reading. Both svPPA groups exhibited a surface dyslexic profile, with relatively preserved regular word reading (96.5% and 97.8% accuracy, respectively) and impaired irregular word reading (74% and 85.5%). The discrepancy in reading irregular versus regular words (regularity effect), however, was almost two times greater in the L-svPPA group (22.5) than the R-svPPA group (12.2). The two svPPA groups performed equally in nonword reading (87%). Linear regression on all patients revealed that solely the word version of the PPT (not the picture version, repetition nor syntax comprehension) was a significant predictor of the regularity effect, suggesting that exception word reading ability is correlated with integrity of a verbal semantic system. Neuroimaging revealed that the distribution of ATL atrophy was relatively more symmetric in R-svPPA. However, there was a greater disparity in the extent of volume loss in lateral left ATL regions than in the basal left ATL (more atrophied in L-svPPA) and this lateral volume correlated with magnitude of the regularity effect. The selective impairment in reading irregularly spelled words in svPPA is greater in magnitude when the ATL atrophy is greater in the left than the right hemisphere. Moreover, the degree of impairment appears to be correlated particularly with the amount of atrophy in the lateral aspects of the left ATL. We hypothesize that the role of the lateral left ATL in irregular word reading is related to representations subserving lexical-semantics and that the lateralization of this role is due to proximity of these regions to the left lateralized speech production network.

D84 Abbreviated Pyramids and Palm Trees Test Effectively Discriminates Semantic-Variant Progressive Aphasia From Other Variants of Primary Progressive Aphasia

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Primary progressive aphasia (PPA) is a pathologically heterogeneous neurodegenerative disease that affects language. PPA is classified into three variants: semantic (svPPA), logopenic (lvPPA), and nonfluent/agrammatic (naPPA), which are diagnosed on the basis of converging clinical, imaging, and genetic/neuropathological evidence. Although clearer diagnostic criteria for PPA variants have been defined (Gorno-Tempini et al., 2011), objective clinical tests are needed to better distinguish language deficits between variants so more reliable diagnoses can be made. Gorno-Tempini et al. observed that while all variants of PPA show impairment with object naming, svPPA has pronounced single-word comprehension deficits which can make diagnosis of this variant more straightforward than diagnosis of lvPPA or naPPA. Moreover, single-word comprehension deficits in svPPA are more commonly seen with concrete object concepts, compared to abstract concepts, and are most frequently associated with larger semantic memory impairments. We used a modified nonverbal semantic task, Pyramids and Palm Trees (PPT) (Howard & Patterson, 1992), to examine semantic memory of concrete object concepts between groups of each variant. The task is administered across two modalities, pictures and words, and includes 14 cross-culturally validated items. Pathology-confirmed PPA patients, svPPA (n=22), lvPPA (n=20), and naPPA (n=8), completed the task. Patients were instructed to point to which of the two objects on the bottom best go with the target object above. Because some participants completed all 14-items across trials that included a combination of both modalities, or only one modality, the scores used for the analysis were prioritized: (1) pictures, (2) words, or (3) mixed - a combination of picture and word items, if other data was not available. A Kruskal-Wallis analysis across all groups was significant (X2=11.57; p<0.003). svPPA patients were significantly impaired in the abbreviated 14-item PPT compared to lvPPA (U=107; p=0.003) and naPPA (U=34.5; p=0.01) patients, while lvPPA patients do not differ from naPPA (U=75; p=0.77). Additionally, svPPA patients had significant semantic memory impairments compared to lvPPA and naPPA patients. The abbreviated 14-item PPT task provides an efficient and objective clinical test to discriminate svPPA patients from other PPA variants.

D85 Using TMS to Predict Language Outcome after Stroke

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INTRODUCTION: Previous studies have used Transcranial Magnetic Stimulation (TMS) to create "virtual lesions" and test whether activation observed in fMRI studies contributes to the task of interest. Here we investigated whether these "virtual lesions" accurately predict the effect of real lesions. We focus on two left hemisphere regions within the pars opercularis (pOp) and anterior supramarginal gyrus (SMG), where rTMS stimulation caused significant increments in response times during phonological decisions [1,2,3]. We therefore selected patients with lesions to either one or both of these sites and report their residual phonological processing abilities. METHODS: Patients were selected from the PLORAS database [4]. All were 1-5 years post left-hemisphere stroke, native speakers of English and right handed (n=101). Lesions were identified from high-resolution T1-weighted MRI scans using the Automated Lesion Identification toolbox in SPM8 [5]. Phonological impairment was operationally defined as aphasic performance on two tasks of the Comprehensive Aphasia Test [6]: digit span (auditory stimuli) and non-word reading (visual stimuli). The composite score for these two tasks is significantly correlated (Pearson's r = .56, p < .001) with that on the phonological decision task used in the TMS experiments [1,2,3]. Patients were grouped according to whether their lesions included 80% or more of spheres (5mm radius) centred on the regions of interest from the TMS studies (xyz = [-52 16 8] for pOp and [-52 -34 30] for SMG). The patients were divided into 4 groups with ≥80% damage to: pOp_not_SMG (n=15), SMG_not_pOp (n=14), both pOp_and_SMG (n=14)

and neither pOp or SMG (i.e. the control group; n=58). RESULTS: Phonological impairment was observed for 10/15 for pOp lesions, 10/14 for SMG lesions, 12/14 for both lesions and 14/58 in the control group. The proportion of patients with phonological difficulties was significantly higher in those with damage to the TMS sites (74.4%) than the control group (24.1%; $X2(1) = 25.17$, $p < .001$), even after factoring out the effect of lesion size. Further investigation into the lesion sites that did and did not cause phonological difficulties, indicated that the lesions extended deep into the white matter underlying either pOp or SMG. CONCLUSION: We show that the effect of "virtual" lesions (TMS) predicted the effect of "real" lesions. However, in the majority of cases, the real lesions impacting upon phonological abilities extended deep into the white matter. Plausibly these areas may also be affected by TMS which penetrates through the cortical mantle, but future studies will need to test this hypothesis by comparing phonological processing abilities in those who have pOp/SMG lesions with or without deep white matter damage. REFERENCES: [1] Gough et al. (Journal of Neuroscience, 2005). [2] Sliwinska et al. (Frontiers in Psychology, 2012). [3] Sliwinska et al. (submitted). [4] Price et al. (Nature Reviews Neurology, 2010). [5] Seghier et al. (Neuroimage, 2008). [6] Swinburn et al. (2004). CAT: Comprehensive Aphasia Test. Hove: Psychology Press.

D86 Phonological processing of spoken language in beginning readers under the risk of dyslexia: an fMRI study

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Phonological awareness is a complex skill based on knowledge that words are divisible into smaller units such as syllables and phonemes. It is considered to be an important predictor of later literacy, and it has been shown to be impaired in children with developmental dyslexia. To test for phonological awareness, rhyme detection task is commonly employed as children master rhyming judgments relatively early. So far only one functional magnetic resonance (fMRI) study used auditory version of the task on English speaking children. This study revealed that only typically developing children but not children with dyslexia recruited left dorsolateral prefrontal cortex while making rhyme judgments. The authors argued that this particular brain area plays a crucial role in development of phonological awareness. Interestingly, in a different fMRI study using auditory presented onset awareness task (participants assessed whether given words start with the same sound or not), other brain regions such as bilateral occipitotemporal and left temporoparietal were underengaged in children with a familial risk for dyslexia compared to the control group. Here, we investigate functional networks during phonological processing in 60 beginning readers and compare those with a familial risk for developmental dyslexia (FHD+, n = 36, average age = 6.9 years, SD=0.5; 15 boys and 21 girls) to age-matched controls (FHD-, n = 24, average age = 6.8 years, SD = 0.6; 6 boys and 18 girls). Both groups did not differ in nonverbal intelligence, vocabulary size, letter knowledge, reading abilities, working verbal memory and rapid naming skills. We found a significant difference only in graphotactic awareness and a trend in one test of phonological analysis – in both tasks FHD+ children scored lower than their control peers. During fMRI procedure children performed a rhyme judgment task. 24 word pairs were presented auditorily accompanied with pictures depicting words. After each pair children had to decide whether the heard words rhymed or not. The control experiment included the same stimuli but participants' task was to assess whether the words were spoken by lectors of the same gender or not. The order of the tasks was counterbalanced between the children. Although both FHD+ and FHD- children recruited more brain areas while making rhyme than gender judgments, FHD+ compared to FHD- children showed lower activity in the perisilvian language cortex. This suggests that differences in phonological processing on both behavioral and neuronal levels are already present in children who start learning to read.

Poster Session E

Auditory Perception, Speech Perception, Audiovisual Integration

E1 The Effect of Segmental-Tonal Neighborhood Density in Chinese Spoken Word Recognition: An Eye-Tracking Study

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According to current models of spoken word recognition, such as Cohort Theory (Marslen-Wilson, 1987), TRACE (McClelland & Elman, 1986), and the Neighborhood Activation Model (Luce & Pisoni, 1998), spoken word recognition is best characterized as an activation-competition process in which acoustic-phonetic input activates a set of representations of similar sounding words in memory that compete for recognition. In experiments using visual word paradigm, it has been demonstrated that words sharing phonetic segments compete with each other for spoken word recognition (e.g., Allopenna, Magnuson, & Tanenhous, 1998).
The present investigation extends this previous work using the eye-tracking methodology to an examination of competition based on lexical tone. In lexical tone languages, tone is used to distinguish word meanings and may play a critical role in spoken word recognition. In Mandarin Chinese, each syllable may be assigned one of four tones, although not all syllables have four possible tone neighbors. Some syllables may be assigned one specific tone (e.g., qun2 "skirt" or "group"), whereas other syllables may be assigned two to four tones. An eye-tracking experiment using visual word paradigm was conducted to examine the effect of segmental-tonal neighborhood density on spoken word recognition in Chinese. Participants saw four pictures on a computer screen, and were asked to follow spoken instructions (e.g., "Please select chest") to select a target picture. The four pictures included a picture for the target (e.g.,

xiong1 "chest"), a tone mismatch competitor (e.g., xiong2 "bear"), an offset mismatch competitor (e.g., xia1 "shrimp"), and an unrelated distractor. The tone mismatch competitors shared the same segments with the targets and only differed in tone, whereas the offset mismatch competitors shared the first consonant with the targets with the same or different tone. The target and tone mismatch competitors were selected so that the minimal tone pairs with shared segments varied in segmental-tonal neighborhood density, and had two, three, or four possible tone neighbors. For example, the minimal tone pair xiong1 "chest" and xiong2 "bear" has two possible tone neighbors, given that the syllable xiong could only be assigned tone 1 or 2 as words. The minimal tone pair deng1 "lamp" and deng4 "stool" has three possible tone neighbors, given that the syllable deng could be assigned in tone 1, 3, and 4 as words. And, finally, the minimal tone pair bi2 "nose" and bi3 "pen" has four possible tone neighbors as the syllable bi could be assigned four possible tones as words. Results showed that participants looked at tone mismatch competitors more often than offset mismatch competitors, which received about the same number of looks as unrelated distractors. Crucially, participants looked more at tone mismatch competitors when targets had four possible tone neighbors than when they had two possible tone neighbors. The results indicate that tonal information is used on-line to recognize Chinese spoken words. All possible tones for the syllable segments are activated in the early phase of lexical activation with greater competition from words residing in the dense tonal neighborhood.

E2 No Place for [h]: an ERP investigation of English [Place] features

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The Mismatch Negativity (MMN) paradigm has been used to investigate whether some speech sounds are stored with a less specific encoding than others (Lahiri and Reetz, 2002; Scharinger et al. 2012; among others), as suggested by theories of lexical representations like the Featurally Underspecified Lexicon (FUL; cf. Lahiri and Reetz, 2002; 2010). FUL suggests that the coronal place of articulation is a default or underspecified feature at the lexical representational level, a proposal that is consistent with evidence from formal phonology. FUL also makes some language-specific predictions, as in the case of vowel height in English, in which phonetically specified mid vowels are encoded in the linguistic system without any height information. Previous neurolinguistic literature has tested and largely confirmed these claims with stop consonants and vowels. We test the prediction of coronal underspecification with the fricatives /s/ and /f/. Fricatives provide a test-case similar to vowels (unlike stop consonants), which can be easily presented in isolation. If coronal is an underspecified feature, then a deviant coronal sound should elicit a strong MMN when labial sounds are used as standards, but not vice versa. In addition to /s/ and /f/, we also use this paradigm as a diagnosis for the representation of /h/, a subject of theoretical debate. Some researchers consider /h/ to be another type of default sound (Goldsmith, 1981), whereas FUL suggests /h/ may be specified for a laryngeal place of articulation (Lahiri and Reetz, 2010). Therefore we compared /s/ (predicted to be underspecified for place of articulation) and /h/. 24 participants were tested using a passive oddball technique with four blocks (150 deviants, 850 standards): deviant [f] in standard /s/, [s] in /f/, [h] in /s/, and [s] in /h/. In the deviant [f] in standard /s/ block, subjects hear 3-8 examples of /s/ before each /f/ token. Measurements were taken at Cz for the 150-250ms time window, though they also hold for the other expected fronto-central sites. In the /f/ and /s/ comparisons, an interaction is detected between phoneme and deviance (Interaction $F=11.96(1,23)$, $p<.005$). A strong MMN is detected for /s/, but not for /f/, following the predictions of the FUL model. There is no strong difference, however, between the /s/ and /h/ comparisons (Interaction $F(1,23)=.015(23)$, $p=.9$). The first important finding we report is that the predictions of FUL are borne out in the /s/ and /f/ contrast. The second and perhaps most interesting finding is that, according to the neurolinguistic evidence presented here, /h/ does not seem to have place of articulation on a par with that of /f/ since the two do not pattern together in inducing a strong asymmetric MMN response when compared to an underspecified sound (/s/). This study then supports a revised FUL model where the place properties of /h/ are unspecified and provides another case study of how the use of neurophysiological evidence can be used to advance debates between competing linguistic theories.

E3 Eye movement evidence of the cohort density effects in Chinese spoken character recognition

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One eye-tracking experiment was conducted to investigate the influence of cohort density on lexical activation of Chinese spoken characters. According to the Cohort model, as speech unfolds over time, the perceived segments activates the words with the same initial segments. As more segments are processed, more unrelated words are inhibited and the target can be recognized. One factor that can affect the spreading activation and inhibition of the non-target words is the number of words sharing the same initial segments, i.e. cohort density. The present study used the visual world paradigm to reveal the time course of lexical competition influenced by cohort density when recognizing Chinese spoken characters. Forty Chinese native speakers of university students were paid for participating in the experiment. All participants were native speakers of Taiwan Mandarin with normal or corrected-to-normal vision. Thirty-two sets of Chinese characters were chosen from the CKIP corpus. Each set comprised a target character (e.g. □ /xan3/), a cohort competitor sharing initial segments except for the final phoneme (e.g. □ /xaj4/), a rhyme competitor sharing the ending segments except for the onset consonant (e.g. □ /p□an2/), and two phonologically unrelated distractors (e.g. □ /ts□□ŋ/ and□ /m□w4/). Half of the target characters were with small cohort density (mean = 43.44) and the other half were with large cohort density (mean = 84.19). An

EyeLink 1000 system was used to record eye movements in the experiment. On each trial, the participants fixated at a central cross and a spoken instruction (e.g. "please use the mouse to click on / xan3/") was delivered over headphone. An array of four characters was displayed on the screen at 200ms before the acoustic target onset. The array included the target, one competitor (cohort or rhyme), and two unrelated characters. The trial ended after the participants clicked on the target. Fixation proportions on the array of characters were analyzed from the acoustic onset of the targets lasting for 1200 msec. For both groups of targets with small and large cohort density, the fixation proportions to cohort competitors increased and diverged from unrelated controls approximately around 200 to 250 msec after the acoustic target onset. The fixation proportions to rhyme competitors were similar to the unrelated controls all the time. Moreover, the cohort competitors had significant higher fixation proportions for the small cohort condition than the large cohort condition. The large competition effect for the cohort competitor but the null effect for the rhyme competitor is consistent with the Cohort model and the previous studies. It indicates that processing auditory segments for spoken word recognition is sequential and continuous. Moreover, there was a stronger cohort competition on the characters with small cohort density than those with large cohort density. Such effect could be due to the suppression of a similar member in a small cohort is more difficult than one in a large cohort, once it is activated. The findings provide the evidence of dynamic lexical activation and competition of spoken word recognition in Mandarin Chinese.

E4 Does the auditory evoked M100 component reflect the assembling of phonological features into natural classes?

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Previous research has proven the auditory-evoked magnetic response M100 to be a valuable tool to investigate the mental representation and organization of the phonological inventory. Extensive experimental evidence has been found in favor of its featural representation. Moreover, certain regularities in the organization of distinctive features into natural classes are likely to have a systematic impact on the source location and timing of neural activation within the auditory cortex. Intending to find the reflection of this systematicity in spatial-temporal organization of auditory processing, we have conducted an MEG experiment with German voiced consonants varying in two dimensions, i.e. place (labial, coronal and dorsal) and manner (stops, fricatives and nasals) of articulation. The consonants were embedded in VCV pseudo-utterances and presented to participants in the pseudo-randomized order. The vowel environment was also balanced for place of articulation features to keep under control the coarticulation effect, i.e. an extension of phonological features to neighboring phonemes. In addition, an effort was made to keep acoustic variance of the stimuli. Latency and topography of the M100 response to German consonants were expected to reflect their organization into natural classes according to different places and manners of articulation. The preliminary data analysis on ten of twenty subjects showed systematic source location differences along anterior-posterior dimension between varying places of articulation, whereas varying manners of articulation did not have an impact on that plane. The coarticulation effect has affected the latency of the evoked M100. Further analysis allowed by the experimental design will give more insight into the influence of featural incongruency in VCV-utterances on the source location and orientation, which goes beyond prior research. Thus, our preliminary findings support the evidence for featural representation of the phonological inventory reflected in the spatial-temporal distribution of the auditory evoked M100 component.

E5 Pre-attentive processing of duration contrasts: an MMN study

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Durational cues are used in language to fulfil several different functions; many languages use the contrast between short (singleton) and long (geminate) consonants to differentiate lexical meaning (e.g. Bengali [pata] 'leaf vs. [pat:a] 'location'). How these durational aspects are represented and how the representations, in turn, affect the processing of length contrasts has not yet been definitively established. Previous research shows that phoneme quality and quantity are processed independently of each other (cf. Ylinen et al. 2005), which has given support to theories proposing a separate level of representation for non-featural contrasts (e.g. duration and tonal accent). Previous experiments on the processing of durational contrasts in Bengali - lexical decision tasks with fragment form priming and full-word semantic priming - showed an asymmetric pattern of results in both the behavioural and ERP (N400) data. When medial consonants in words with medial singletons (e.g. [□ona]) are mispronounced as geminates, the resulting nonwords (e.g. *[□on:a]) are still accepted as the real word singletons but nonwords with singletons (instead of real words with geminates) do not lead to facilitation. To investigate whether this asymmetry is also evident in pre-attentive auditory processing, we conducted a mismatch negativity (MMN) study. Bengali word/nonword pairs which only differed in the duration of the medial consonant ([ghen:a]/*[ghena] and [kena]/*[ken:a]) were presented in a standard oddball paradigm (15% deviants). The results show a latency difference with the singleton nonword *[ghena] being significantly slower than the real word geminate [ghen:a] while [kena]/*[ken:a] peak at similar latencies. The asymmetry is thus already evident in pre-attentive processing despite the distance of deviance in the stimuli being identical (which is evidenced by the lack of amplitude difference between conditions). In the case of a nonword, where there is no available lexical representation, the MMN response is slower than when a lexical entry can be accessed. This is in line with previous evidence that the MMN also reflects higher cognitive processes and access of linguistic long-term memory traces and lends support to the theory that the singleton

nonword (*[ghena]) is treated as a nonword while the geminate nonword *[ken:a] elicits the same pattern as the corresponding real word [kena]. These findings provide greater insight into the processing of linguistic duration and how this is mapped onto a representation of length in the mental lexicon. Geminates are represented by a length specification (e.g. mora) on the prosodic level while singletons are not. A geminate mispronunciation subsumes the singleton real-word representation because all other (featural) information is identical. However, when a geminate is mispronounced as a singleton, the length specification necessary to match a geminate representation is lacking and activation fails. Thus, full lexical access is achieved through a mispronunciation only if there is sufficient duration in the acoustic signal to map onto the length specification of the corresponding real-word. Ylinen, S., Houtilainen, M., and Näätänen, R. (2005). Phoneme quality and quantity are processed independently in the human brain. Cognitive Neuroscience and Neuropsychology, 16, 1857-1860.

E6 Cross-linguistic differences in automatic perception of allophonic vowel duration

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In speech, durational differences can lead to categorical contrasts in perception, such as voice onset time differences in voiced and unvoiced consonants and consonantal durational differences between singleton and geminate consonants. Finnish is one of many languages where vowel length is phonologically contrastive, e.g. /tuli/ = 'fire' vs. /tu:li/ = 'wind', and has been used in a number of studies examining automatic auditory change detection by utilising the Mismatch Negativity (MMN) component of the evoked auditory ERP (Event Related Potential). Previous studies have shown asymmetric processing of duration within Finnish language speakers, where long vowel deviants give smaller, earlier latency MMNs than short vowels, and processing differences between native and non-native speakers. The present study examines monosyllabic words in two languages that do not have phonologically contrastive vowel length (Bengali and English). In English vowel quantity changes accompany vowel quality changes (e.g. bit vs. beat) and in Bengali vowel lengthening applies in monosyllabic words, so that all monosyllables have long vowels. However, both languages exhibit allophonic differences in vowel length, where vowels before voiced consonants are longer than vowels before unvoiced consonants. In Bengali this rule applies to polysyllabic words but not to monosyllables where vowels are always long. We conducted an ERP study and measured MMN responses in English and Bengali native speakers for vowel duration changes (increases and decreases) in the pseudowords chak and chag. In both language groups, all vowel length deviant stimuli elicited MMN responses indicating that both increases and decreases in vowel duration were pre-attentively discriminated. For the Bengali speakers, both amplitudes and latencies showed an effect of vowel length consistent with previous studies, with short vowels giving higher amplitude and slower latency peaks, reflecting the fact that short vowels are atypical in monosyllables in Bengali. However, as could be expected because of the allophonic difference, English speakers showed an interaction of vowel length and consonant type, where vowel length affected latency only in the context of a following voiced consonant /g/. That is, for the pseudoword chag, long vowel deviants elicited a short latency MMN and short vowel deviants elicited a longer latency peak since they are atypical for English in this context. But for the pseudoword chak, both vowel deviants elicited the same latency MMN. To explore this further, the English speakers listened to stimuli with changes in the final consonant, keeping the vowel length constant. These final consonant changes did not elicit MMN responses and all stimuli within a condition were treated as identical. The results here show a difference in the way that vowel length is processed in languages that use vowel length allophonically. While in Bengali vowel length is treated as a purely durational difference, in English it is also used as a marker of consonant voicing that is more salient than the consonant quality itself. The MMN indexes both acceptability of pseudowords and durational differences, and these effects can be additive or subtractive in MMN latency.

E7 Asymmetry effects on the mismatch response (MMR) to speech sounds: an MEG/ERF study of [t] vs. [d]

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Introduction: Is the perceptual distance from [d] to [t] the same as it is from [t] to [d]? To address this question we investigated the mismatch response (MMR) to [t] as a deviant sound against [d] as the standard sound, as well as to [d] as a deviant against [t] as the standard. The MMR has been shown to be equally sensitive to deviant sounds regardless of them being shorter or longer – or of lesser or stronger intensity – than the standard sounds. This symmetry in the MMR has been explained by the MMR being an index of change detection, not of the sound processing per se. Therefore, the MMR is only sensitive to the size of the change, not the direction of it. Hence, if we see a difference in MMRs to any of the change directions, this could be taken as an index of a difference in the perceptual distance between the change directions. Methods: The stimuli consisted of the four Danish syllables: [tæ] and [dæ] (meaning 'take' and 'then', respectively), and [æt] and [æd] (both meaning 'that'). [t] and [d] were thus presented in both phonemic and allophonic contexts. The four stimuli were presented in a passive listening multi-feature MMR paradigm where three other linguistic features (vowel, syllable structure and intensity) were used as filler deviants. We used MEG (magnetoencephalography) to measure the participants' (n = 17) mismatch field (MMF, the magnetic counterpart of the mismatch response (MMR)). For the calculation of participants' MMFs we compared their ERFs to acoustically identical sounds (e.g. [tæ] as both deviant and standard sound) to ensure that their

obligatory responses (e.g. M1) to the sounds would not differ. We focused on the data from the magnetometers, and we employed the SPM approach to analyzing M/EEG data. Results: Comparing participants' brain responses to the relevant pairs of deviant and standard sounds, we found a main effect of contrast direction (pFWE=0.001 at the cluster-level), peaking around 124 ms after deviance onset over the left hemisphere. Contrast estimates revealed that this main effect was driven by stronger MMFs to both [tæ] and [æt] as deviants in contrast to [dæ] and [æd] as deviants. Participants' MMFs to both [tæ] and [æt] showed opposite polarity patterns over both hemispheres typical of the MMF. Conclusion: Based on participants' MEG it seems that their brains experience the perceptual distance from [d] to [t] as larger than that from [t] to [d]. This is reflected in their MMFs being significantly stronger to [t] as a deviant than to [d] as a deviant. And this is so, despite the acoustic change being the same for both contrasts: [t] was perceived as a deviant against a background of [d] as the standard, and [d] was perceived as a deviant against a background of [t] as the standard. We further discuss this finding in relation to participants' abilities to behaviorally detect the different deviants.

E8 Online processing of co-articulated information in words and pseudowords

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It is a matter of debate how detailed lexical representations in speech recognition are and on which stage subphonemic information is used in lexical access. Here we investigate the use of anticipatory coarticulation by means of lexical decision latencies and ERPs (Event-Related Potentials) recorded in cross-modal word onset priming. Auditory primes with consonant-vowel (c-v) structure were followed by visual German target words. Primes were either the onsets of their following target words, e.g., ri- taken from RINNE (Engl., chute; matching condition), or the onsets of pseudowords with a different place of articulation of the consonant following the initial vowel, e.g., ri- taken from RIMME (variation condition). Primes only differed in anticipatory co-articulation carried by the vowel (ri[n] and ri[m] respectively). Unrelated prime-target pairs were taken as controls (do[g]-RINNE). Lexical decision times for target words were fastest in the matching condition, intermediate in the variation condition and slowest in the control condition. In contrast, responses to pseudowords were slowest in the control condition, but did not differ between the matching and variation condition. The finding that co-articulatory information differently affects behavioral responses to words and pseudowords suggests that lexical representations are involved in resolving co-articulation. ERPs for both the matching condition and the variation condition started to differ from the control condition at 200 ms over the left hemisphere for both, words and pseudowords. Starting at 300 ms the matching and variation condition differed from each other. Thus, less detailed (phonological) representations appear to be accessed faster than more detailed (lexical) representations. These results are evidence for parallel activation of more and less detailed representations along the complex stream of speech recognition. Whereby, co-articulation seems to be used at a lexical level.

E9 Identification of functional acoustic cues involved in speech perception: recent advances using Auditory Classification Images.

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Although there is a large consensus on the involvement of fine acoustic cues in speech perception, the precise mechanism underlying the transformation from continuous acoustical stream into auditory-phonetic primitives, and finally into a discrete phonemic unit still remains largely unknown. The acoustic-phonetic interface has been extensively studied since the 50's. Among the most well-known attempts is the series of papers from the Haskins Laboratories, using synthetic speech. Although extremely helpful for identifying the main functional acoustic cues involved in speech perception, the conclusions of these works are inherently limited by the non-naturalness of the synthesized stimuli: the variations of synthetic stimuli being restricted to a small number of cues, they may not be processed in the same way than natural stimuli. In a recent paper (Varnet et al., 2013) we proposed to fill this gap by adapting a method mostly developed for visual psychophysics: the Classification Image technique. We developed Auditory Classification Images (ACI) by transposing this experimental and statistical framework to an auditory categorization task between two target speech sounds and proved that we could successfully see where people listened to in speech samples. In the current communication, we will present a series of results obtained with this new psychophysical imaging method: first, we ran our first group-study (N=20) and developed statistical methods for evaluating significant effects inside individual ACI, as well as at the group level. We further developed statistical tests that allow the comparison between different conditions or participant groups. The categorization task was based on the [alda]/[alga]/[arda]/[arga] experiment (Mann, 1980). Participants were asked to perform 10.000 classifications in the presence of Gaussian noise, judging at each trial if they heard /da/ or /ga/, independently of the preceding context. The calculation of ACI at the group-level revealed that well-defined acoustic cues on the onsets of the F2 and F3 formantic transitions are involved in this categorization task in neurotypical participants, as well as secondary cues. When splitting images according to the context we could reveal real-time adaptation in the auditory/speech perception system. The second part of the communication will be dedicated to demonstrating

that ACI can provide a way of directly "visualizing" allophonic speech processing in adult participants with dyslexia (Serniclaes et al., 2004). We ran the same [alda]/[alga]/[arda]/[arga] experiment on 20 dyslexic adults. The analysis of auditory classification images obtained in dyslexic participants offers a direct visualization of allophonic speech perception. Further analyses showed that dyslexics exhibit mostly two differences when compared with NT participants: i) there images are less well defined and they seem to be more sensitive to the presence of noise masking non task-relevant portions of the stimulation, a marker of allophonic perception and ii) the distribution of weights inside dyslexic's ACI suggests a specific preference in this population for different auditory cues than those preferentially exploited by NT participants. Altogether these results demonstrate that ACI is a very promising method to study natural speech processing in NT and in the context of various speech or auditory perception deficits.

E10 How does musical expertise shape speech perception? Visual evidence from Auditory Classification Images. *Tianyun Wang[1,3], Léo Varnet[1,3], Chloé Peter[1,3], Gustavo Estivalet[2,3], Fanny Meunier[2,3], Michel Hoen[1,3]; [1]Lyon Neuroscience Research Center, CNRS UMR 5292, Auditory Language Processing (ALP) research group, Lyon, France., [2]Laboratoire sur le Langage le Cerveau et la Cognition, CNRS UMR 5304, Auditory Language Processing (ALP) research group, Lyon, France., [3]Université de Lyon, Université Lyon 1, Lyon, France.*

An essential step in understanding the processes underlying speech comprehension is to identify which auditory/phonetic primitives are extracted from the acoustic signal and used to categorize a speech stimulus as one phoneme or another by listeners (i.e., /b/ or /d/ for example). In this context, we have already demonstrated that a psychophysical imaging method called Classification Images could be adapted to the study of speech perception thanks to recent theoretical developments, in particular in the domain of statistical models used to derive classification images (Varnet et al., 2013). In the current experiment, we wanted to assess the sensitivity of the auditory classification image approach to small interindividual differences in auditory processing abilities. It is now well established that extensive musical training is triggering neurophysiological plasticity in the auditory system, causing different effects as a sharper tuning of cochlear filter-responses, better detection and discrimination abilities etc. It was even demonstrated that musical training could improve the neurophysiological encoding of speech sounds. If auditory classification images are sensitive enough to identify fine acoustic cues used during speech sounds categorization and really reflect the intrinsic sensitivity of the hearing system of the participants then we should observe differences in the size, extent and time-frequency distribution of acoustic cues exploited by control participants vs. professional musicians. The purpose of this experiment was therefore to directly compare auditory classification images obtained from a group of 16 normal hearing control participants, who did not follow any kind of musical training to a group of 16 professional musicians, who had been practicing their instrument (piano) for at least 10 years and who still studied at the local conservatoire de musique. Participants were engaged in an [alda]/[alga]/[arda]/[arga] experiment (Mann, 1980). Participants were asked to perform 10.000 forced-choice categorization between /da/ and /ga/, independently of the preceding consonantic context. We then derived auditory classification images for musicians and non-musicians by fitting a statistical model (Generalized Linear Model with smoothness priors) between the specific noise field at each trial and the corresponding response of the observer (/da/ or /ga/). We could thus identify which time-frequency regions of the speech targets are crucial for their identification and could examine differences between musicians and non-musicians. As expected, professional musicians showed a better resistance to noise (the performed classifications at an average SNR that was 3dB less favorable than non-musicians) and the classification images obtained for musicians show the specific hyper-sensitivity of their over-trained auditory skills. In particular, it appears that they are much more selective compared to non-musicians when looking at the regions inside the stimuli that they use to perform the categorization. In general functional auditory cues used to perform speech sound categorizations in musicians showed a more restrained extent in the time-frequency domain, revealing finer auditory abilities both in temporal and spectral processing. Altogether these observations, confirm the sensitivity of the auditory classification method and provide a direct visualization of auditory plasticity consecutive to intensive musical training and its effect on speech perception.

E11 Asymmetric processing of word accent in Norwegian *Allison Wetterlin[1], Adam C Roberts[1], Sandra Kotzor[1], Jacques Koreman[2], Aditi Lahiri[1]; [1]University of Oxford, [2]Norwegian University of Science and Technology*

The processing of tone has been examined primarily for Asian languages. The research has focused on four general areas: lateralization of the processing of tones, non-native vs. native perception of tone, within- and across-category differences in processing, and tone vs. intonation. The effect of the complexity of tones on native versus non-native perception has also been touched upon, the claim being that complex contour tones are more difficult for non-natives compared to static tones which only differ in height. A persistent finding is that phonemically contrasting tones trigger a mismatch negativity (MMN) in native speakers. However, the relationship between lexical status and the processing of tones that differ in their acoustic manifestation is still unclear. For example, although Mandarin Tone2 and Tone3 both trigger MMNs with respect to a common standard, there is no evidence that one has a stronger effect. The default assumption is that the MMN differences are symmetric. Our focus is on the lexical status of tonal accent in a North Germanic language, i.e. in Norwegian. North Germanic languages (NGmc) have two word-accents (Acc1 & Acc2) of which most theories assume only one is lexical. This opposition distinguishes

NGmc from Asian tone languages such as Mandarin that has 4 lexical tones. Following standard assumptions concerning Asian tone languages, one may assume that Acc1 vs. Acc2 (e.g. banken 'the bank' vs. banken 'the sandbank', respectively) would lead to symmetric MMNs, i.e. the MMN resulting from Acc1 standard vs. Acc2 deviant would equal the MMN of the reversed standard-deviant pairs. However, linguistic evidence suggests that only one tone is lexically contrastive and therefore specified in the mental lexicon of native speakers: Acc1 is specified and thereby unalterable, while Acc2 is realised by default for disyllabic words. We examined the possibility of asymmetry under these assumptions. EXPERIMENT: This auditory MMN study was conducted using 3 sets of minimal pairs differing only in word-accent. Although all monosyllables in Norwegian have the acoustically more simplex Acc1 (LH) some of these are lexically specified, i.e. always show up with Acc1 as first element of a compound, whereas unspecified monosyllables become Acc2 as soon as more syllabic material is available (in a compound). Two noun pairs with the enclitic definite article =en were used: bank=en (lexically specified Acc1) 'bank-the', banke=n (unspecified Acc2) 'sand bank-the', tank=en (unspecified Acc1 'tank-the') and tanke=n Acc2 (unspecified Acc2) 'thought-the'. Furthermore, one non-word pair was used: *janken Acc1, *janken Acc2. RESULTS: Unlike findings for Mandarin and Thai tone, that find similar MMNs across categories, this study uncovered strong asymmetries when looking at difference waves (standard-minus-deviant). Acc1-deviants produced clear MMNs whereas Acc2 did not, reflecting the difference in perception of the H and L tones on the stressed syllable in Acc2 and Acc1 respectively. Within Acc1-words, lexically specified Acc1 bank=en showed significantly faster MMN responses than unspecified Acc1 tank=en. The nonword jank=en appeared latest in the time course and showed maximal responses over the right hemisphere, in comparison to the word stimuli which were maximal over the left hemisphere.

E12 Adult listeners handle speaker and dialect variation differently: evidence from an ERP study

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The human ability to comprehend speech signals regardless of variation across speakers and dialects has long puzzled researchers. Previous studies assume that during speech comprehension, differences between speakers and dialects are normalized using the same underlying mechanism (exemplar theory; Pierrehumbert, 2002). However, dialect normalization by adults and older children appears to rely on lexical knowledge and exposure (Clarke & Garrett, 2004; White & Aslin, 2011). In contrast, speaker normalization seems to occur automatically and without lexical knowledge since not only human infants (Jusczyk, et el., 1992; Kuhl, 1983), but also other mammals and birds can discriminate human speech sounds and syllables across different voices (Kuhl, 1975; Ohms, et el., 2010). To examine whether listeners handle between-speaker variability in vowel acoustics differently than between-dialect variability, we used a pre-attentive event-related potential (ERP) oddball experiment. It has been shown that a linguistically significant change, such as a change in vowel category, clearly elicits larger mismatch negativity (MMN) at later time windows (Näätänen et al., 1997). Therefore, if speaker and dialect normalization are handled by different underlying mechanisms, and dialect normalization involves more abstract (lexical) knowledge, listeners will be able to normalize variability in isolated vowels caused by speaker differences, but not the variability caused by dialectal differences. Thus, changes in dialect should elicit a larger MMN than changes in speaker or sex. Eight students from the University of Western Sydney were presented with an EEG oddball paradigm comprising an array of frequent (standard) and infrequent (deviant) auditory stimuli. Isolated natural tokens of Dutch vowels /□/ and /□/ were used to avoid the activation of lexical knowledge. The standard stimulus was a natural vowel produced by a female North Holland Dutch speaker and the four deviant stimuli differed from the standard stimulus in speaker, sex, dialect (East Flanders Dutch), and category membership, respectively. For each deviant type, we subtracted the average response to the deviant stimulus in the oddball block from the average response to the physically identical stimulus in the control block for each participant and computed the grand average difference waveform by pooling across participants. In the grand average difference wave per deviant type, we quantified the average MMN amplitude in a 40-ms window at a negative peak determined between 150 ms and 250 ms relative to stimulus onset. A repeated-measures ANOVA with within-subjects factors Deviant type (4 levels: Vowel category, Speaker, Sex, Dialect), Anteriority (3 levels: Frontal, Fronto-Central, Central) and Laterality (3 levels: left, midline, right) showed a significant effect of Deviant type ($F[3,21]=8.038$, $p=.001$). The Sex deviant yielded a stronger MMN than the Speaker deviant ($p=.001$) and than the Vowel deviant ($p=.005$). Furthermore, the Dialect deviant elicited a stronger MMN than the Vowel deviant ($p=.042$). The Dialect deviant tended to give stronger MMN than the Speaker deviant, but this effect did not reach significance ($p=.055$). The results suggest that listeners automatically normalize changes in speaker but not changes in sex or dialect. Thus, while speaker normalization seems to be automatic, dialect variation may require metalinguistic knowledge for successful recognition.

E13 Repetition attenuation and stimulus specificity in long-latency auditory evoked responses to vowels

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The N1 and P2 components of the auditory evoked response are known to attenuate with stimulus repetition. A number of studies report stimulus-specific effects by which more pronounced attenuation occurs when

sound pairs or sequences are composed of more similar (or identical) sounds. The purpose of the present study was to investigate the repetition attenuation effect on the N1 and P2 components in response to a specific class of sound, namely, vowels. We are particularly interested in whether phonemic categories can be reflected in patterns of repetition attenuation of ERP components. Twenty-six Brazilian Portuguese native speakers participated in an experiment in which pairs of successive vowel sounds (S1-S2) were presented in three different conditions: "identical sounds" (S1 and S2 are identical), "within-category" (two acoustically different but phonologically equivalent sounds), and "between-category" (two sounds identified as exemplars of different vowel categories). The experiment was designed to test whether 1) responses to S2 are more attenuated in the "identical sounds" condition, 2) responses to S2 are less attenuated in the "between-category" condition, and 3) different vowels elicit different N1 and P2 responses. Based on results of each participant in a vowel classification task, six sounds were selected from a /i/-/e/ continuum such that the resulting stimuli set consisted of three "i" sounds and three "e" sounds forming a series ranging from /i/ to /e/ in equal steps in the Bark scale (i1; i2; i3; e1; e2; e3). For each of the three conditions, two sound pairs were used, one with i3 and one with e1 at the S2 position. The resulting six S1-S2 pairs were then [i3 - i3], [e1 - e1], [i1 - i3], [e3 - e1], [e2 - i3], and [i2 - e1]. Participants were instructed to ignore the sound stimuli and watch a silent movie during the eeg recording. As expected, a robust attenuation effect was observed for both N1 and P2. However, no evidence of stimulus-specific attenuation was obtained, since responses to S2 are similar across conditions. Concerning responses to S1, the N1 recorded at the mastoid sites and the P2 at Cz showed significant amplitude effects of vowel category – only the latter seeming to follow the continuous change in spectral content from the most extreme /i/ to the most extreme /e/. Thus, the present results indicate that, although N1 and P2 in response to complex sounds like vowels reflect stimulus-specific perceptual processing, the repetition attenuation of those components is, at least in the case of unattended stimuli, not stimulus-specific.

Motor Control, Speech Production, Sensorimotor Integration

E14 Motor and somatosensory adaptation during overt and imagined orofacial and speech actions

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Online sensory feedback control mechanisms play a key role in orofacial and speech motor control. In order to monitor and control production, auditory and somatosensory consequences of the intended motor act are thought to be estimated by means of efference copies and to be compared with actual feedback (Guenther, 2006; Hickok et al., 2011; Houde and Nagarajan, 2011; Tian and Poeppel, 2012). Since imagery process is well known to depend on internal sensory-motor simulation (Jeannerod, 1994, 2001), we here examined whether these internally-generated motor-to-sensory predictions might also occur during orofacial and speech motor imagery, in the absence of overt motor behavior and sensory feedback monitoring. In order to test whether motor simulation might also partly rely on motor-to-sensory state estimation common with those for motor execution, we used a repetition-suppression (RS), or adaptation, paradigm while measuring neural activity with sparse sampling fMRI during overt and covert repeated orofacial and speech actions. RS refers to the phenomenon that repeated motor act or stimulus presentation leads to a reduction in BOLD signal and is associated with enhanced adaptive learning and increased processing efficiency. A convergent neurocomputational interpretation, based on sensory-motor adaptive control, proposes that RS arises from sensory-motor adaptive learning and reduced prediction errors for online state estimation and motor correction. From that view, RS is thought to reflect a combination of attention and predictive mechanisms. In order to examine whether overt production and motor simulation might both induce RS in relation to auditory and somatosensory speech and non-speech adaptive coding, a factorial design was used with the production mode (overt action vs. covert action), the task (silent orofacial action, audible orofacial action, syllable production) and the stimulus repetition (first production, second rpdouction) as experimental factors. To this aim, participants were asked to overtly or covertly produce silent orofacial actions (lip protrusion, tongue retraction), audible orofacial actions (kiss, tongue click) and syllables (/pa/, /ta/) in trains of two consecutive trials. Suppressed neural responses during both overt and covert repetitions were observed in motor and associative somatosensory regions (the left premotor cortex and adjacent inferior frontal gyrus, the left insular cortex, the supplementary motor area and the posterior parietal cortex). In addition, reduced activity of the auditory cortex was observed during overt but not covert production of audible orofacial actions and syllables, a finding likely reflecting a motor rather an auditory imagery strategy. By providing evidence for motor and somatosensory adaptive changes, the observed RS suggest online state coding of orofacial and speech actions in somatosensory and motor spaces with and without motor behavior and sensory feedback. This result suggests that efference copies are automatically sent to the somatosensory system even when corrective motor adjustments are not needed.

E15 Lexical-perceptual influences on sensorimotor adaptation in speech

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The perception of speech sounds often occurs under noisy or variable conditions. In the face of this, listeners are capable of drawing upon higher-order linguistic cues (e.g., sentential context or lexical information) to facilitate phonetic processing of the speech stream. A well-known illustration of such a top-down influence on speech perception is the "lexical effect" (Ganong, 1980), whereby the perceptual categorization of a phonetically ambiguous sound is biased towards real words, effectively shifting the phonemic boundary in favour of existing lexical entries. While such lexical biases have been demonstrated in the purely perceptual domain, it has been unclear whether such an influence of lexical status on phoneme perception might also play a role in sensory-guided speech motor function. In the present study, we addressed this question by combining a manipulation of lexical status with a test of speech motor adaptation involving a real-time manipulation of auditory feedback during vowel production (Houde & Jordan, 1998). Subjects produced a series of words or non-words containing the target vowel /□/ (as in "head") under conditions of normal or altered auditory feedback. The feedback alteration involved a decrease in the first formant frequency, resulting in a vowel that was perceived by the talker to be closer to /I/ (as in "hid"). Two conditions were tested that differed in the type of stimuli being produced (real-words vs. non-words), and that also differed in the consequence of the auditory feedback manipulation on the lexical status of the production output – in one case, changing from real-word to non-word (e.g., "death" to "dith") and in the other case changing from non-word to real-word (e.g., "kess" to "kiss"). The magnitude of participant's speech motor adaptation to the altered auditory feedback showed a clear influence of lexical status, consistent with the phonetic boundary shift observed at the perceptual level in studies of the lexical effect. A control study was carried out contrasting two similar speaking conditions (real-words or non-words), but for which the vowel feedback manipulation had no effect on the target's lexical status. In contrast with the experimental manipulation, the control conditions showed no differential effect on the speech motor adaptation response. These results provide new evidence for an influence of lexical status on both sensory and motor aspects of speech, supporting an interactive model of speech production encompassing not only sensorimotor, but higher-order linguistic information as well (e.g., Hickock, 2012). In addition, because the speech production task used in the present study required no explicit perceptual judgments of vowel or word identity, the present results provide insights into the nature of the lexical effect on phoneme perception. Specifically, they support the view that lexical status directly alters the phonetic perception of speech sounds (i.e., the perceptual boundary between speech sound categories) and does not simply bias post-perception decision-making processes (Myers & Blumstein, 2007).

E16 Phoneme sequence probability encoding during speech production *Matthew Leonard[1], Ryan Morrill[1], Edward Chang[1]; [1]University of California, San Francisco*

The language-level statistics of sound sequences, known as phonotactics, are hypothesized to play a role in integrating low-level speech representations (such as acoustic-phonetic units) and higher-level linguistic representations (such as words). Lifelong exposure to these phoneme-level co-occurrence statistics likely shapes the organization and synaptic weights of neural circuits that process sounds in a given language. Previously, we showed that during speech perception, neural populations in the superior temporal gyrus (STG) encode English transition probabilities between phonemes in a dynamic pattern that may help facilitate the transformation from sub-lexical to lexical representations. Here, we ask whether phoneme transition probabilities are also reflected in neural activity during speaking. We recorded and analyzed electrocorticographic (ECoG) neural activity in the high-gamma (HG) frequency range (70-150Hz) in four neurosurgical patients while they produced consonant-vowel-consonant (CVC) tokens with varying English transition probabilities. We examined the encoding of two distinct phonotactic measures: (1) The probability of the upcoming vowel given the first consonant ('forward probability'), and (2) the probability of the preceding vowel given the second consonant ('backward probability'). Similar to the previous results for speech perception, we found a dynamic pattern of activity that correlated with transition probabilities over time. The earliest effects began prior to acoustic speech onset in ventral sensorimotor cortex (vSMC), followed by probability effects in posterior and middle STG. These effects persisted even when neural activity was controlled for articulatory (vSMC) and acoustic (STG) speech features, including dynamic coarticulation effects. We observed both negative and positive modulations of neural activity as a function of transition probability, consistent with both predictive and Hebbian encoding frameworks of sensorimotor processing. The majority of significant forward probability effects were in vSMC, while backward probability was encoded in both vSMC and STG. Finally, transition probabilities that were controlled for the frequency of the words in which those biphones occur accounted for less variance in the neural response compared to when transition probabilities were not controlled for lexical frequency. This difference suggests that these neural populations are sensitive to higher-order lexical statistics independent from phonotactic statistics. Overall, these results support the hypothesis that the language-level statistics of phoneme sequences are encoded dynamically during speech production. The fact that these effects occur in regions that are known to control the movement of the speech articulators, as well as auditory areas that receive acoustic feedback during self-produced speech, suggests that phonotactic encoding may play a role in movement planning during word production.

E17 Neural basis of syllable frequency effects in speech perception and production *Pascale Tremblay[1], Claudie Ouellet[1], Isabelle Deschamps[1], Mylène Bilodeau-Mercure[1], Uri Hasson[2]; [1]Université Laval, [2]University of Trento*

According to contemporary models of language (e.g. Levelt et al., 1999) frequent syllables are easier and faster to produce because, unlike rare ones, they are pre-compiled as holistic motor routines, whereas infrequent syllables must be assembled from phonemes. To determine whether syllables are indeed stored in the brain, we constructed a stimulus set that allowed us to evaluate the impact of statistical features of single-syllables (syllable frequency) and the frequency of syllable pairs (COOC) on brain activity, studied using fMRI, during the perception and production of disyllabic non-words. Twenty right-handed participants (mean age = 24.45±4.6 years) were asked to (1) passively attend to 225 meaningless disyllabic non-words presented one at a time, and (2) listen to and repeat 225 meaningless disyllabic non-words. For each non-word, the frequency of the first syllable (FS1), the frequency of the second syllable (FS2) and the co-occurrence frequency (FCOOC) of the syllable pair, derived from corpus data, were included in the regression model as parametric regressors (amplitude modulated). The stimulus set was constructed such that FS1, FS2 and FCOOC were uncorrelated. This experimental design allowed examining frequency effects during both speech perception and speech perception. Structural and functional MRI images were acquired on a 4T Bruker MRI system in Trento, Italy (EPI sequences: 37 axial slices, 3x3x3.45 mm voxels; TR = 3.74 sec, delay in TR = 2 sec). All analyses were conducted with AFNI/SUMA on the cortical surface. We identified areas sensitive to FS1, FS2 and FCOOC, as well as those where such sensitivity varied by task (Production vs Perception). For all analyses, an individual vertex threshold of $p < .01$ was used, corrected for multiple comparisons to achieve a family-wise error (FWE) rate of $p < 0.005$. Trials with mistakes in repetition were excluded from the analysis. The results reveal that different areas track FS1, FS2 or FCOOC, with different patterns of interaction with task. Areas generally sensitive to FS1 included the right ventral premotor cortex, but a strong interaction of Task x FS1 was found in regions including the bilateral pre-SMA, intraparietal cortex and anterior dorsal insula. In contrast, sensitivity to FS2 was found in bilateral ventral central sulcus, left SMA-proper and parts of the posterior supratemporal cortex bilaterally, with few areas showing interactions with task. For FCOOC, activity in several areas was negatively correlated with frequency: the left SMA-proper, bilateral central sulcus and right ventral premotor cortex. The results suggest that sensitivity to syllable frequency is mediated predominantly in motor and sensorimotor cortices, and that sensitivity to co-occurrence frequency cannot be reduced to sensitivity to single-syllable constituents. In addition, this is the first demonstration that the distributional properties of syllables influence both speech perceptual and motor processes, and that syllable position has an effect on frequency effects.

E18 ASSESSING THE LINK BETWEEN SPEECH PERCEPTION AND PRODUCTION IN SPEECH MOTOR CONTROL THROUGH INDIVIDUAL DIFFERENCES

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Recent studies on speech motor control have shown an intricate connection between speech perception and production. This line of research has among other things suggested that at least some of the goals of speech movements are regions in auditory space, i.e. they are specified in auditory terms. This is in line with recent modeling work (for example, see Guenther, Ghosh, & Tourville, 2006). The current study aims to test a prediction of this framework: if speech production targets are specified in auditory terms, people with better auditory acuity should have more precise speech targets. To investigate this, we had participants perform both speech perception and production in a counterbalanced order. To assess speech perception acuity, we used an adaptive speech discrimination task on two Dutch vowel continua (/□/-/□/ and /□/-/□/). This aimed to assess the participants' discrimination performance for the given vowel continua. To assess variability in speech production, participants performed a a pseudo-word reading task, which required them to read 80 different non-words, each four times in randomized order. All pseudo-words contained one of the four Dutch vowels used as endpoints of the vowel continua. For each recording, the first (F1) and second (F2) formant values were measured. There were two primary goals of the study. The first was to assess the extent of speech production and perception variability. The second was to determine whether this variability is related correlating participants' speech target precision to their performance in the discrimination task using these same vowels. There are two measures of speech production that might capture variability associated with speech perception. First, we take average vowel spacing as a proxy of speech target precision: the more precise the speech targets, the greater the acoustic distance between people's pronunciation of neighboring phonemes would be. Therefore, we expect speech production variability to correlate positively with discrimination performance. The second measure is simply the amount of pronunciation variability, measured as the variance in F1/F2 for each vowel. Presumably, people with more precise target specifications will reject and/or correct erroneous speech more often. Over time, this leads to less variable speech production. Therefore, we expect speech production variability to correlate inversely with discrimination performance. Preliminary results suggest that people do vary in their production and perceptual abilities, and that better discriminators have vowel production targets spaced further apart. The poster will illuminate this further, as well as examine differences in pronunciation variability. This study thus highlights the importance of individual differences in the study of speech motor control, and sheds light on speech production-perception interaction. Guenther, F. H., Ghosh, S. S., & Tourville, J.

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E19 The inner workings of inner speech: An fMRI investigation using phonetic features

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Despite being one of the most intuitive and phenomenologically "human" aspects of cognition, little is known about the neural basis of inner speech. Previous neuroimaging research has suggested that inner speech recruits brain areas within the fronto-parietal language network (Jones & Fernyhough, 2007), and while it possesses both perceptual and motor qualities, it is necessarily different from both speech perception and speech production. The surface-impoverished hypothesis suggests that inner speech has weakened or absent low-level featural representations yet intact deeper lexical representations. Behavioural evidence supports this hypothesis (Oppenheim & Dell, 2008) but relies on self-report measures and cannot provide a clear neural mechanism for such representations. The objective of the current study was to isolate the motor, auditory, and linguistic aspects of inner speech in a three-part within-subject fMRI paradigm. Participants took part in three different fMRI sessions within approximately one week. During one session, participants were asked to subvocally rehearse a set of eight consonant-vowel syllables (i.e., "ba"), with special instructions to not move their mouths or make any sound (inner speech condition). Another session investigated the neural correlates of passive listening to the same syllables, during which external auditory stimuli were perceived but motor commands were not explicitly initiated (speech perception condition). A final session required participants to silently mouth the same syllables while in the scanner (mouthing condition). Thus, information regarding articulatory gestures was recorded in the absence of external auditory stimuli. Multivoxel pattern analysis (MVPA) was performed in order to map the distributed activity reflecting three phonetic features: voicing, manner of articulation, and place of articulation. Results show robust classification accuracy in the mouthing condition for place and manner across bilateral pre/motor cortex, and weaker classification for voicing in ventral motor cortex. Interestingly, classification was also observed in the mouthing condition for all three features across the length of the superior temporal gyrus (STG). Similar patterns were observed in the STG during speech perception, but not during the inner speech condition. During inner speech, classification accuracy was observed for place of articulation in more posterior auditory areas as well as in a subset of the dorsal premotor activity that was observed in the mouthing condition. Consistent with the surface-impoverished hypothesis, classification accuracy for low-level features was weakest in the inner speech condition. That the mouthing condition produced stronger classification accuracy in the auditory cortex than inner speech suggests that articulatory gestures may be driving low-level featural representations and that the lack of explicit motor execution in the inner speech condition may be the cause of impoverished phonemic processing during inner speech.

E20 Cortical Network for Sensorimotor Integration of Audio-Visual Speech

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On-line mimicking of audiovisual speech, also referred to as Speech Entrainment (SE), allows patients with Broca's aphasia to increase their speech output by a factor of two or more. This effect is not observed for on-line mimicking of auditory- or visual-only speech, which suggests the following: (1) motor commands for speech are relatively intact in Broca's aphasia, and (2) visual speech when combined with auditory speech provides crucial information allowing these patients to increase speech output. Previous functional imaging data from Broca's aphasics and healthy controls suggests that SE engages a gating mechanism in Broca's area that entrains (pulls along) a ventral-conceptual language network. Here, we investigate a complementary hypothesis – namely, SE improves speech production via activation of multiple dorsal stream (sensory-motor) pathways. In particular, audiovisual speech may activate visual-to-motor and/or somatosensory-to-motor pathways in addition to auditory-to-motor pathways, thereby boosting activation of preserved (but impoverished) motor speech commands. We have begun to explore this hypothesis by mapping sensory-motor speech networks in healthy subjects in the context of multimodal speech inputs. A typical auditory-motor integration imaging paradigm involves presenting subjects with blocks of auditory non-words in each of the following conditions: listening followed by covert rehearsal (L+Reh), listening followed by rest (L+Rest), and continuous listening (CL). The Motor phase of the task is isolated by the contrast L+Reh>L+Rest, the Sensory phase is isolated by CL>baseline, and the conjunction of the two contrasts identifies sensorimotor areas. In the current fMRI study, we asked whether using audiovisual (AV) stimuli as the input recruited different sensorimotor networks over auditory (A) stimuli alone. Nineteen subjects were presented with 6s blocks of L+Reh, L+Rest, and CL (along with rest blocks). It should be noted that for the AV condition, "listening" (e.g. in L+Reh) now also includes watching the concurrent visual speech gestures. Stimuli were 4-syllable sequences drawn from the following set of visually-distinguishable CV non-words: /ba/, /bi/, /tha/, /thi/, /va/, /vi/. Three runs each of the A and AV conditions were presented in random order. The current analysis compares activation across modalities (AV>A) in the Motor phase. We found that subvocally rehearsing speech presented in AV form (AV sensorimotor integration) recruited additional areas beyond those involved in rehearsing speech presented in A-only form, even when activations associated with the sensory phase of the two conditions were factored out (perceive+rehearse>perceive+rest). This "additional" AV sensorimotor network includes bilateral ventral occipital-temporal cortex, left posterior MTG, left somatosensory

cortex, and left primary motor cortex. We suggest that AV speech affords a distinct pathway to lower-level somatosensory speech targets and motor cortex speech codes, not directly accessible to auditory-only signals.

Orthographic Processing, Writing, Spelling

E22 Learning to read words and name novel objects: overnight changes to neural and behavioural responses

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There is great debate concerning whether neural systems are specialised for reading, or whether the same regions are engaged in other language tasks such as naming objects. Both word reading and object naming are learned visual-verbal associations. However, words contain systematic mappings between visual-verbal forms, e.g. the words cat and cap share both letters and sounds whereas the relationship between visual and verbal forms of objects is arbitrary – cats and caps don't look alike. A recent fMRI study (Taylor et al. in press) found that learning to read new words written in unfamiliar symbols induced greater activation in left parietal cortex, whilst learning names for novel objects induced greater activation in anterior fusiform gyri. These results suggest that left parietal cortex is important for reading words by translating individual letters into sounds, whereas left anterior fusiform represents whole items. Activity in left posterior fusiform did not differ for word reading vs. objects naming, which is at odds with arguments that this region is specialised for representing orthography (Dehaene & Cohen, 2011). Here we explore the impact of overnight consolidation on learning the systematic vs. arbitrary visual-verbal associations that are inherent in a novel writing system vs. novel object names. Computational accounts of learning suggest that offline consolidation helps to avoid 'catastrophic interference' between new and old knowledge for arbitrary mappings, whereas interference effects should be less apparent for systematic mappings (French, 1999; McLelland et al., 1995). Evidence for consolidation has come from overnight changes in behavioural and fMRI responses to newly-learned spoken words (Dumay & Gaskell, 2007; Davis et al., 2009). Thus, offline consolidation may be necessary for newly learned orthographic representations to resemble those of natural languages. We therefore combined the word/object learning paradigm from Taylor et al. (in press) with a train-twice, scan-once design from a previous fMRI study (Davis et al., 2009). We taught 25 participants to read 18 novel written words and 18 names for novel objects on two successive days prior to fMRI scanning of all items on Day 2. Thus, written words and object names learned on day 1 but not day 2 should be consolidated at the time of scanning. Participants viewed and read/named aloud trained and untrained items while BOLD signals were measured using sparse imaging. Reading/naming performance during scanning was better overall for words than for objects. However performance was equivalent for words learned on day 1 and day 2 (perhaps due shared systematic letter-to-sound mappings for both sets of words) whereas objects learned on day 2 were read more accurately than objects learned on day 1. Imaging data will be analysed to assess neural correlates of proficiency and consolidation of systematic and arbitrary visual-verbal associations with a particular focus on responses in parietal and fusiform regions believed to contribute to object naming and word reading.

E23 Distinctive effects of regularity and consistency in orthography-phonology mapping in a logographic writing system: An ERP study

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In alphabetic scripts, phonological regularity and consistency of print-to-sound mapping are not clearly separable. In contrast, these variables are operationally distinct in Chinese. About 80% of Chinese characters are phonograms, containing a semantic radical that provides a clue to the meaning of the character and a phonetic radical providing a clue to the pronunciation (e.g. □ zi2 'toe' has a semantic radical □meaning 'foot' and a phonetic radical □ zi2). The orthography-phonology mapping in Chinese can be characterized in terms of regularity defined as the congruence between the pronunciation of a phonogram and that of its phonetic radical, and consistency indexing the proportion of orthographic neighbors that share the same pronunciation as the phonogram. The distinction is evidenced by their independent effects and interaction based on behavioural measures of accuracy and response latency (Lee et al., 2005). Previous ERP studies, however, have focused almost exclusively on the consistency effect, and might have also confounded consistency with regularity (Lee et al. 2006, 2007; Hsu et al., 2009). In the current investigation, regularity and consistency were contrasted in an event-related potential (ERP) study using a lexical decision task and a delayed naming task with native Chinese readers. We predict that the two variables have different neural correlates. In particular, the regularity effect may emerge earlier and last longer than the consistency effect. This is because a skilled reader may be able to immediately segment the character into radical components and access the corresponding phonological forms, i.e. the whole character and the phonetic radical. The consistency effect appears only when the phonetic radical spreads activation to phonograms containing it. The phonograms then access their phonological representations, which compete with one another. The longer duration of regularity effects is the result of sustained activation by orthographic forms in the stimulus, which is not the case with consistency effects. ERP results showed that effects of regularity occurred early after stimulus onset and were long-lasting. Regular characters elicited larger N170, smaller P200, and larger N400 compared to irregular characters. In contrast, significant effects of consistency were only seen at the

P200 and consistent characters showed a greater P200 than inconsistent characters. Thus, both the time course and the direction of the effects indicated that regularity and consistency operated under different mechanisms and were distinct constructs. Additionally, both of these phonological effects were only found in the delayed naming task and absent in lexical decision, suggesting that phonological access was non-obligatory for lexical decision. In short, our findings differ importantly from alphabetic scripts in that regularity/consistency effects mainly occur in the N400 and late positive complex (LPC) (Rugg & Curren, 2007; Van Patten & Luka, 2012), and have thus captured a fundamental difference between logographic and alphabetic writing systems, that is, addressed phonology vs. inherently assembled phonology. Moreover, the comparison between lexical decision and delayed naming has demonstrated that access to phonological information from print is not automatic and subject to task demands.

E24 Neural language processing in musicians vs. nonmusicians: An investigation of the 'visual word form area' *Michelle D. Cohn[1,2], Laurel A. Lawyer[1,2], David P. Corina[1,2]; [1]Center for Mind and Brain, [2]University of California, Davis*

INTRODUCTION: In an effort to better classify how the brain processes visually-presented words, many researchers have focused on a small, yet functionally particular area of the left fusiform gyrus: the visual word form area (VWFA) (Cohen & Dehaene 2004). This region has shown to reliably activate when a person reads a word in a language they know, often yielding a left-lateralized activation for most alphabetic languages (Jamal et al. 2011, Bai et al. 2001). Certain types of scripts (e.g., logographic such as Chinese characters) and complex graphical forms such as musical notation have been shown to generate bilateral activity in the fusiform (Nelson et al. 2008, Tan et al. 2006; Wong & Gauthier 2010). This bilateral pattern of activation for music raises an important question: would experience with a musical notation system influence the typical left-lateralized VWFA activation pattern seen for English orthography? To explore this question, we conducted a neuroimaging (fMRI) pilot study. METHODS: Eight participants (4 untrained nonmusicians, 4 trained musicians) were recruited to participate based on their years of musical training (musicians x□=12.75, nonmusicians x□=0) and their language background (L1=English). The experiment used a block-design with three functional (EPI BOLD) runs, each consisting of nine blocks interleaved with a baseline fixation condition. Each block consisted of 10 stimuli (2s duration, 1s ISI) and randomly featured 0-2 consecutive repeats. Subjects were asked to indicate when they saw a repeat by means of a counterbalanced key press. In total, subjects saw 270 stimuli (90 words, 90 chords, 90 nonobjects). RESULTS: Both groups performed with a high degree of accuracy on the 1-back task (nonmusicians 100%, musicians 95.5%). Functional imaging data was preprocessed and statistically analyzed using SPM8. Using MarsBar, we additionally defined a region-of-interest (ROI) that included both the left (-44, -58, -15) and right fusiform (33, -67, -14) regions (10mm radius) based on meta-analyses of alphabetic (Jobard et al. 2003) and logographic languages (Bolger et al. 2005). Statistical analyses ($p<.001$, voxel threshold=10) revealed that musicians had bilateral VWFA activation for words (relative to fixation), while nonmusicans only showed activation in the left VWFA. Despite this difference in word processing, both groups had a significant ($p<.001$) bilateral VWFA effect for visual representations of nonobjects and chords (both relative to fixation). CONCLUSION: These results indicate that experience with musical notation systems might have an effect on word reading, even in a language that would normally prompt a left-lateralized activation (i.e., English). However the functional significance of this right fusiform activation is not understood. Our findings may have implications for language rehabilitation, potentially in using musical training therapy for patients with left-hemispheric damage to engage the right VWFA to process written language.

E25 Recycling the left fusiform gyrus for reading. *Ileana Quinones[1], Jon Andoni Duñabeitia[1], Manuel Carreiras[1,2]; [1]Basque Center on Cognition, Brain and Language (BCBL), Mikeletegui 69, 2°, 20009 Donostia-San Sebastian, Gipuzkoa, Spain, [2]IKERBASQUE, Basque Foundation for Science, Alameda Urquijo, 36-5, 48011 Bilbao, Bizkaia, Spain*

Reading is a learnt skill that entails structural and functional brain changes. Recent research has demonstrated that these changes involve the left inferior occipito-temporal region (the so called Visual Word Form Area [VWFA]). This critical region of the reading circuitry that becomes increasingly responsive to visual word forms with literacy acquisition has been suggested to develop from recycling a cortical territory evolved for object and face recognition (Dehaene et al., 2010). This theory is mainly based on studies with expert readers demonstrating that while the left ventral occipito-temporal cortex is highly responsive to printed words, the right occipito-temporal cortex is mainly active during the processing of faces (Fusiform Face Area [FFA]). In contrast, the same functional lateralization pattern does not seem to take place in novel readers and illiterates. The main goal of the current study is to explore the plausibility of the recycling hypothesis in a context where faces and words compete for the same resources. We combine fMRI and probabilistic tractography information to explore possible functional and anatomical interconnectivity between VWFA and FFA. Twenty-two healthy expert adult readers participated in this study. The stimulation set consisted of 46 high-frequency words superimposed on 46 famous faces and 46 pseudo-objects (objects created artificially that bear no explicit semantic information) superimposed on 46 strings of false fonts (FF). We also included additional conditions in which the stimuli were presented in isolation. Participants were instructed to detect if the same stimulus was presented consecutively (N1-back design), but they were asked to change the focus of attention between sessions. In half of the sessions participants were instructed to focus on the faces/objects and to ignore the words/FF, while in the other half they were instructed to focus on the words/

FF while ignoring the faces/objects. In addition, each participant completed an independent event-related localizer session to define face and word-selective regions for constraining the data analysis. Critically, we found a clear-cut difference in the response activation of these two regions when comparing responses to the stimuli presented in isolation and stimuli presented simultaneously. While face-selective regions did not show significant difference as a function of the presence or absence of superimposed words, the response pattern in word-selective regions was highly dependent on the presence or absence of superimposed images. Higher activation was found for words presented in isolation than for words presented with a superimposed image. Importantly, this competition effect was significantly greater when the superimposed image corresponded to a face as compared to an object. Anatomical and functional connections between these two regions were also explored, demonstrating a close structural and functional link between these two critical regions. These results demonstrate the existence of a tight relationship between these two well-differentiated areas, and suggest that in spite of the immutable nature of face-selective areas, which seem to be determined by phylogenetic heritage, word-responsive areas lack this invariable nature and are greatly influenced by the presence of competing visual objects that activate adjoining brain regions.

E26 Shared vs. specific brain activation changes in dyslexia after training of phonology, attention, or reading

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Whereas the neurobiological basis of developmental dyslexia has received substantial attention, only little is known about the processes in the brain during remediation. This holds in particular in light of recent findings on cognitive subtypes of dyslexia which suggest interactions between individual profiles, training methods, and also the task in the scanner. Therefore, we trained three groups of German dyslexic primary school children in the domains of phonology, attention, or visual word recognition. We compared neurofunctional changes after 4 weeks of training in these groups to those in untrained normal readers in a reading task and in a task of visual attention. The overall reading improvement in the dyslexic children was comparable over groups. It was accompanied by substantial increase of the activation level in the visual word form area during a reading task inside the scanner. Moreover, there were activation increases that were unique for each training group in the reading task. In contrast, when children performed the visual attention task, shared training effects were found in the left inferior frontal sulcus and gyrus, which varied in amplitude between the groups. Overall, the data reveal that different remediation programmes matched to individual profiles of dyslexia may improve reading ability and commonly affect the visual word form area in dyslexia as a shared part of otherwise distinct networks.

E27 Is there a connectivity deficit in poor readers?

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Introduction: Examining the relationship between distinct brain regions is needed to further our understanding of complex cognitive functions. Reading draws upon many distributed regions in the brain, and dyslexia has been hypothesized to be a disconnection syndrome – e.g. it develops as a result of abnormal connectivity patterns. However, few studies have investigated how functional connectivity patterns relate to reading outcome. This study examines the reading network in adult readers (typical and dyslexic) using task-based fMRI and resting-state fMRI. Methods: 42 monolingual English speakers were included in the analyses: 21 adults with dyslexia and 23 age, gender and IQ matched controls. Participants were assessed for IQ, reading, and phonological ability. They were scanned on a 1.5T Siemens Avanto MRI scanner with 40mT/m gradients and a 32-channel receive head coil. BOLD fMRI was acquired during a simple reading task (TE = 30 ms, flip angle = 85°, matrix size=64x64, FOV=24 cm, slice thickness = 2.5 mm, 1mm gap, number of slices=33; TR=2376 ms). Participants were presented with linguistic (40 words and 40 pseudowords) and non-linguistic (fixation and strings of symbols) stimuli and were asked to press a button after presentation. Structural T1-weighted 3D images were also acquired (flip angle = 15°; TR = 11 ms; TE = 4.94 ms; voxel size = 1x1x1mm; slices = 176). Lastly, a subset of these participants (19 controls, 19 dyslexics) also underwent 10 minutes of resting-state fMRI with same acquisition parameters as task fMRI. SPM8 was used for preprocessing and analyses of task fMRI. The CONN toolbox was used for rs-fMRI analyses. Results: The dyslexic group performed significantly worse on measures of reading accuracy, spelling, phonological processing, working memory and rapid naming. The groups did not differ on measures of IQ and reading comprehension. Task-based fMRI revealed a network of posterior brain regions for semantic reading conditions (words>symbols; words>fixation) and additional frontal regions for the phonological reading conditions (pseudowords>fixation; pseudowords>symbols), which are in line with previous literature (Richlan, Kronbichler, & Wimmer, 2009). Group differences were found for the left middle temporal gyrus (MTG), which showed greater activation in the controls than in the dyslexic adults during pseudoword reading (pseudowords>fixation). Activation in this region was positively correlated with pseudoword reading scores in both groups. Direct comparisons in resting-state functional connectivity further indicated group differences in the left MTG. Left inferior frontal gyrus (IFG) and left fusiform gyrus (FFG) were found to connect more strongly to the left MTG in the typical readers than in the dyslexic readers. The functional connectivity in these regions were correlated

with reading and phonological processing. In contrast, dyslexic readers showed increased connectivity between left FFG and right somatosensory regions in the parietal lobe, and this connectivity strength correlated negatively with pseudoword reading. Conclusion: Combining task-based and resting-state fMRI suggests that the reading deficits in dyslexia are related to deviant connectivity patterns of language regions in the brain. Interestingly, we also found overconnectivity in the poor readers, suggestive of compensatory mechanisms.

Phonology, Phonological Working Memory

E28 Exploring the added value of Spherical Deconvolution for reading-related white matter pathways

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Reading elicits a widespread network of activation in the brain, therefore it is essential to examine how these brain regions are connected with each other through white matter pathways. Diffusion Tensor Imaging (DTI) studies have shown that white matter organization in the left temporoparietal region is related to phonological aspects of reading. However, given that this region hosts many crossing fibers and given that DTI can only estimate one fiber direction per voxel, DTI lacks the sensitivity to determine which of the crossing tracts are driving the relation with reading. Spherical Deconvolution (SD) is a non-tensor model which enables a more accurate estimation of fiber directions in crossing fiber regions. Hence, we tested whether the observed relation with reading aspects is increased by applying SD relative to traditional DTI-analyses. In this study 71 children aged 5 to 6 years with a wide range of phonological awareness skills participated. DTI and SD tractography were applied to delineate three white matter tracts which all cross in the left temporoparietal region: left arcuate fasciculus, left corona radiata and corpus callosum splenium. Measures of degree of diffusion anisotropy, which indirectly informs about white matter organization, were extracted for each of the three tracts. In DTI this index was represented by fractional anisotropy, and in SD by quantitative hindrance modulated orientational anisotropy. DTI results showed that diffusion anisotropy in both the arcuate fasciculus and corona radiata were positively correlated to phonological awareness. In the SD results, diffusion anisotropy of only the arcuate fasciculus was significantly correlated to phonological awareness. In sum, the use of SD relative to traditional DTI tractography, increases the specificity of the relation between phonological aspects of reading and white matter organization in the left temporoparietal region, by limiting it to the arcuate fasciculus only.

E29 ERPs reveal automatic activation of speech variants in lexical tones processed below the level of awareness

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In alphabetic languages, speech sounds have been posited to be processed as abstract sound units (phonemes). But the actual realisation of speech sounds varies by context (e.g. allophones). Many current psycholinguistic models fail to account for processing of context- specific realisations. Moreover, very little is known about processing of lexical prosody. The present study investigated processing of masked lexical tone variants. ERPs were recorded from 24 native speakers of Beijing Mandarin as they read aloud words preceded by a brief (48 ms) masked prime. Mandarin has four lexical tones. Tone 3 (T3) has two realisations ('allotones'). T3 characters (=syllables) usually have a low contour (low T3). But when two T3 characters occur together, the first has a rising contour: tone sandhi. Moreover, Tone 2 (T2) also has a rising contour, making sandhi ambiguous with T2. The present study investigated whether the context-specific sandhi allotone in ignored primes facilitates naming of two-character T2 targets with matching rising contour, but mismatching tone category (match condition), compared to low-T3 primes, which mismatch in both (mismatch condition). Critical targets were 2-character words beginning with T2 (i.e. T2Tx). Primes were sandhi (T3T3) or low-T3 words (T3Tx). The initial character of the prime was identical between prime conditions. If differences are found between contour-match and mismatch conditions, this indicates activation of the context-specific rising contour. RTs: RT analysis was conducted using linear mixed effects modelling. No significant differences were found in RTs between conditions. EEG: Traditional methods of ERP analysis collapse over items, so that only by-subject (F1) and no by-item (F2) analysis is possible (no F', min F'; Consider the 'language-as-fixed-effect-fallacy', Clark, 1973; Coleman, 1964). The present data were analysed using Generalised Additive Mixed Modelling (GAMM) in R. Data from individual experimental trials were exported and analysed. Full random effects structure for subjects and items, as well as word-specific predictors (frequency) and change over the experiment (trial) were included in the model. The best-fit model revealed a significant smooth of prime over time ($p<.001$) and interaction of time, prime and target frequency ($p<.001$). Greater negativity for contour-match compared to mismatch primes occurred from 300ms-350ms. This was modulated by target frequency, with greater negativity for low-frequency items. The greater negativity found in the match, compared to mismatch condition indicates processing of the context-specific sandhi allotone, even in brief masked visual primes. Because initial characters were identical between conditions, this can only be due to the matching rising contour, not the tone category.

The timing of the effect is consistent with previous findings of sub-lexical phonological processing (e.g. Carreiras et al. 2009; Grainger et al. 2006). The effect was strongest for low-frequency targets. This probably reflects increased benefit from phonological overlap with greater processing difficulty. This last finding also suggests it is useful to account for word-specific characteristics in ERP research on language processing.

E30 Rhythmic pattern functions in syntactic structuring during sentence reading: An fMRI study

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Empirical studies have been conducted to uncover the brain correlates of interactions between phonological and syntactic information processing during speech comprehension (Sammler et al., 2010; Strelniko et al., 2005); a rare few did, however, concern with the neural mechanism through which phonology imposes constraints on syntactic structure in understanding written language. In Chinese, the rhythmic pattern, i.e., the combination of words with different syllabic lengths, could drive the change of syntactic word order. For instance, a disyllabic verb requires its object to be more than one syllable (Luo & Zhou, 2010) based on phonological rules, and also leads to the change of word order: a reversed object-verb order (OV) instead of the canonical verb-object order (VO) should be employed when this verb-object phrase (VP) is to modify a noun, forming a VP-noun compound. By manipulating the validity of VP-noun compounds with respect to rhythmic pattern and word order in written sentences, we investigated 1) the brain networks underlying the processing of rhythmic pattern and 2) the neural activities that may account for how the processing of phonological information modulates the build-up of syntactic structure during sentence reading. Twenty-one native Mandarin speakers underwent fMRI while reading sentences embedding a VP-noun compound. The VP-noun compound either carried a correct or a violated rhythmic pattern on the VP (disyllabic verb-disyllabic object, i.e. [2+2] / disyllabic verb-monosyllabic object, [2+1]), while at the same time was either sequenced in a correct or a violated order (OV / VO). Participants were required to rate the comprehensibility of each sentence, which was presented segment by segment. Online comprehensibility ratings showed the main effects of both rhythmic pattern and word order, suggesting that both violations could lead to difficulties in reading comprehension. Although the online comprehensibility score did not reveal an interaction between the two factors, the offline grammaticality rating did show such an interaction. This discrepancy suggests that there may be additional psychological and neural processes that serve to recover the mismatch and achieve normal comprehension. At the neural level, we found that the processing of rhythmic pattern recruited a bilateral neural network similar to that observed for prosodic processing in listening tasks. Effective connectivity analysis further revealed that the rhythmic pattern (correct vs. violated) modulates the connectivity from the primary visual cortex to the bilateral superior temporal cortex. This may indicate a pathway for transferring visual inputs into phonological information during sentence reading. Moreover, the violation of word order induced an increase of activation in left inferior frontal gyrus only in sentences with correct rhythmic pattern, but not in sentences with violated rhythmic pattern, which is considered to evidence the modulation of syntactic structuring by the information of rhythmic pattern in compound processing. Taken together, we suggest a common bilateral neural network responsible for the processing of prosodic features in both written and spoken language processing. Moreover, the rhythmic pattern may modulate the syntactic structuring by weakening the reanalysis of violated word order when the rhythmic pattern also needs repair.

E31 Phonotactic violations and case violations activates the left inferior frontal gyrus

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The structured sequence processing perspective on language describes common aspects of processing of language, musical and action sequences. For instance, syntactic structure across sequences of word or word categories enables prediction of e.g. the case of words further down the sentence. When presenting violations to sequential regularities in natural or artificial syntax, a common finding is left inferior frontal gyrus (LIFG) activation, indicating the involvement of LIFG in structured sequence processing. However, to our knowledge, only one FMRI-study (Nieuwland, 2011) investigated activity by (Basque) case violations and did not find LIFG activation. In phonology, especially its sub-domain phonotactics, there is structure in phoneme and syllable sequences. So far, one FMRI-study (Vaden, 2011) investigated their brain level substrate using a phonotactic frequency manipulation. High (spill, probe) vs. low (sneak, jolt) phonotactic frequency activated the anterior LIFG. The present FMRI-study (we present results from the first 12 out of 24 planned participants) manipulates syntactic case and phonotactics at the sentences final noun phrase of sentences with high cloze probability. Across participants, the same German sentences appeared in one of three conditions: correct, syntactically incorrect (using a case violation on the sentence final noun phrase) and phonotactically incorrect (using a phonotactically illegal sound cluster in the sentence final word). A pilot study (N=5) indicated that both phonotactic and syntactic violations would activate the LIFG in at least one of three regions of interest (ROIs): the pars opercularis, the pars triangularis and the pars orbitalis. Neither of the two main effects: syntactically incorrect vs. correct and phonotactically incorrect vs. correct generated any significant clusters at FWE correction 0.05 on the whole brain level. In our planned ROI-analysis with a focus on LIFG, the syntactic violations activated pars triangularis while the phonotactic contrast activated pars opercularis and pars triangularis. Our results show that phonotactic violations

and syntactic case violations activate LIFG, which is expected from the point of view that LIFG is involved in structured sequence processing in natural language. In our design which controlled for the exact lexical items used, phonotactic violations resulted in activation in the posterior LIFG. In Vaden (2011), phonotactic frequency activated the more anterior parts of LIFG, for high vs low phonotactic frequency. The degree of lexical control, or alternatively our violation (rather than frequency) manipulation, might have caused the differences. In any case, together, these two studies provide a basis for the study of phonotactic representation in LIFG. Since both our phonotactic violations and syntactic case violations activate LIFG at the group level, our paradigm provides a good test bed for investigating neural representation of syntax and phonotactics in LIFG at the single subject level. The single subject approach might increase sensitivity when testing for functional specialization.

Language Development, Plasticity, Multilingualism

E32 An investigation of automatic Chinese phonological activation during English word reading in Chinese-English bilinguals

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When Chinese-English bilinguals read English words they spontaneously activate the corresponding Chinese translations (e.g., Zhang et al., 2010). Brain potentials have further revealed that Chinese-English bilinguals activate the sound rather than the spelling of the Chinese translations (Thierry & Wu, 2007; Wu & Thierry, 2010). The phonological component of Chinese words consists of syllable segments (consonants and vowels) and lexical tone. It is, however, unclear whether the segmental (S) and/or tonal (T) information of the Chinese words becomes available when Chinese-English bilinguals read their English translations. To investigate this, a behavioural and an ERP experiment were conducted with two groups of Chinese-English bilinguals. The experiments involved a semantic relatedness judgment task with English word pairs (prime-target) in which the repetition of segmental (S) and tonal (T) information of the concealed Chinese translations (i.e., the first character of Chinese translations for the English words) was systematically manipulated in semantically and orthographically unrelated word pairs. The behavioural experiment involved 4 counterbalanced lists in which the second word (target), e.g. place [□□(di4dian3)] was preceded by 4 different primes to create four conditions: repeated segment and tone (+S+T), e.g. empire [□□(di4guo2)], repeated segment (+S-T), e.g. enemy [□□(di2ren2)], repeated tone (-S+T), e.g. author [□□(zuo4zhe3)], and a control condition with no repeated segment and tone (-S-T), e.g. aspect [□□(fang1mian4)]. The design of the ERP experiment involved different target words across the same 4 experimental conditions: +S+T e.g. media-rose [□□-□□(mei2ti3-mei2gui4)]; +S-T e.g. mail–humour [□□-□□(you2jian4-you1mo4)]; -S+T e.g. black-editor [□□-□□(hei1se4-bian1ji2)]; -S-T e.g. card-frog [□□-□□(ka3pian4 -qing1wa1)]. Stimuli of both experiments were selected from a large translation study (N=14) with 1429 English words and an off-line semantic rating study (N=20) with 450 word pairs. All conditions in both experiments were carefully matched in terms of word frequency and length. Unlike Wu and Thierry (2010), who did not find any behavioural evidence of the activation of Chinese sounds, the behavioural experiment (N=32) revealed a trend towards a repeated Chinese tone effect (30 ms inhibition; $p < .08$). In line with the behavioural results, preliminary analyses of difference waves in the ERP experiment also revealed that the repeated tone is the major contributor of the modulation in N400 component, which is an index of the phonological repetition priming effect. The current findings suggest that Chinese tonal information becomes available when Chinese-English bilinguals read English words.

E33 Learning to read a logographic writing system as a second language: An ERP study of L2 Chinese proficient readers

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For native readers of alphabetic scripts, learning to read a logographic system such as Chinese is challenging. This is not only because Chinese characters look drastically unlike from words in alphabetic scripts, but also because mappings between orthographic and phonological units in the two systems are different. In this study, we investigated two measures of orthography-phonology mapping-- phonological regularity and consistency-- in relatively proficient late-acquired second language (L2) readers of Chinese in lexical decision (LD) and delayed naming (DN) tasks. Most Chinese characters are phonograms, which have a phonetic radical that carries phonological information. Regularity in these phonograms is defined by the congruence between the pronunciation of a phonogram and that of its phonetic radical. Consistency is the extent to which the pronunciation of the phonogram is shared by other phonograms with the same phonetic radical. A recent study has shown that in native Chinese readers, regularity and consistency produced divergent effects in behavioral measures as well as event-related potentials (ERPs) (Yum et al., 2014). Native readers showed regularity effects at the N170, P200, and N400 components, and consistency effects at the P200 component. These effects were only observed in DN, and were not present in LD. The current study aimed to examine the sensitivity of L2 Chinese readers to regularity and consistency effects in DN and LD. Participants were native readers of alphabetic systems who acquired L2 Chinese after age 5 with a reading level at or above grade 4 in Hong Kong. Similar to native Chinese readers of grade 4 reading level, L2 participants were faster to respond to and more accurately named regular than irregular phonograms, but did not show significant consistency effects behaviorally. ERP effects

of regularity were found to begin at the P200 component, with irregular phonograms generating a greater positivity over the right hemisphere in LD compared to regular phonograms. Irregular phonograms also elicited diminished N400 in DN and enhanced late-positive component (LPC) in both tasks. In contrast, inconsistent phonograms elicited enhanced N400 in LD and attenuated LPC in both tasks relative to consistent phonograms. The regularity effects were consistent with previous reports, suggesting that L2 readers accessed the pronunciation of the phonetic radical, which created interference with the whole character pronunciation and lexico-semantics. L2 readers also processed the neighborhood characteristics of the phonetic radicals, although consistency effects emerged after regularity effects, possibly because regularity is inherent in a character's orthography, but consistency is derived from the activation of phonological forms of its orthographic neighbors. The different directions and time courses of the effects supported that even in late-acquired L2 Chinese readers, regularity and consistency were distinct mechanisms of orthography-phonology mapping. Relative to native readers, both regularity and consistency effects appeared at slightly later components, reflecting lower efficiency in character processing in L2. Moreover, unlike native readers, L2 readers showed phonological effects in lexical decision, suggesting that less skilled readers may access phonological representation of the character to support lexicality judgment.

E34 Functional Connectivity Related to Chinese Lexical Tone Discrimination: A Comparison of Participants with Continued versus Discontinued use of Chinese *Lara Pierce[1], Denise Klein[2], Jen-Kai Chen[2], Martha Shiell[2], Fred Genesee[1]; [1]McGill University, [2]Montreal Neurological Institute*

For humans, the first year of life is thought to be a period of optimal development during which infants form the sound categories of their native language (e.g., Kuhl et al., 2005). In the case of internationally-adopted (IA) children, however, this period is disrupted as children are exposed to one language from birth before they are adopted into families whose language differs. Previous research in our lab has shown that native language representations persist in the brain despite the fact that IA children get no subsequent input in that language. However, there are clearly differences in the experiences of IA children who are exposed to a language from birth, discontinue that language, and learn a second first language, as compared to children who are exposed to a new language after a similar delay, but retain their original language (i.e., young second language (L2) learners). Namely, L2-learners go on to become proficient users of their birth language. In the present study we were interested in whether these different experiences lead to activation of distinct networks of functional connectivity when performing a task in the birth language, even if regions of peak activation were similar. To test this, we scanned 3 groups of 9-17 year old participants using BOLD fMRI (n = 10 per group): (1) IA participants from China who were adopted into French-speaking families (mean age of adoption: 12.8 months) and now speak only French; (2) children who learned Chinese from birth, but began learning French as an L2 at the same age as the IA participants, and now speak Chinese and French; and (3) French monolingual children who were exposed to French from birth and had never been exposed to Chinese. While in the scanner, participants made same/different judgments of pairs of auditory three-syllable phrases composed of Chinese pseudo-words that were either identical or varied on the final syllable in terms of lexical tone information only. Lexical tone carries meaning in Chinese, but not French, meaning that IA participants would only have been exposed to this linguistic element prior to adoption. A previous analysis revealed that IA children and Chinese/French L2-learners activated left superior temporal gyrus (STG)/planum temporale (PT) in response to lexical tone, while French monolinguals did not. In order to determine whether this region was functionally connected to other brain regions and whether this was similar or different across groups, a psychophysiological interactions (PPI) analysis was performed using left PT as a seed region. This analysis determines regions that are co-activated with the seed region only while the task is performed, and implies a functional relationship of these regions during task performance. Results showed that left PT was functionally connected to parietal regions for both the IA children and L2-learners. However, the L2-learners showed greater functional connectivity than the IA participants between left PT and left inferior frontal gyrus. This likely reflects the fact that these L2-learners currently speak Chinese and begins to tease apart the effects of early exposure to, versus continual use of a language.

E35 6-month-olds do not get stressed by stress *Claudia Teickner[1], Angelika C. Becker[1], Claudia K. Friedrich[2]; [1]University of Hamburg, [2]University of Tübingen*

Separate networks for processing phonemes and prosody in speech recognition appear to be sequentially shaped during the first year of life. Recently we showed that six-month-olds focus on phoneme overlap, but neglect stress overlap in word onset priming. Here we investigated the processing of phonetic detail (place of articulation) in stress overlapping and non-overlapping prime-target pairs. We recorded event-related potentials (ERPs) while infants listened to single syllables (primes) followed by complete German words (targets). Common disyllabic words, frequently used in caregiver-infant interactions, were chosen from an early words screening inventory (German version of the McArthur Communicative Development Inventories) and parental questionnaires. The prime were either stressed or unstressed first syllables of German words, presented in three conditions. In an identity condition, primes matched the onsets of the target words (e.g., ma – Mama). In a variation condition, primes deviated from targets in their initial place of articulation (e.g., na – Mama). In a control condition, phonemes of primes and targets differed completely (e.g., vo – Mama). We tested adults and six-month-olds. For adults, complete match and variation differed for stressed, but not for unstressed primes. This suggests

that adults rapidly integrate phonemes and prosody and that stress triggers more detailed phoneme processing. For infants, complete match and variation differed for both stressed and unstressed primes. This confirms the assumption that phoneme processing is selectively shaped half a year after birth.

E36 Acquisition of novel morphosyntax by language learners: an EEG study *Alina Leminen[1,2], Laura Hedlund[2], Lilli Kimppa[2], Suzanne Hut[2], Yury Shtyrov[1]; [1]Aarhus University, [2]University of Helsinki*

Whereas most of language-learning research is focused on acquisition of novel lexemes, little is known about how our brain goes about learning new grammatical information. To investigate the acquisition of novel morphosyntax, we presented second-language (L2) learners and native (L1) speakers of Finnish with a balanced set of real inflected (e.g., kuva-sta – 'from picture') and derived (e.g., kuva-sto – 'catalogue') words that were contrasted against non-existing combinations of stems and affixes (e.g., *kuva-la – 'picture place'). Acoustically similar pseudowords (e.g., *kuva-lo, *kuva-spa) were used as a control. We recorded high-resolution EEG in a passive multifeature paradigm, an established tool to probe automatic linguistic processing in the brain. L1 speakers showed a characteristic syntactic ERP pattern – an increased deviant response to novel stem-affix combinations, which was reduced in L2 learners. L1 speakers also replicated a recently found morphological ERP pattern (cf. Leminen, Leminen, Kujala & Shtyrov, 2013, Cortex) that showed stronger responses for derived words (e.g. kuva-sto) than for inflectional words (e.g. kuva-sta). This pattern demonstrates the existence of word-specific memory traces for derived words. Interestingly, L2 learners showed a reversed effect, suggesting that they do attempt syntactic parsing of inflected words but do not have automatic access to memory traces for derived words, even for frequent familiar items. Furthermore, native speakers demonstrate that novel but meaningful derivations are also processed through a syntactic-parsing route, rather than whole-form access. These preliminary results suggest that parsing takes place early on in course of L1 and L2 word learning, and even L2 learners seem to be able to automatically parse complex words into their constituents. However, even when they have acquired basic knowledge of lexemes and morphosyntactic combinations, they have not yet developed memory traces for derived words, unlike L1 speakers. The results suggest a flexible and dynamic switching between segmentation and holistic access of novel complex words in the process of their acquisition in both native and foreign languages.

E37 Structural property of the left arcuate fasciculus as an indicator of individual syntactic abilities in a second language *Kayako Yamamoto[1,2], Kuniyoshi L. Sakai[1,2]; [1]Dept. of Basic Sci., Grad. Sch. of Arts and Sci., Univ. of Tokyo, Tokyo, Japan, [2]CREST, Japan Science and Technology Agency, Tokyo, Japan*

The arcuate fasciculus in the left hemisphere has long been believed to play an important role in language processing. In the present study, we examined whether the differences in structural property of the tract reflect individual linguistic abilities, especially in a second language (L2). Using diffusion magnetic resonance imaging with an objective method to set regions of interest (ROIs) in the arcuate fasciculus, we quantified the two metrics: thickness and fractional anisotropy (FA). FA represents the diffusion anisotropy in a voxel, reflecting the property of fiber bundles, such as fiber organization and myelination. In Experiment I, we examined whether any structural property of the arcuate fasciculus was correlated with syntactic abilities in L2. In Experiment II, we recruited monozygotic twins to examine whether individual differences in L2 performance, as well as those in structural property of the tract, were determined by shared/non-shared factors. In Experiment I, native Japanese speakers (age: 16–17) participated, and performed two error–detection tasks in L2: an English syntactic task (Syn) and an English spelling task (Spe). To ensure the basic knowledge in English, 26 participants who correctly answered more than 80% of Spe were included in the analyses. After the arcuate fasciculus in each hemisphere was reconstructed, we objectively selected a 20-mm-long ROI at the most straight part of the arcuate fasciculus, thereby excluding the branching or curved parts of the tract that differed significantly among the participants. In the ROI, mean FA and thickness were obtained. We found that FA in the left arcuate fasciculus significantly correlated with the accuracy of Syn. Neither FA in the right hemisphere nor thickness in either hemisphere was correlated with the accuracy of Syn. These results demonstrate that structural property, FA, of the left arcuate fasciculus indicates individual syntactic abilities in L2. In Experiment II, twelve pairs of monozygotic twins (age: 16–17) performed Spe and Syn tasks. Individuals of each twin pair showed significantly correlated performances for reaction times (RTs) and the accuracy in the Spe task ($r > 0.84$). As regards the Syn task, RTs were significantly correlated within twin pairs ($r = 0.77$), while the correlation of the accuracy was not significant ($r = 0.64$, corrected $p > 0.05$). Moreover, the mean thickness within each ROI (as in Experiment I) of the left arcuate fasciculus was significantly correlated within twin pairs ($r = 0.79$), while the correlation of mean FA was not significant ($r = 0.33$). These results indicate that thickness of this tract was determined by genetic and/or environmental factors shared within twin pairs, while FA was more influenced by the non-shared environmental factors. Taken these experiments together, we conclude that individual syntactic abilities in L2 were determined by non-shared environmental factors, partially mediated by structural property, FA, of the left arcuate fasciculus.

E38 How Gender, Handedness, and L1 Processing Strategy Influence L2 Grammatical Processing *Emma Wampler[1], Judith McLaughlin[1], Lee Osterhout[1]; [1]University of Washington*

Models of second language acquisition suggest that learners progress from lexical processing of grammatical errors in their second language (L2) to grammaticalizing the rule and relying on automatic syntactic processing. However, recent research has suggested that even for native speakers and highly proficient language learners, the type and magnitude of event-related potential (ERP) responses to syntactic violations is not as uniform as previously believed (Tanner and van Hell 2014). We investigated factors that influence L2 grammatical processing by examining L2 learners' ERP responses to grammatical errors. The ERP response to L2 linguistic errors (N400- or P600-dominant) was quantified by comparing the magnitudes of the two effects, using the response dominance index (RDI; Tanner et al., 2013, 2014); the RDI is a continuous scale ranging from N400 dominant to P600 dominant. Our participants were 20 L1 English speakers in their second year of French (L2) instruction. Participants read grammatically well-formed and ungrammatical sentences in their L1 and L2, where the critical verbs in the ungrammatical sentences were in the incorrect verbal person. RDI values were separately calculated for the L1 and L2 sentences. Participants showed striking individual differences in their brain responses to grammatical violations in both languages, with some showing primarily an N400 effect and others showing primarily a P600 effect (cf. Tanner & Van Hell, 2014). For the French (L2) sentences, women showed greater P600 dominance than men. This result is consistent with prior evidence that females learn a second language more quickly and achieve higher proficiency than do male learners (Chavez 2001, Gu 2002, Kissau 2006). Although Tanner & Van Hell reported that L1 RDI values are predicted by familial sinistrality, no such relationship was found here for either language. Finally, participants' English RDI was unrelated to their French RDI, suggesting that early in the learning process, an individual's ERP response dominance in their native language does not predict the dominance for their second language. It remains to be seen whether this relationship would change as more learning takes place, and whether learners' L2 RDI would more closely resemble the RDI of their native language if they were to attain native-like proficiency in their L2.

E40 Effects of age of acquisition (AoA) and proficiency on processing of syntax in 6- to 8-year old monolingual and bilingual children: an ERP study

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Even though language proficiency in children is strongly related to success in almost all domains, neurocognitive studies of L2 processing are typically limited to adults with several years of exposure, who may use general cognitive mechanisms to compensate for any difficulties in L2 processing. For example, whereas previous studies of adult bilinguals have reported differences in the anterior negativity elicited by syntactic violations with delays in exposure to English of less than 3 years (Weber-Fox & Neville, 1996) a precursor to the anterior negativity has been reported in monolingual children as young as 2.5 years of age (Oberecker, et al., 2005). In the current ERP study, processing of English phrase structure was explored in 6- to 8-year old monolingual and bilingual children who acquired English as a second language around 4 years of age. Monolingual children of higher proficiency displayed relatively mature processing of phrase structure violations as indicated by a left anterior negativity over lateral sites and a posterior positivity. High-proficiency bilingual children tended to display a medial anterior negativity and a posterior positivity. The difference in distribution of the anterior effect across groups could only be explained by AoA. However, lower proficiency affected the posterior ERP effect and amplitude of the anterior effects in response to syntactic violations. These results suggest that the more automatic syntactic processing in children is affected by AoA while more controlled, metalinguistic processing may be related to language proficiency.

E41 Today read she the paper: An ERP study of the processing of word order in Swedish as a second language

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There is ample evidence that word order is a problematic domain in second language (L2) usage, in particular the production of verb-second (V2, i.e., a finite verb in second position in main clauses; e.g., Ganuza, 2008 for an overview). This difficulty is only partially modulated by L1 background. In Swedish, a further complication for L2 users is that even native speakers occasionally produce V2 violations depending on the preposed adverbial (e.g., Bohnacker, 2006). Despite this body of research, we know very little about how these structures are processed. We therefore examined how advanced German (n=14) and English (n=14) adult learners, matched for proficiency and age of acquisition (AoA), process word order in Swedish compared to native speakers (n=20) depending on language background (L1 with [German] or without [English] V2), preposed adverb frequency (frequent idag 'today' vs. infrequent hemma 'at home'), and length of the preposed constituent (short vs. long prefield), the latter two factors being relevant to processing. We examined responses to word order violations in an acceptability judgement task and an ERP experiment, and probed the production of word order in a sentence completion task. Preliminary results from the acceptability judgement task indicated that native speakers were faster and more accurate on judging sentences than both L2 groups who did not differ. The more frequent adverb, idag, also affected accuracy and reaction times positively in all groups. The sentence completion task showed similar results. In contrast, the ERP data displayed different patterns. In native speakers V2 violations elicited a bimodal ERP response, an anterior negativity followed by a posterior P600. These effects were increased in amplitude and the anterior negativity was left lateralized (LAN) with long prefields. In the German group a bimodal response was detected only when V2 violations followed a frequent adverb in a long prefield. In other cases only a posterior P600 was evident. The English group, in contrast, showed an early anterior

positivity, and a lateral parietal negativity in the N400 time window that was followed by a posterior P600. The amplitude of responses was affected by prefield length only. Overall, the results indicated that, although the advanced German and English L2 users performed similarly on behavioural measures of comprehension and production of word order, they nevertheless differed in online processing. Language background mattered: the German learners, whose L1 share V2 with target Swedish, showed similar ERP patterns to native speakers overall. In contrast, the English learners, whose L1 does not share V2, showed more variation in their ERP responses. We discuss the implications of these findings for theories of crosslinguistic influence and theories of nativelike syntactic processing.

E43 Tracking sensitivity to L2 morphosyntax: Evidence for the role of the L1 from two longitudinal studies of early learners

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Several proposals on second language acquisition in the ERP literature argue for a similar starting point for the processing of all morphosyntactic structures: at the initial stages, all morphosyntactic violations should elicit either no effects (Steinhauer et al. 2009; McLaughlin et al. 2010) or an N400 (McLaughlin et al. 2010, see also Ullman, 2005). At later stages, different structures may transition to the P600, a native-like response, at different rates. In contrast, theories of transfer predict different starting points for different linguistic properties depending on the inventory of features in the L1 and L2 (e.g. Schwartz and Sprouse, 1996). Under the transfer proposals, features that are shared by the L1 and L2 may show evidence of a P600 from the earliest stages of acquisition. The present study examines the role of the L1 in the processing of gender and number agreement in English-speaking learners of Spanish, tracking development in two longitudinal studies. In Study 1, first-year learners of Spanish were tested in three sessions: after two months, six months, and eight months of instruction (n=23). In Study 2, second-year learners of Spanish were tested in two sessions: after two months and six months of second-year instruction in Spanish (n=10). The experiment targeted three types of agreement: number agreement on verbs, which is similar in Spanish and English (ex. La pasajera-SG brasileña desembarca-SG/ *desembarcan-PL en San Diego. 'The Brazilian passenger disembarks at San Diego.'); number agreement on adjectives, which is a feature shared by the two languages, although it is instantiated differently in the L2, and gender agreement on adjectives, which is unique to Spanish (La biblioteca-FEM.SG es moderna-FEM.SG/ *modernas-FEM.PL/ *moderno-MASC.SG y la escuela también. 'The library is modern and the school too.') Results for the Spanish native controls (n=12) revealed reliable P600s for all violation types. For first-year learners (Study 1), a small positivity emerged in midline electrodes for number violations on both verbs (1b) and adjectives (2b) across sessions. However, after sessions two (six months) and three (eight months), this positivity evolved into a more broadly distributed, canonical P600, which was significant at both the midline and lateral regions, although the effect was only numerical for number violations on adjectives after eight months. Gender violations did not yield any effects at any point. For second-year learners (Study 2), a positivity emerged in the posterior region for both subject-verb agreement violations and number violations on adjectives in the first session and remained stable in the second session, with the effect for subject-verb agreement becoming more positive. Similar to Study 1, gender violations did not yield significant effects at any point. The results show that it is possible to observe effects related to grammatical processing for features shared between the L1 and L2 even after very little exposure to an L2. This result is in line with theories of transfer and is inconsistent with approaches that assume a uniform starting point (N400, no effects) for the processing of all morphosyntactic structures.

Lexical Semantics

E44 Surface-based searchlight mapping of modality-independent responses to semantic categories using high-resolution fMRI

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Previous studies have shown the possibility to decode the semantic category of an object from the fMRI signal in different modalities of object presentation. Furthermore, by generalizing a classifier across different modalities (for instance, from pictures to written words), cortical structures that process semantic information in an amodal fashion have been identified. In this study we employ high-resolution fMRI in combination with surface-based searchlight mapping to further explore the architecture of modality-independent responses. Stimuli of 2 semantic categories (animals and tools) were presented in 2 modalities: photographs and written words. Stimuli were presented in 40-seconds blocks with 10-seconds intervals. Subjects (N=3) were instructed to judge whether each stimulus within a block was semantically consistent with the others. The experiment also included 8 free recall blocks, in which name of a category appeared on the screen for 2 seconds, followed by 40 seconds of a blank screen. In theses blocks subjects were instructed to covertly recall all entities from the probed category that they had seen during the experiment. Subjects were scanned with 7 Tesla MRI-scanner, using 3D EPI sequence with isotropic resolution of 1.5 mm. In each subject, reconstruction of cortical surface was performed. After that, for each vertex on the surface, a set of adjacent voxels in the functional volume was assigned. Subsequently, a linear support vector machine classifier was used to decode object category in each surface-based patch. Generalization analysis across picture and written word presentation was performed, where the classifier was trained on the fMRI data from blocks of written words, and tested on the data from

picture blocks, and vice versa. The second analysis was performed on the free recall blocks, where the classifier was trained on merged data from pictures and written words blocks, and tested on the free recall blocks. Further, we explored how the decoding accuracy in the inferior temporal cortex changes with the diameter of the searchlight patch. Since surface-based voxel grouping takes into account the cortical folding and ensures that voxels belonging to different gyri do not fall in the same searchlight group, it allows answering the question, at what spatial scale is the modality-independent information is represented. The cross-modal analysis in all three subjects revealed a cluster of voxels in inferior temporal cortex (lateral fusiform and inferotemporal gyri) and posterior middle temporal gyrus. The topography of significant clusters also suggested involvement of the inferior frontal gyrus, lateral prefrontal cortex, and medial prefrontal cortex. Interestingly, these areas were the most evident in the free recall test, although the searchlight maps of the three subjects showed substantial individual differences in this analysis. Overall, the data yield a similar picture as previous research, highlighting the role of IT/pMTG and prefrontal cortex in the cross-modal semantic representation. We further extended previous research, by showing that the classification accuracy in these areas decreases with the increase of the searchlight patch size. These results indicate that the modality-independent categorical activations in the IT cortex are represented on the spatial scale of millimetres.

E45 Language and perception: Hemispheric involvement in the Whorfian effects of color labels

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Introduction: Hemispheric asymmetry for language has implications for the debate on whether language affects perception. Gilbert et al. (2006) showed that the faster discrimination of two colors that fall on either side of a lexical boundary (green and blue), than of two colors that fall within one lexical category (light blue and dark blue), occurred in the right visual field/left hemisphere (RVF/LH) and not in the LVF/RH. This has been replicated and the conclusion drawn that language affects perception in the LH and not in the RH. All of the previous studies used a paradigm which doesn't optimally reflect hemispheric differences, and the lateralization of the stimuli in these studies is questionable. Because the RH also has access to linguistic resources, we tested the hypothesis that the RH is able to perform a categorical judgment independently of the LH. Methods: We used a divided visual field paradigm and manipulated the need for inter-hemispheric transfer of visual stimuli (unilateral vs. bilateral displays) and motor responses (left vs. right hand). This allowed us to examine conditions where no information transfer between the hemispheres was necessary, versus conditions requiring transfer of a motor command, versus conditions requiring transfer of visual information. The task was to decide if two color stimuli were "same" or "different". There were three interference conditions: none, verbal, non-verbal. Results: In the conditions that didn't require callosal transfer, we found a larger CP effect in the RVF/LH than in the LVF/RH. Importantly, there was a significant categorical effect in the RH 'pure' condition, suggesting that this lexical effect on color perception occurs in the RH independently of the LH. With verbal interference, the categorical effect remained only when the LH was not involved, suggesting that the LH performed the interference task and this erased the lexical effect in color perception; Non-verbal interference had no effects. The necessity of transferring visual or motor information resulted in differing patterns in the two VF/hemispheres. For the LH, the category effect was larger when the RH was not involved in any way. For the RH, the size of the effect depended on the type of information that was transferred. When the RH saw both stimuli, but the LH controlled the response hand, the CP effect was small and insignificant. However, when the LH was involved in the decision itself, by receiving one of the stimuli to be compared, the CP effect was actually larger than when the RH saw both stimuli and could make the decision independently. This suggests that even though the RH can utilize lexical labels on its own, the CP effect is enhanced when the LH is involved in the perceptual decision. Conclusion: We replicated the "Lateralized Whorf" effect in Hebrew speakers by utilizing a paradigm in which lateralization of the stimuli and of the response can be well controlled. We showed that the largest CP effect occurs when the LH is involved in the perceptual judgment, but that the CP effect cannot be attributed to exclusive LH abilities.

E46 MEG-derived neural oscillatory activity differentiates sentence processing from word list processing in theta, beta, and gamma frequency bands across time and space

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Oscillatory brain activity may provide a good tool for capturing language processes that are not strictly time- and phase-locked. Here, we used magnetoencephalography (MEG) combined with frequency domain beamforming to explore the spatiotemporal dynamics of oscillations in sentence processing. We measured MEG from 102 subjects while they read sentences (Sent) and word lists (List; scrambled sentences) word-by-word. Neural oscillatory activity at frequencies in the theta and beta bands (4 – 7.5 and 13 – 30 Hz, respectively) has been suggested to be involved in sentence processing. Here we explored this large data set and analysed a wide frequency range from 2.5 to 100 Hz. For each condition we analysed the time-frequency response from -0.15 to 0.5 s around the onset of each word, with a mean of 950 words per condition (across subjects). Subsequently we averaged the data across all words, independently for each subject. We computed the difference between conditions across subjects, and used a non-parametric permutation test for statistical inference. We observed Sent < List ($p < 0.001$) in the theta and beta bands (centred at 7.5 and 16 Hz, respectively), between

0.3–0.5 s after word onset. Effects in both frequency bands localised to the bilateral occipito-parietal and left frontal cortices; only theta localised to the middle temporal cortex. In the gamma band, we observed Sent > List ($p < 0.001$) at 40–60 Hz and 80–90 Hz. These effects localised to left occipital, parietal, frontal, and middle/superior temporal cortical areas, and varied in time for each region. Our results revealed a number of regions that include and extend beyond the classical language areas. The differences found in bilateral parietal areas may be related to working memory, attention or a deactivation of the default mode network; functions that all have been linked to these areas and that are important in sentence reading. The more classical effects found in the left temporal and frontal areas between conditions are in line with the prediction of the Memory, Unification and Control model (Hagoort, 2005, 2013), relating these areas to lexical-retrieval and unification, respectively. Together, these findings suggest a dynamic network of sentence processing that can be captured by brain activation that is not strictly time- or phase-locked, in both classical and non-classical regions. Further research will be needed to clarify, in more detail, the functional properties of oscillations at the different frequencies.

E47 Semantic category fluency performance is correlated with regional brain volume in older adults

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Several studies have shown that individuals with Alzheimer's disease (AD) perform worse on neuropsychological tests that involve living items than on tests that involve non-living items, suggesting that there is a category-based dissociation in the representation of semantic information in the brain. Indeed, functional neuroimaging and behavioral studies implicate brain circuitry involving the lateral portion of the fusiform gyrus and the posterior superior temporal sulcus in the processing of living or animate objects compared with non-living or inanimate objects. Dissociations between category representations in the brain are studied typically with lexical naming and comprehension tasks. The purpose of the current study was to examine whether performance on generative tasks of semantic fluency involving living and non-living categories is associated with regional brain volume in non-demented older adults. A subset of non-demented older right-handed individuals (mean age = 79.5) with available magnetic resonance imaging (MRI) and neuropsychological data (n = 111) from an ongoing community-based study of cognitive aging were included in the analyses. As part of their neuropsychological evaluation, participants performed three semantic fluency tasks, generating exemplars for the categories animals, clothing, and food in separate 60-second trials. The mean scores for the clothing and food categories represented non-living category performance, whereas performance on the animal fluency test was chosen to represent living category performance. T1-weighted MRI scans were analyzed with FreeSurfer to derive regional brain volumes in the right and left hemispheres. We calculated the relative performance on each of the categories by dividing each participant's score for the living category by their total category fluency performance, and likewise for their mean non-living fluency. Subsequently, we calculated the ratio of their relative living fluency to relative non-living fluency. The more this ratio deviates from 1, the more difference in performance there is between the living and non-living categories, with better living performance if the ratio is more than 1, and better non-living performance if the ratio is less than 1. We used multiple regression analysis to investigate whether there was a relationship between performance and regional brain volume. Controlling for sex, age, years of education, and total hemispheric brain volume, a higher living/non-living fluency ratio score was associated with larger left hemisphere fusiform gyrus volume, but not with any other surrounding area in the temporal-parietal cortex, nor with right hemisphere fusiform gyrus volume. A repeated-measures ANOVA was used to examine whether there were behavioral performance differences between the two categories. Again controlling for sex, age, years of education, and total hemispheric brain volume, no difference in fluency performance between the relative living and non-living scores was seen. This study demonstrates the sensitivity of the verbal fluency task for investigating processing of semantic categories. Despite the fact that non-demented participants performed similarly for living and non-living semantic categories, our results support the idea that individual differences in generating words in living versus non-living categories are linked to brain volume in specific areas in the temporal cortex. Research supported by the National Institutes of Health (NIH AG037212 and AG034189).

E48 Sensory-Motor Attribute Ratings Predict Brain Responses to Individual Words

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Activation of sensory and motor networks during language comprehension is well documented, however it remains unclear to what extent these "perceptual" representations account for overall activation during retrieval of word meaning. In a previous study, we obtained neural activation maps for five distinct sensory-motor attributes of word meaning (color, shape, sound, visual motion, and manipulation) by collecting ratings of the relative salience of these attributes to the meaning of 900 words, and using these ratings as predictors in a multiple regression analysis of functional MRI data. In the present study, we asked whether the information encoded in those sensory-motor attribute maps predicts activation patterns of individual words when combined with the attribute values for each word. Participants were 44 healthy, right-handed, native speakers of English. They were required to decide whether a word shown on the screen refers to something that can be experienced through the senses (semantic decision) and respond as quickly as possible by pressing one of

two keys. All 900 words had been previously rated by a separate group of participants on the five sensory-motor attributes, using a 0-6 scale. Stimuli were presented in pseudo-random order in a fast event-related design. Group-level activation maps for the sensory-motor attributes (henceforth Attribute Maps, AMs) were generated by fitting individual time courses with a Generalized Least Squares (GLS) regression model including the attribute ratings as predictor variables. We also generated group-level activation maps (Observed Maps, OMs) for a subset of 80 "test" words (51 concrete, 29 abstract) relative to a pseudoword baseline. The GLS regression was done separately for each of the 80 test words, with the following explanatory variables: (1) a binary regressor coding the selected word; (2) a binary regressor for the non-selected words (i.e., the other 899 words in the original study); (3) a binary regressor for the pseudowords; (4) five continuous regressors coding the ratings for each of the five semantic attributes for all non-selected words; and (5) a continuous regressor coding response time for each trial. Finally, we computed predicted activation maps (Predicted Maps, PMs) for each of the 80 test words as linear combinations of the AMs, weighting each AM by the word's corresponding attribute rating. We tested the accuracy of each PM by ranking the 80 OMs on strength of correlation with the PM, and converting the rank of the corresponding OM to a percentile score. Mean prediction accuracy across all 80 test words was well above chance at .775 ($p < .001$), with similar results for concrete (.79) and abstract (.76) items. Leave-one-out analyses, in which one of the five attributes was left out in creating the PMs, were performed for each attribute to assess its individual contribution to the success of the prediction. Accuracy was reduced by ~13% in all of these analyses, indicating that all five attributes contributed to prediction success. The five sensory-motor attributes investigated here explain a large portion of the neural activation patterns associated with the meaning of both concrete and abstract words.

E49 The Representation of Mammals in the Human Brain

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Introduction Neural representation of objects and concepts is one of the key topics in modern cognitive neuroscience. A large number of neuroimaging studies explores neural responses to meaningful objects. Typically, such studies focus on categorical distinctions between objects. In our study we examine the neural representational space within a relatively homogeneous but abundant category of mammals. Our key assumption is that the inner structure of this space, on the one hand, reflects major taxonomic distinctions between animals and, on the other hand, is organized along such important dimensions as familiarity, typicality and emotional valence. Methods We conducted a multi-session fMRI experiment in which participants viewed photos of 344 unique mammals presented on a neutral black background. Each subject (N=3) took part in four 1–hour fMRI sessions, thus each photo was presented 8 times. Participants were instructed to focus on the fixation cross in the center of the image, and provide familiarity ratings for the animal in catch trials. In a post-hoc experiment fMRI participants rated each animal for familiarity, typicality, emotional valence and arousal on a five-point Likert scale, and named each animal. Additionally, an independent group of 50 subjects rated the stimuli in the same manner. FMRI data were preprocessed using SPM8, and individual beta values for each animal exemplar were estimated. Searchlight analysis was performed on the beta estimates to localize brain regions exhibiting high accuracies for decoding semantic dimensions (high versus low familiarity, high versus low typicality), on the one hand, and biological distinctions (decoding the taxonomical groups: carnivora, primates, rodents, ungulates), on the other hand. Results Analysis of the behavioural data reveal high correlation between familiarity and typicality ratings (mean across animals $r = 0.45$ for fMRI post-hoc, $r = 0.4$ for independent testing). Biological distinctions: decoding of four distinct orders of mammals results in above-chance (over 0.31, $p <= 0.015$) accuracies in Supramarginal gyrus and Left Middle Temporal gyrus in Participants 1 and 3, and middle Cingulate gyrus in Participants 1 and 2. Semantic dimensions: in case of familiarity, highest decoding accuracies (over 0.70, $p <= 0.01$) are exhibited by spheres in Left Fusiform gyrus, Right Supramarginal gyrus, Left Inferior Temporal gyrus and Right Cerebellar Crus in all participants. When decoding typicality, highest accuracies are localized in Left Inferior Frontal gyrus, Right Middle Temporal gyrus and Cerebellum in all participants. Occipital cortex also yields high decoding accuracy for both dimensions in all participants, which most likely happens due to an increased demand for visual recognition caused by unfamiliar and atypical stimuli. To further look at the inner structure of this representational space, we are planning to include the naming results and the emotional ratings in the representation model, and perform non-parametric clustering on the neural data. Conclusion The present results agree with the previous research, highlighting the role of temporal and temporal–parietal cortices in semantic processes. The results also show that familiarity and typicality form important dimensions in the neural representations of mammals and can be successfully decoded from the BOLD signal.

E50 A task comparison of motor activation in online sentence comprehension.

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Although motor activation has been observed during comprehension, establishing the functional role of such activation remains unclear. The current EEG study evaluates the functional issue in terms of task demands. Specifically, a semantic evaluation task and a letter-matching task were each expected to differentially

engage the comprehension processes which, critically, may or may not reveal corresponding motor activation. Mu desynchronization (8 – 12 Hz) from the motor cortex was measured on critical verbs embedded in visually presented Dutch sentences (e.g., De winkelkarretjes die zij wegduwt zijn kapot./The trolleys that she pushes away are broken.). Manipulation of the verbs' action specificity was intended to elicit differences in mu desynchronization (e.g., more action specificity for pushing trolleys than delivering trolleys). Half of the stimuli were constructed as semantically congruent sentences, the other half as semantically incongruent sentences to elicit an N400 effect, a measure of semantic comprehension, which was indeed observed in both tasks (e.g., The trolleys that she pushes away/sews are broken.). The preliminary results indicate that the motor system is activated in both tasks yet differently so in interesting ways. Whereas the semantic evaluation task shows the predicted main effect of action specificity, the letter-matching task shows an interaction of congruency and action specificity, with greater motor activation for action non-specific verbs than action specific ones in semantically incongruent sentences. Notably, the latter result was previously observed in a passive reading task using similar stimuli (Lam, Bastiaansen, Dijkstra, & Rueschemeyer, in preparation). This study underscores the claims of theories of embodied language by showing that (1) motor activation occurs even in a task that does not necessitate explicit retrieval of meaning, and that (2) the task-dependent patterns of motor activation reveal the different functional interactions between the motor system and comprehension processes.

E51 Sentence Construction by Stored-Form Retrieval and by Combination: ERP Evidence for Early and Interactive Processing

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Introduction: The human brain stores an immense repertoire of meaningful signs and combines them into a virtually unlimited set of well-formed strings. Communicative function is impaired if strings include meaningless, not stored items ("pseudowords"), or if the combinatorial rules are violated. Success or failure of access to stored signs and of application of combinatorial mechanisms are reflected in brain responses, so that event-related potentials, ERPs, can be used for determining the time course and putative interaction of combinatorial and access processes. Methods: We probed spoken mini-constructions (16 short pronoun-verb German sentences) composed of stored meaningful morphemes and novel meaningless pseudo-morphemes that obey or violate combinatorial syntactic rules. Information about morpho-syntactic and lexico-semantic violations was first available at the same point in time, the "divergence point" (DP) that corresponded to the onset of the last syllables of stimulus phrases and served as time locking point for the ERPs. The 4 groups of 4 constructions each were either 1) morphosyntactically well-formed [ich leide (=suffer), ich zeige (=show), wir schweigen (=keep silent), wir scheiden (=separate)], 2) violated pronoun-verb agreement (*ich schweigen, *ich scheiden, *wir leide, *wir zeige), 3) containing a morphologically correct but unfamiliar and meaningless pseudo-verb (ich schweide*, ich scheige*, wir leigen*, wir zeiden*), or contained a pseudo-verb that also violated morphosyntactic agreement (*ich leigen*, *ich zeiden*, *wir schweide*, *wir scheige*). This design therefore orthogonally varied the Storage [stored word vs. pseudo-word] and Combinatorial [well- vs. ill-formed] factors with the critical, phrase-final syllables being constant over conditions. Spoken phrases were presented in 2 blocks of a MMN multifeature paradigm that used the pronoun (ich or wir) as standard stimulus and the 8 (pseudo)verbs as deviants. Data from 23 subjects were analyzed with repeated-measures ANOVAs. Results: The ERPs showed significant [$F(1,22)=4.6$, $p=0.04$, $\eta p2=0.17$] neurophysiological differences between stored morphemes as compared with novel pseudomorphemes 100-200ms after the DP. 270ms after the DP and later, concordant violation responses emerged for both infelicitous combinations and pseudo-verb-containing strings, but double violations failed to elicit a violation response, possibly indexing abortive processing of entirely implausible strings. This pattern was manifest in a significant interaction of the Storage and Combination factors [$F(1,22)=6.9$, $p=0.01$, $\eta p2=0.25$]. Conclusions: These results show that combinatorial morpho-syntactic and storage-related lexico-semantic processes occur in parallel and do interact in the brain, already at 270ms. They also confirm that lexico-semantic processing takes place very early, around 100-200ms after information is available. Construction processes operating on stored forms and combinatorial schemas appear as near-simultaneous and independent initially and interactive slightly later. Supported by the DAAD, the DFG and the Freie Universität Berlin

E52 Does the prediction benefit outlast grammatical violations? A double-violation ERP study.

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Prediction in language comprehension has been shown to have beneficial effects on the processing of incoming information, be it in terms of facilitated lexical-semantic access/ retrieval, easier integration, or – on a behavioural level – reduced reaction times for predictable versus unpredictable words in a variety of tasks. However, it is unclear how predictable versus unpredictable linguistic input is processed when grammatically erroneous, i.e. whether or not the prediction benefit outlasts grammatical violations. We employed an event-related potential (ERP) paradigm to test this. Therefore, we used 60 German sentences with a verb that was highly predictable (high cloze probability, as assessed by a pre-test) and morphosyntactically congruent (1A; Der Torhüter behauptet, dass der rutschige Ball einfach zu HALTEN war. Literal translation: The goalkeeper claims that the slick ball easy to STOP was.) or incongruent (1B; Der Torhüter behauptet, dass der rutschige Ball einfach zu *HÄLTST war. Literal translation: The goalkeeper claims that the slick ball easy to *STOPS was.), and another 60 sentences with a verb that was

unpredictable but still plausible (low cloze probability) and morphosyntactically congruent (2A; Die Kinder prahlten, dass das junge Pferd einfach zu BÜRSTEN war. Literal Translation: The kids boast that the young horse easy to BRUSH was.) or incongruent (2B; Die Kinder prahlten, dass das junge Pferd einfach zu *BÜRSTEST war. Literal translation: The kids boast that the young horse easy to *BRUSHES was.); note that infinite verbs rendered the sentences ungrammatical. An additional 200 sentences served as fillers. The EEG of 23 German native speakers was recorded while they were reading the sentences word-by-word and asked to give an acceptability judgement after each sentence, by pressing the corresponding button. ERPs were then calculated for the critical words (capitalized in the examples above). Lower RTs for ungrammatical compared to grammatical sentences suggest that participants employed an error detection strategy to accomplish the task. However, for grammatical sentences, there seems to be a beneficial prediction effect reflected in the RTs, which is absent in the ungrammatical condition (RTs: 1B = 2B < 1A < 2A); yet, a ceiling effect as an alternative explanation cannot be excluded. Regarding the ERPs of the grammatical sentences, unpredictable verbs led to a typical biphasic N400-P600 effect relative to predictable verbs, indicating easier lexical-semantic access/ retrieval (as reflected in the smaller N400) as well as easier subsequent integration (as indexed by the smaller P600) for the predictable verbs. Ungrammatical sentences also led to an N400 effect for unpredictable versus predictable verbs, comparable to the N400 effect of the grammatical sentences. Additionally, both ungrammatical verbs led to a pronounced P600, but strikingly, without the positivity effect for unpredictable versus predictable verbs, like in the grammatical sentences. This shows that although lexical-semantic processing is facilitated for predictable vs. unpredictable words (N400), the subsequent integration – which is assumed to be reflected in the P600 – benefits from greater predictability only, when the input is grammatical.

E53 Individual Differences in L1 Sentence Processing: an ERP Study

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This study sought to characterize individual differences in event-related potential (ERP) responses to semantic and syntactic violations in sentences, and investigate whether there are systematic relationships between such differences and behavioural measures of cognitive-linguistic abilities. We examined three ERP components typically elicited in sentence processing studies: the N400, typically associated with lexical semantic processing; the LAN, associated with the detection of syntactic violations as well as working memory; and the P600, thought to index the reanalysis and/or repair of syntactic constructions. Although studies of native language speakers (L1) typically assume uniformly high language proficiency and homogeneity of ERP responses across subjects, recent studies have called these assumptions into question (e.g., Newman et al., 2012; Tanner and Van Hell, 2014). In the present study, we recorded ERPs from native English speakers in response to visually presented English sentences containing lexical-semantic, morphosyntactic (past tense), or phrase structure violations, as well as control sentences. Participants were asked to rate the acceptability of each sentence using a 5-point Likert scale. Language proficiency scores were obtained from Listening Grammar (LG), Listening Vocabulary (LV), and Speaking Grammar (SG) subtests of the TOAL-3. Participants were also assessed on a range of other cognitive measures, including working memory and executive control of attention. In contrast to previous work, we considered the relationship of each of the measures with ERP responses, rather than using an aggregate measure of proficiency that combined vocabulary and grammatical measures. Mean amplitudes in the 300-500 and 600-800 ms windows were analyzed using linear mixed effects modelling, with proficiency measures included as continuous fixed effects terms. At the group level, biphasic early negativity-late positivity patterns were observed for all three types of violation, although the scalp distribution varied with violation type. In particular, the early negativity for morphosyntactic and phrase structure violations was more left-lateralized than for lexical-semantic violations. However, closer investigation revealed systematic differences in the magnitude and scalp distribution of these components as a function of language proficiency. Interestingly, ERP responses to lexical-semantic violations correlated with both vocabulary and grammar proficiency measures, as did some aspects of ERP responses to grammatical violations. These findings are consistent with previous observations of individual differences in ERP responses to lexical-semantic and syntactic violations, and provide insight into the ways in which these responses may be modulated by cognitive-linguistic abilities such as native language proficiency.

E54 Fishing is not wrestling: Neural correlates of the verb instrumentality effect

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Previous clinical research has revealed the positive effect of instrumentality on verb retrieval and access in individuals with aphasia, both fluent and non-fluent (Malyutina, Iskra, Sevan, & Dragoy, in press). Performance on instrumental verbs referring to actions for which an instrument (not being a body part) is required (e.g. to cut) is more accurate as compared to non-instrumental verbs for which a tool is not obligatory (e.g. to tie). This effect was attributed to richer conceptual representations of instrumental verbs facilitating concept-lemma mapping (Breedin, Boronat, Saffran, & Shipley, 1999). Seeking for the neural correlates of the difference between instrumental and non-instrumental verbs, we investigated the effect of verb instrumentality on BOLD signal in neurologically intact individuals without

language impairment. Seventeen German speakers (9 female, M = 33.4 years) performed a noun-verb matching task with instrumental and non-instrumental verbs in a block design fMRI paradigm. A verb (e.g. to cut) and two nouns (e.g. bread and blood) were presented in a triangular array; participants were required to choose the appropriate object for the verb by pressing a button. Groups of verbs and pairs of nouns were balanced on frequency and length; appropriateness of objects was tested in a preliminary questionnaire; instrumental and non-instrumental verbs did not differ in imageability and the degree of association between a verb and a matching noun. The semantic category of the verb and both deep semantic processing and sequential binding of a verb with a noun was insured by the task used. Imaging was performed on a 1.5-T Siemens Avanto scanner. The obtained data were analyzed in SPM8. The results revealed that, in neurologically intact individuals, processing non-instrumental verbs requires extra neural resources as compared to processing instrumental verbs. Those resources involve both frontal and temporal language-related areas of the left hemisphere. These areas are usually compromised in brain-damaged individuals with aphasia resulting in deteriorated performance on non-instrumental verbs. An additional implication of the study is related to the beneficial impact of instrumentality on both lexical-semantic access and sequential binding operations associated with the temporal and frontal networks of the left hemisphere correspondingly. Acknowledgments: this research was implemented as a part of the Basic Research Program of the National Research University Higher School of Economics.

E55 An ERP study on the processing of monosyllabic and disyllabic nouns and verbs in Chinese

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1. Introduction Although there has been a group body of behavioral and neuropsychological studies trying to figure out the neural underlying of noun and verb, different investigations provided inconsistent results. One important reason is that the processing of noun and verb in morphologically-rich languages may result in both semantic activation and morpho-syntactic operation. The investigation on Chinese will contribute to deal with this problem because of its simple system of morphology. Moreover, Chinese words could consist of one, two or more syllables. Little attention was paid to the neural processing of nouns and verbs with different syllables in previous studies. The current study aims to investigate the processing of monosyllabic and disyllabic nouns and verbs in Chinese. We predict that A) distinct neural mechanisms are involved in the processing of Chinese nouns and verbs; B) the processing differences between monosyllabic nouns and verbs are not identical to the differences between disyllabic nouns and verbs. 2. Methods 2.1 Participants Twenty-five native speakers of Chinese participated in the experiment. 2.2 Materials There were 22 monosyllabic nouns (MN), 22 monosyllabic verbs (MV) in the monosyllabic group and 22 disyllabic nouns (DN), 22 disyllabic verbs (DV) in the disyllabic group. Within each group, the lexical-semantic variables, such as frequency, familiarity, number of strokes, age of acquisition, neighborhood size, were matched between nouns and verbs (ps>0.05). The concreteness and imageability were not controlled because the prototypical and unambiguous nouns and verbs were selected. But the statistical results showed that the difference between MN and MV on concreteness and imageability equaled to the difference between DN and DV (p>0.05). The nouns and verbs were embedded in the syntactically well-defined contexts respectively (noun contexts, one + noun classifier; verb contexts, not + auxiliary verb). According to the results of norming procedure, both noun and verb contexts were weakly constrained (cloze value: 22% or lower) and the stimuli were plausible but unexpected completions for the contexts (the percentage of appearance: 2.5% or lower). 2.3 Paradigm & Task The experimental paradigm largely followed the previous study (Lee & Federmeier 2006). The participants were instructed to judge the semantic relatedness between the targets and the probes or press buttons to initiate next trail. The probes were presented on one-third of the trails randomly. 3. Results & Discussion The repeated two-way (word class and electrode) ANOVA was performed separately for monosyllabic and disyllabic words. The results showed that, over the central and posterior sites, both MV and DV elicited more negative N400s than MN and DN respectively (ps<0.05), indicating more information (e.g. subjects, actions) was induced by verbs than nouns in the context. Furthermore, the frontal positivity for DN was larger than DV (p<0.05) but was approximately equal between MN and MV (p>0.05), which indicated more integration difficulty for DV than DN but similar cost for MN and MV. The results proved our predictions and revealed distinct neural processing of nouns and verbs in Chinese and different brain response to monosyllabic and disyllabic nouns and verbs.

Discourse, Combinatorial Semantics

E56 Participants strategically exploit dependencies hidden in studies designed using Latin Square designs

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Latin Square designs are widely used in psycholinguistic experiments, because they offer a convenient way to balance stimuli across conditions. A hypothetical experiment could include following items: Participant-A 1.He spread the warm bread with butter. 2.The bill was due at the end of the month. Participant-B 1.He spread the warm bread with month. 2.The bill was due at the end of the butter. In many experiments (as in above examples) target words are predictable given the preceding sentences. This exposes a dependency which can be exploited by participants. For example, after reading sentence 1 participant-B could remember that it ended with the incongruent word “month”, instead of the expected word “butter”. When she then processes sentence 2, she can realize that it should be continued with “month”. However, since “month”

has already been used up, she will know that this sentence is in the incongruent condition, even before encountering the target word. We present an ERP study demonstrating that participants do indeed exploit such dependencies. Participants were presented with short stories. In half of them, a target word (the direct object noun of the main clause of the story-final sentence) was semantically congruent with the preceding context (congruent condition[C]), while in the other half it was not (incongruent condition[IC]). The incongruity was introduced by reassigning target nouns from a given story to another story. In addition to the Congruity manipulation, in half of stories, just before the story-final sentence, explicit information was introduced, telling the participants that in the following sentence one of two specific target words will appear (Expectancy condition[E]). The two words cued were the congruent and the incongruent target word (participants did not know which of the two words will appear). In the other half of items, no information concerning the target word was given (No Expectancy condition[NE]). Expectancy and Congruity manipulations were fully crossed. The analysis of ERPs elicited by the words of the story-final sentence preceding the target word presentation revealed that they were processed differently in the E-C and E-IC conditions, even though up to the target word items were identical in both of the conditions. This indicated that participants must have made strategic between-item predictions concerning the items, along the lines we described above. To follow-up this result, for each participant, based on his/her individual history of items, we split items into those where the participant could and could not have guessed item congruity value based on prior items. It turned out that the difference between the E-C and E-IC conditions was carried exclusively by the predictable items. In addition, the standard N400 effect for target nouns in the NE-IC condition (relative to NE-C condition) was smaller for predictable items. Additional splits revealed that this pattern of effects is carried only by participants with high episodic memory, and primarily by stories that were semantically highly constraining at the target word position. These results indicate that using Latin Square designs with predictable stimuli can invite unwanted strategies for participants with good episodic memory.

E57 Discourse predictions are processed in the dorsal auditory stream: An fMRI study using naturalistic stories.

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Hierarchical predictive coding has been hailed a possible unifying principle of brain function (Friston, 2010). Here, we use syntactic and semantic cues to manipulate discourse prominence and thus predictability of the upcoming topic. Subjects are default topics and passive voice modulates topic prediction by realising a non-default (undergoer) argument as subject (Givón, 1994). Event type also influences prominence: highly causal verbs (e.g. "hit") foreground both sentence participants by emphasising the prototypicality of actor and undergoer, while low causality verbs (e.g. "see") foreground neither participant (Pyykkönen, Matthews, & Järvikivi, 2010). For highly causal events, passive voice thus signals intentional topicalization of the less prominent undergoer. In low causality events passive voice is less motivated because actor and undergoer are more closely aligned in prominence. In a naturalistic fMRI study, we examined the hypotheses that (a) passive increases future predictability of the subject; (b) this is modulated by the event-internal motivation for a passive (lower event-internal motivation equals higher discourse predictability); (c) predictions are encoded hierarchically. We obtained images (3T) of 20 healthy right-handed German monolinguals (9 male), employing a 2x2 design: voice (active vs. passive) x causality (high vs. low). Conditions were embedded in 20 two-minute long stories. Act/Pass-high: event["Then the clown pushed the princess/Then the clown was pushed by the princess] and the teddy bear appeared again from under the dress." reference["The clown] …", Act/Pass-low: event["The professor agitated his assistant/The professor was agitated by his assistant] because the papers had been reporting about an unstable roof construction." reference["The professor] …". Subjects were instructed to listen carefully and were asked two comprehension questions after each story. Analyses included position of measurement (event vs. reference) resulting in a 2x2x2 model. We report clusters of $p<.005$ and volumes of at least 72 voxels (Monte Carlo corrected). Voice, causality and position interacted in bilateral dorsal stream regions, including the left posterior STG, bilateral Rolandic operculum, premotor cortex and postcentral gyri. All interactions resulted from effects for the target referent as opposed to the context and to higher activation for act-low/pass-high versus act-high/pass-low. Two-way interactions of voice and position due to higher activation for active versus passive conditions at the referent were observed in left frontomedian regions (ACC and SMA). Position and causality interacted in the left angular gyrus, with higher activation for low vs. high causality on the referent. The elevated activation for less predicted topics may reflect prediction error or increased effort associated with processing a non-predicted referent. Our data thus support the assumption that topicality-related discourse predictions are processed in the dorsal stream (Bornkessel-Schlesewsky & Schlesewsky, 2013). They provide initial evidence for a hierarchical organisation, with frontomedial cortex encoding predictions for passive versus active subjects, the angular gyrus encoding higher predictions for participants in causal events, and the posterior STG encoding highly specific predictions for a particular referent based on both voice and causality. Importantly, our data cannot be explained purely by syntactic differences between active and passive sentences since the crucial effects were observed on referents rather than events.

E58 An FMRI study of the interaction between sentence-level syntax and semantics during language comprehension

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Hagoort [1] suggested that the posterior temporal cortex is involved in the retrieval of lexical frames that form building blocks for syntactic unification, supported by the inferior frontal gyrus (IFG). FMRI results support the role of the IFG in the unification operations that are performed at the structural/syntactic [2] and conceptual/semantic levels [3]. While these studies tackle the unification operations within linguistic components, in the present event-related FMRI study we investigated the interplay between sentence-level semantics and syntax by adapting an EEG comprehension paradigm [4]. The ERP results showed typical P600 and N400 effects, while their combined effect revealed an interaction expressed in the N400 component ([CB-SE] - [SY-CR] > 0). Although the N400 component was similar in the correct and syntactic conditions (SY □ CR), the combined effect was significantly larger than the effect of semantic anomaly alone. In contrast, the size of the P600 effect was not affected by an additional semantic violation, suggesting an asymmetry between semantic and syntactic processing. In the current FMRI study we characterize this asymmetry by means of a 2x2 experimental design included the conditions: correct (CR), syntactic (SY), semantic (SE), and combined (CB) anomalies. Standard SPM procedures were used for analysis and only clusters significant at P <.05 family-wise error corrected are reported. The main effect of semantic anomaly ([CB+SE] > [SY+CR]) yielded activation in the anterior IFG (BA 45/47). The opposite contrast revealed the theory-of-mind and default-mode network. The main effect of syntactically correct sentences ([SE+CR] > [CB+SY]), showed significant activation in the IFG (BA 44/45), including the mid-anterior insula extending into the superior temporal poles (BA 22/38). In addition, significant effects were observed in medial prefrontal/anterior cingulate cortex, posterior middle and superior temporal regions (BA 21/22), and the basal ganglia. The reverse contrast yielded activations in the MFG (BA 9/46), the inferior parietal region (BA 39/40), precuneus and the posterior cingulate region. The only region that showed a significant interaction ([CB□SE] □□ [SY□CR] > 0) was the left temporo-parietal region (BA 22/39/40). In summary, the results show that the IFG is involved in unification during comprehension. The effect of semantic anomaly and its implied unification load engages the anterior IFG while the effect of syntactic anomaly and its implied unification failure engages MFG. Finally, the results suggest that the syntax of gender agreement interacts with sentence-level semantics in the left temporo-parietal region. [1] Hagoort, P. (2005). On Broca, brain, and binding: A new framework. TICS, 9, 416-423. [2] Snijders, T. M., Vosse, T., Kempen, G., Van Berkum, J. J. A., Petersson, K. M., Hagoort, P. (2009). Retrieval and unification of syntactic structure in sentence comprehension: An fMRI study using word-category ambiguity. Cerebral Cortex, 19, 1493-1503. doi:10.1093/cercor/bhn187. [3] Hagoort, P., Hald, L., Baastiansen, M., Petersson, K.M. (2004). Integration of word meaning and world knowledge in language comprehension. Science 304, 438-441. [4] Hagoort, P. (2003). Interplay between syntax and semantics during sentence comprehension: ERP effects of combining syntactic and semantic violations. Journal of Cognitive Neuroscience, 15, 883-899.

E59 A Spiking Recurrent Neural Network for Semantic Processing

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Sentence processing requires the ability to establish thematic relations between constituents. Here we investigate the computational basis of this ability in a neurobiologically motivated comprehension model. The model has a tripartite architecture where input representations are supplied by the mental lexicon to a network that performs incremental thematic role assignment. Roles are combined into a representation of sentence-level meaning by a downstream system (semantic unification). Recurrent, sparsely connected, spiking networks were used which project a time-varying input signal (word sequences) into a high-dimensional, spatio-temporal pattern of activations. Local, adaptive linear read-out units were then calibrated to map the internal dynamics to desired output (thematic role sequences) [1]. Read-outs were adjusted on network dynamics driven by input sequences drawn from argument-structure templates with small variation in function words and larger variation in content words. Models were trained on sequences of 10K words for 200ms per word at a 1ms resolution, and tested on novel items generated from the language. We found that a static, random recurrent spiking network outperformed models that used only local word information without context. To improve performance, we explored various ways of increasing the model's processing memory (e.g., network size, time constants, sparseness, input strength, etc.) and employed spiking neurons with more dynamic variables (leaky integrate-and-fire versus Izhikevich-neurons). The largest gain was observed when the model's input history was extended to include previous words and/or roles. Model behavior was also compared for localist and distributed encodings of word sequences. The latter were obtained by compressing lexical co-occurrence statistics into continuous-valued vectors [2]. We found that performance for localist-input was superior even though distributed representations contained extra information about word context and semantic similarity. Finally, we compared models that received input enriched with combinations of semantic features, word-category, and verb sub-categorization labels. Counter-intuitively, we found that adding this information to the model's lexical input did not further improve performance. Consistent with previous results, however, performance improved for increased variability in content words [3]. This indicates that the approach to comprehension taken here might scale to more diverse and naturalistic language input. Overall, the results suggest that active processing memory beyond pure state-dependent effects is important for sentence interpretation, and that memory in neurobiological systems might be actively computing [4]. Future work therefore needs to address how the structure of word

representations interacts with enhanced processing memory in adaptive spiking networks. [1] Maass W., Natschläger T., & Markram H. (2002). Real-time computing without stable states: A new framework for neural computation based on perturbations. Neural Computation, 14: 2531-2560. [2] Mikolov, T., Chen, K., Corrado, G., & Dean, J. (2013). Efficient estimation of word represen-tations in vector space. Proceedings of the International Conference on Learning Represen-tations, Scottsdale/AZ. [3] Fitz, H. (2011). A liquid-state model of variability effects in learning nonadjacent dependencies. Proceedings of the 33rd Annual Conference of the Cognitive Science Society, Austin/TX. [4] Petersson, K.M., & Hagoort, P. (2012). The neurobiology of syntax: Beyond string-sets. Philo-sophical Transactions of the Royal Society B 367: 1971-1883.

E60 Integrate or Repair? ERP responses to semantic anomalies depend on processing strategy.

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Recent ERP studies of sentence processing have found that some types of sentence-embedded semantic anomaly (e.g., "The hearty meal was devouring …") elicit P600 effects, while many other semantic anomalies (e.g., "The sealed envelope was devouring…") elicit N400 effects. Theoretical accounts have agreed that such "semantic P600's" challenge an earlier view that the P600 is elicited specifically by syntactic anomaly, but convergence on a unified, alternative account of the processes underlying P600 and other language-related ERPs remains elusive. Several inter-related but distinct accounts have attributed semantic P600 effects variously to extended combinatory processing triggered by highly anomalous words, monitoring in response to conflict between incompatible representations, and the difficulty of semantically integrating highly unexpected words. We tested the hypothesis that semantic P600 effects reflect an attempt to structurally repair an anomalous sentence. This response is encouraged by sentences like the first example above, in which "meal" is a semantically attractive Patient of "devouring", but the sentence is grammatically incompatible with this plausible interpretation ("Semantic Attraction" anomalies). In the sentences without semantic attraction ("No-Attraction" anomalies), the unexpected word is difficult to retrieve from semantic memory, leading to N400 effects. Participants read sentences with Semantic Attraction and No-Attraction anomalies while we attempted to bias brain responses by manipulating the task that participants performed as they read. All participants received pre-recorded auditory instructions. 22 participants in the "repair condition" were told that some sentences in the experiment were "taken from conversations in which the speaker made an error" and given examples of how such sentences should be "fixed in order for the sentence to make sense". A separate group of 21 participants (the "integrate condition") were told that some sentences may have "bizarre meanings" and were instructed to think about what they "could literally mean". Participants read sentences one word at time from a computer screen, while EEG was recorded from 64 channels at 1000 Hz. For participants in the Repair condition, the Semantic Attraction anomalies elicited a robust P600 effect but no N400 effect. No-Attraction anomalies elicited an N400 effect but no P600 effect. For participants in the Integrate condition, semantic attraction anomalies elicited no P600 effects and instead elicited a left anterior negativity (LAN) 350-650 ms post stimulus onset, with a mean amplitude effect of about 1.25 microvolts. No-Attraction sentences in the Integrate condition also elicited this LAN effect, with a larger mean amplitude of 2.63 microvolts, which overlapped with a robust, shorter-duration central-parietal N400 effect. Because P600 effects occurred exclusively when participants were instructed to repair anomalous sentences, the results support a theory that posits structural repair as a key process underlying the semantic P600. LAN-like effects generated by participants instructed to integrate the anomalous sentences could reflect demands on verbal working memory, resulting when comprehenders attempt to integrate the semantically anomalous representation in which a meal is the Theme of devouring. Finally, the shift between P600 and LAN effects for the same stimulus sentences show that the processes underlying these effects are flexible and modifiable by the comprehenders' goals.

Syntax, Morphology

E61 A Neuronal Gamma Oscillatory Signature during Morphological Unification in the Left Occipito-Temporal Junction

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Morphology is the aspect of language concerned with the internal structure of words. In the past decades, a large body of masked priming (behavioral and neuroimaging) data has suggested that the visual word recognition system automatically decomposes any morphologically complex word into a stem and its constituent morphemes. Yet, it remains equivocal whether this morphemic decomposition relies primarily on orthography or on semantics. Here, we approached the issue straightforwardly by applying a task of morphological unification, that is, by assembling internal (morphemic) units into a whole-word. Morphemic units were sequentially presented while participants were requested to judge whether their assemblage represented real- or pseudo-words. Trials representing real words were divided into words with a transparent (true) or a non-transparent (pseudo) morphological relationship. Morphological unification of truly suffixed words occurred in a more straightforward way (shorter RT and higher accuracy). Additionally, oscillatory brain activity was monitored with magnetoencephalography and revealed that real, compared to pseudo morphological

unification enhanced narrow gamma band oscillations (60-85 Hz, 300-450 ms) in the left posterior occipito-temporal junction, which is known as a cerebral hub for visual word processing. This neural signature could not be explained by a mere automatic lexical processing (i.e. stem perception), but more likely it related to a semantic access step during the morphological unification process. These findings highlight a plausible retrieval of lexical semantic associations for enabling true morphological unification, and further instantiate the pivotal role of the left occipito-temporal junction in visual word form processing.

E62 Neurocognitive expressions of derivational morphology in Italian: evidence from univariate and multivariate fMRI analyses.

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Spoken language comprehension engages a bilateral fronto-temporal network supporting perceptual/semantic interpretation of whole-word forms and a left-lateralised fronto-temporal system (encompassing left inferior frontal gyrus, LIFG), specialised for combinatorial grammatical sequences (Marslen-Wilson & Tyler, 2007; Bozic et al., 2010). Cross-linguistic evidence from English and Polish shows that morphological derivation activates the bilateral fronto-temporal network, but does not selectively involve the LIFG (Bozic 2013), suggesting that derived words are stored as whole forms rather than analysed decompositionally. This bilateral activity reflects perceptual/semantic relations between derived words and their embedded stems. However, transparent productive words (brave-ly) pattern with simple words (brave), whilst the bilateral competition effects appear to be predominantly driven by opacity. These results suggest that word internal structure might be relevant for processing transparent productive words, leading to the question whether morphological structure affects derivational processing under specific linguistic conditions. Are there distinct bihemispheric patterns for different types of morphological complexity along transparency/opacity, productivity and 'storedness' dimensions? We addressed this question by investigating the morphological system of Italian, an inflectional synthetic Neo-Latin language, in which distinct suffixes convey specific semantic and morpho-syntactic information (parl[meaning]-a[conjugation]-t[past participle]-a[gender+number]: dialect). Italian morphology relies on root-based processes similar to Polish, as opposed to English whole-word stems. These morphological properties might be expected to trigger combinatorial derivational mechanisms under certain complexity conditions, potentially reflected in selective LIFG activation. Combinatorial/compositional complexity was manipulated across 5 conditions (80 words per condition): 1) transparent productive (gelat-eria, ice-cream shop); 2) transparent non-productive (pin-eta, pinewood); 3) opaque productive (tomb-ino, manhole); 4) opaque non-productive (prem-ura, urgency); 5) simple words (albero, tree). 20 right-handed native Italian speakers performed a 1-back semantic judgment task (5% of trials) while listening to 400 words interspersed with 200 acoustic envelope-shaped length-matched baseline and 200 null events (pseudo-randomised across 4 runs of 12 minutes each in a fast sparse fMRI EPI protocol, TR = 3.4s). Data were analysed with SPM5 and Representational Similarity Analysis (RSA) toolbox. Univariate results showed bilateral temporal activations common to all conditions (against baseline), but no selective LIFG activation to transparent productive words. Parametric modulator analyses tested for activity modulation as a function of semantic relatedness and lexical competition. Increased lexical competition elicited stronger bilateral MTG activations. Similar MTG activations were associated with weaker semantic relatedness. The lexical competition effects were primarily driven by non-compositional opaque words. To further explore information encoding within the fronto-temporal systems, continuous voxel-by-voxel maps of neural activity were computed for each condition and participant. Using searchlight RSA, these maps were correlated to theoretical models coding for the effects of semantic relatedness and lexical competition. Significant correlations with lexical competition were found in IFG and MTG bilaterally. Models expressing the interaction of lexical competition with semantic relatedness elicited bilateral IFG, precentral and middle/superior temporal activations. Consistent with previous cross-linguistic results, these findings uniformly suggest that the neurocognitive properties of Italian derived words reflect underlying whole-word representations, while preserved marking of morphological structure in transparent productive words generates reduced competition effects but without selective LIFG engagement.

E63 Aging and individual differences in pronoun comprehension: an ERP investigation

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Compared to many cognitive functions that tend to decline with advancing age, language has long been considered as an ability that is relatively preserved across lifespan. However, recent studies showed that language processes that require more top-down resources, such as processing sentences with complex structure or selecting appropriate meanings for ambiguous words in a context, could be compromised with advancing age. For instance, previous ERP studies on homographs showed that while stimulus-driven meaning processing mechanisms are relatively age-constant, top-down executive mechanisms are disproportionally affected by advancing age (Lee and Federmeier, 2011, 2012). Specifically, older adults as a group fail to elicit a frontal negativity that younger adults routinely show to aid difficult meaning selection. This deterioration does not seem inevitable though as a subset of older adults still show young-like brain response patterns. Lexical ambiguity can come from different sources. While homograph ambiguity arises when a word is linked to multiple meanings in the long-term memory, referential ambiguity, indexed by a similar frontal negativity (Dutch: Nieuwland & Van Berkum, 2006), arises when a pronoun can be linked to

multiple antecedents in the discourse. To investigate whether age affects the latter aspect of lexical ambiguity comprehension, we used ERPs to examine age differences in processing ambiguous pronouns in Mandarin Chinese. Referential relations between pronouns and the number of possible antecedents in the sentences were manipulated. Each pronoun has either (1) two possible antecedents (referentially ambiguous), (2) one possible antecedent (referentially unambiguous), or (3) zero possible antecedent (referential failure). Our results showed that, consistent with Dutch findings, relative to unambiguous pronouns, younger adults showed a central-posterior P600 effect to referentially failing pronouns and a sustained frontal negativity to ambiguous pronouns. Older adults as a group did not show a reliable P600 effect to referentially failing pronouns. However, inspection on the individual data suggests that the null effect at the group level may result from a cancellation between the P600 effects in some participants and the N400 effects in others. Older adults as a group also did not show a reliable frontal negative ambiguity effect, but a trend of central-posterior negativity instead. This central-posterior negativity is correlated with subjects' verbal fluency scores, with higher scores associated with larger negativity. Our present findings suggest that, consistent with previous findings, top-down or more controlled resources involved in comprehending pronouns are also less available with advancing age. These age effects are modulated by individual differences and may be compensated with different processing strategies as reflected by the posterior negativity in the ambiguous condition and the N400 mismatch effect in the failing condition.

E64 Individual Differences in Right Hemisphere Language Contributions: A Transcranial Magnetic Stimulation Investigation

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Although it is uncontroversial that the right hemisphere (RH) homologues of left hemisphere (LH) language regions participate in language comprehension processes, the nature of their contributions remains debated. One reason for this debate is that results from both neuroimaging and neuropsychological investigations have often been inconsistent, with multiple failures to replicate. The research of Prat and colleagues has demonstrated considerable individual differences in RH contributions to reading comprehension processes (e.g., Prat, Long & Baynes, 2007; Prat, Mason & Just, 2011; 2012), which may underlie replication failures. Specifically, less-proficient readers recruit reliably more RH than do more-proficient readers. In light of these findings and others in the field of cognitive neuroscience, we proposed the Spillover Theory, which states that for linguistic tasks, the RH serves as a processing reserve that it is recruited when the task demands outstrip the resources available to the LH alone. Therefore, given a task with fixed processing demands, individuals with lower skill levels should experience greater difficulty, and consequently recruit more RH. Thus, according to the Spillover theory, increase in RH involvement in less-skilled readers is facilitating their LH comprehension processes; however, another plausible explanation is that individuals who are less lateralized for language processes have poorer reading comprehension ability, or that RH involvement in less-skilled readers is disadvantageous. The current study used low frequency (1Hz) repetitive Transcranial Magnetic Stimulation (TMS) to test the hypothesis that RH contributions to language are helpful, and that they may be more necessary in less-skilled readers. Using the 10-20 system, we applied 300 1Hz-TMS pulses to either Wernicke's area (CP5), it's RH homologue, or the vertex (sham) to 31 healthy participants (19 females) of varying reading skill levels. For each participant, two stimulation locations were used (with a 30 minute break between) and two tasks were completed in varying order: a naming task consisting of equal numbers (80) of high- and low-frequency words, pronounceable nonwords, and line-drawings, and a sentence comprehension task consisting of 80 visually presented sentences of varying syntactic complexity followed by true/false comprehension probes. Surprisingly, no significant interactions were found as a function of TMS to LH versus RH when compared to vertex stimulation for either naming [$F(1,25) = .02$, $p = .89$] or sentence comprehension [$F(1,26)=.53$, $p = .47$]. However, the effects of RH TMS varied significantly as a function of reading skill, with significant correlations between reading experience and TMS-induced impairments in low-frequency word and non-word naming [$r(15) = .56$ and $.54$; $p = .03, .04$ respectively] and in sentence reading time [$r(13) = .72$, $p = .005$]. These results complement previous research demonstrating considerable variability in RH language contributions; however the fact that skilled readers showed larger deficits following RH TMS is somewhat inconsistent with patterns of activation observed in neuroimaging investigations. It may be the case that integration of RH processes into LH representations is an important facet of language skill that has yet to be considered.

E65 The role of prominence in Spanish sentence comprehension: an ERP study

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One of the major tasks involved in comprehending sentences is understanding 'who did what to whom'. In order to do so, readers need to link sentential syntactic constituents to the appropriate thematic role for each verb. Evidence from German, an SOV language, has shown that the parser does not wait until the verb is read in order to form a prediction about how such linking should proceed (Bader and Bayer, 2006). Moreover, a number of studies shows that appearance of an unexpected verb after prominence (the hierarchical relationship between sentential arguments) is wrongly computed entails differential electrophysiological correlates due to thematic reanalysis effects (Bornkessel, Schlesewsky and Friederici, 2003, Bornkessel- Schlesewsky and Schlesewsky, 2009 among others). However, up to the best of our knowledge, little

is known about the role of prominence in SVO languages that also allow word order variation. In order to fill this gap, we conducted and ERP study in Spanish (N=23), and examined the role of prominence for comprehension in this language by testing the interplay between word order (SVO vs. OVS) and type of verb (Activity vs. Object Experiencer psych verbs). While the verb in sentences (a) and (b) assign the most prominent role (i.e. Agent) to the nominative constituent, the verb in sentences (c) and (d) assign the most prominent role (i.e. Experiencer) to the dative constituent. Activity SVO: (a) María le grita a Juan (MaríaNOM yells at JuanDAT); Activity OVS: (b) A María le grita Juan (JuanNOM yells at MaríaDAT). OE SVO: (c) María le gusta a Juan (MaríaNOM appeals to JuanDAT); OE OVS: (d) A María le gusta Juan (JuanNOM appeals to MaríaDAT); Predictions: If computation of prominence indeed plays a role for comprehension in languages that allow word order variation, an ERP effect should be found in both SVO sentences with object experiencer (OE) verbs, and OVS sentences with activity verbs, due to difficulty of integration of these verbs after a constituent that comprises the least prominent argument of the event. Results: At the disambiguating region of the verb , subject-initial sentences show a positivity for OE verbs (maximum at 600 ms; centroparietal topography); and object-initial sentences show a negativity (maximum at 400 ms, centroparietal topography), and a positivity (maximum at 600 ms, broadly distributed topography) for activity verbs. Conclusion: Results suggest that in context-free declarative sentences, subject-initial arguments are firstly linked to the Agent role, the highest ranked thematic role for nominative case in Spanish. When an OE verb is encountered, thematic role for the previous argument needs to be revised. Conversely, object-initial arguments are firstly linked to the role of Experiencer, the most prominent thematic role for this constituent in initial position. When an agentive verb is encountered, this decision needs to be amended. All in all, results demonstrate that thematic expectations -and thus, linking- are generated incrementally, and may even be based upon the appearance of a single argument, as it occurs in SVO languages.

E66 Top-down modulation in the frontotemporal network during syntactic processing: A dynamic causal modeling analysis

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In spoken language, ambiguity occurs frequently at all levels – phonological, lexical and syntactic. Here we investigate processes of ambiguity resolution in the syntactic domain, asking how the left fronto-temporal network involved in syntactic processing [the LIFG, LpMTG and the white matter tracts connecting them] is modulated by syntactic ambiguity resolution. We collected magnetoencephalographic (MEG) data while subjects naturally listened to spoken sentences. Sentences were either unambiguous or contained a local syntactic ambiguity [Tom noticed that landing planes…] immediately followed by a disambiguating verb which was consistent with either the expected (dominant – DOM) […landing planes is…] or less expected (subordinate – SUB) […landing planes are…] interpretation of the ambiguity. We predicted that multiple syntactic readings will be activated for ambiguous sentences (i.e. SUB and DOM), with higher activation for the most expected reading [DOM]. Moreover, SUB sentences will require reanalysis when the disambiguating verb indicates that the expected syntactic reading is incorrect [1]. Following our previous studies [2] we predicted that the activation of multiple syntactic representations will engage the LpMTG and syntactic reanalysis the LIFG. To test directionality of the flow of information between LIFG and LpMTG during the re-analysis required for SUB sentences when the disambiguating word is heard, we performed dynamic causal modeling for event-related potentials (DCM-ERP). We asked whether the LIFG or the LpMTG would drive the re-analysis effects. We estimated the condition-dependent modulations in multi-directional connectivity between key regions in the left frontotemporal syntax network – LIFG and LpMTG. We specified L Heschl's Gyrus (LHG) as the model's input region. To define the exact time windows of transient connectivity changes we tested the modulations in connectivity via a 100 ms moving time window. In the comparisons of SUB to DOM sentences, the hierarchical Bayesian model selection showed that the SUB sentences required both feedforward and feedback connectivity. We found increased feedback [i.e. top-down] connectivity from the LIFG to LpMTG between 1-200 ms and 300-400 ms, and 400-500 ms after the onset of the disambiguating verb. Between 500-600 ms the LpMTG modulated activity in LIFG. These results show that the syntactic disambiguation involves a recurrent interaction between the LIFG and the LpMTG, and support our predictions that LIFG responds to and resolves local syntactic ambiguities through re-entrant activity in the LpMTG by means of top-down signaling [2]. 1. Macdonald, M.C., N.J. Pearlmutter, and M.S. Seidenberg, Lexical Nature of Syntactic Ambiguity Resolution. Psychological Review, 1994. 101(4): p. 676-703. 2. Tyler, L.K., Cheung, T. P., Devereux, B. J., & Clarke, A., Syntactic computations in the language network: Characterising dynamic network properties using representational similarity analysis. Frontiers in Psychology, 2013. 4: p. 271.

E67 Morphological triggers and the P600: ERP evidence for morphological expectations during sentence comprehension

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Although the P600 ERP component is traditionally associated with the processing of morphosyntactic anomalies, our understanding of this component is severely limited by confounds in stimulus design used in many studies. In many cases, morphological complexity of the critical word is fully confounded with the grammaticality of the sentence. In such cases, ungrammatical sentences either lack a required morpheme or contain an extra illicit morpheme, and the factors of grammaticality and morphological complexity

are not crossed. More recently, some have advocated balanced stimulus designs where stimulus complexity and grammaticality are fully crossed. However, these approaches do not account for possible modulatory influences of complexity on how morphosyntax is processed, such that valuable information may be lost when collapsing across levels of complexity in order to study effects of grammaticality. As numerous ERP studies have reported electrophysiological indices of morphological decomposition during lexical processing (in particular in single-word or priming tasks), this may mean that processes related to morphological decomposition and reprocessing ungrammaticality may have independent and additive effects on the P600 during sentence comprehension. However, given the aforementioned design confounds, such effects have not been systematically investigated. Here we investigated interactions between morphological complexity and grammaticality in English using a fully-crossed 2 (morphological complexity) by 2 (grammaticality) design. Native English-speaking participants read sentences that were either well-formed or ill-formed, and where the critical word was either morphologically simple or complex (e.g., "The sheep [should graze/*grazing]/[were grazing/*graze] in the pasture"). Results showed a reliable interaction between grammaticality and complexity, suggesting non-independent effects of the two manipulations. Specifically, there were no differences between the well-formed simple and complex critical verbs (was grazing/ should graze). However, there was a large difference in P600 amplitudes between the simple and complex ungrammatical conditions: P600s were significantly larger for morphologically complex ungrammatical stimuli (*should grazing) than for simple stimuli (*were graze). These findings have both methodological and theoretical implications. Methodologically, our results show that previous designs which both confounded and averaged across levels of complexity may not have provided an adequate characterization of factors related to reanalysis during morphosyntactic processing. Theoretically, our results show that overt morphological cues are most relevant and robustly processed in the face of an ungrammaticality, since there were no clear effects of morphological decomposition in grammatical sentences. However, in ungrammatical circumstances, overt morphology provides a more robust and reliable cue than null affixation. We discuss the grammatical/ ungrammatical dissociation in use of morphological cues in the context of expectation-based parsing models (cf. Lewis & Vasishth, 2005; Wagers et al., 2009).

E68 Asymmetric ERP responses within sub-conditions of "balanced" syntactic violation paradigms: P600s, "LANs", and additivity.

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[INTRODUCTION] Left/anterior negativities in syntax ERP research — both early (ELANs) and later onset variants — have been controversial and inconsistent, but the reasons for their unreliability remain unclear. Steinhauer & Drury (2012) argue one relevant factor may be that context-manipulations (e.g., "John wanted THE/TO ENJOY…") can introduce effects in baseline intervals that distort target-word responses, yielding artifacts that could be misinterpreted as violation effects. They recommend employing balanced/symmetrical paradigms (e.g., "John wanted to ENJOY/*MEAL… "/"John wanted the ENJOY/MEAL…") where both contexts/targets can contribute to averaged correct/ violation ERP responses. We have previously reported violation main effects for such paradigms (i.e., collapsing over the sub-conditions). Here we examine the (target-manipulation) sub-conditions, both for noun/verb word-category violations (examples above; STUDY-1) and for subject-verb agreement violations (STUDY-2: "The boys WALK/*WALKS…"/"The boy WALKS/*WALK…"). Our question was simply whether the sub-conditions within these paradigms generate uniform responses. [METHODS] Participants (STUDY-1, N=18; STUDY-2, N=30) viewed all sentences with standard RSVP (500 ms/word), and completed sentence-final acceptability judgments. EEG was recorded continuously and ERPs were extracted for 1700ms epochs time-locked to the onset of the pre-target word in STUDY-1. This allowed for different baseline analyses (intervals before the pre-target word onset and before the targets). For STUDY-2, we extracted 1000 ms epochs time-locked to the target verbs. Mean amplitude was the dependent measure in repeated measures ANOVAs for latency ranges consistent with LAN/N400 and P600-type effects. [RESULTS] STUDY-1 revealed a broad N400 effect for nouns in verbal contexts ("…wanted to *MEAL…"). Verbs in noun contexts ("…wanted the *ENJOY…") elicited a biphasic left temporal negativity (LTN) followed by a P600. In STUDY-2, illicit affixes ("They *WALKS…") yielded a LAN/P600, while the omission of a required affix ("He *WALK…") produced a monophasic P600. However, differences between sub-conditions in both studies may have been driven by the P600s. For STUDY-1, the violation negativity was N400-like when there was only a weak trend towards a subsequent positivity, and was left lateralized when there was a clear/significant P600. In STUDY-2, comparison of the violation sub-conditions showed broadly distributed posterior differences (not left/anterior differences) consistent with an earlier P600 onset for "He *WALK…" (i.e., canceling out the LAN). [CONCLUSIONS] Though the intent of STUDY-1 was to create balanced syntactic/word-category clashes, our findings may be reflecting two different types of violations: (i) an argument structure violation involving disruption of the expected thematic link between the main verb and the embedded infinitival clause ("… wanted to *MEAL…"), versus (ii) a local syntactic word category clash ("…wanted the *ENJOY…"). Earlier onset P600 effects in STUDY-2 for the missing affix case may reflect higher salience of the violation when the predicted form of the verb is the marked case. More broadly we argue that the combined set of results shed some new light on the (un)reliability of LAN-type responses and the importance of balanced/symmetric violation paradigms

in ERP research. We also discuss our data in light of recent suggestions that some LAN-type responses may be the result of superposition of N400 and P600 effects.

E69 The role of motor-relatedness and priming type in the processing of Dutch derived verbs

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There are several ways to find out whether morphologically complex derived words are decomposed or processed holistically. One possible method is morphological priming (priming between a complex word and its stem; e.g., understand – stand) [1], another is 'semantic-morphological' priming (priming between a complex word and a word semantically related to its stem; e.g., understand – sit; for a similar logic applied to compounds, see [2]). Semantically transparent derived words (derived words semantically related to their stems, e.g., koelen 'cool' in afkoelen 'cool down') are usually found to be primed with both types of priming, suggesting they are decomposed [1]. For semantically opaque derived words (derived words semantically unrelated to their stems, e.g., springen 'jump' in omspringen 'deal with'), results are mixed: Many priming studies (morphological and semantic-morphological) find no priming for opaque words, suggesting they are processed holistically [1], whereas results of some morphological priming studies suggest they are decomposed [3]. We used both types of priming with the same stimuli to find out whether type of priming influences results. In addition, we tested whether verbs of the more 'concrete' type, i.e. motor-related verbs, are processed differently from non-motor verbs. Another type of 'concrete' words, i.e. words with high 'perceptual strength' (degree to which a word is experienced through the senses), has been found to reduce lexical decision times compared to verbs with low 'perceptual strength' [4]. Two visual priming experiments were conducted (SOA 400 ms), one in which morphological priming was used (Experiment 1), one in which semantic-morphological priming was used (Experiment 2). Two different groups of 28 participants made lexical decisions on Dutch derived particle verbs. Half of these target verbs contained a stem with a motor-related meaning, the other half did not. In each condition, half of the verbs were semantically transparent, the other half were opaque. In Experiment 1, results showed an overall morphological priming effect: Particle verbs preceded by their stem were responded to more quickly than those preceded by an unrelated prime, independent of Transparency or Motor-Relatedness. With semantic-morphological priming (Experiment 2), however, only transparent motor-related particle verbs were primed by words semantically related to their stem. Results suggest that the morphological priming method may overestimate the degree of morphological decomposition, possibly due to method-specific processing strategies, and that robust evidence for morphological decomposition of verbs exists in particular for transparent and highly concrete, i.e. motor-related verbs. This finding will also be discussed in the context of embodied cognition theory. References: [1]Marslen-Wilson, W. D., Tyler, L. K., Waksler, R., & Older, L. (1994). Morphology and meaning in the English mental lexicon. Psychological Review, 101(1), 3-33. [2]Zwitserlood, P. (1994). The role of semantic transparency in the processing and representation of Dutch compounds. Language & Cognitive Processes, 9(3), 341-368. [3]Smolka, E., Komlósi, & Rösler, F. (2009). When semantics means less than morphology: The processing of German prefixed verbs. Language & Cognitive Processes, 24(3), 337-375. [4]Connell, L., & Lynott, D. (2012). Strength of perceptual experience predicts word performance better than concreteness or imageability. Cognition, 125(3), 452-465.

E70 A novel approach to investigating the neural correlates of syntax: a 'syntactic perturbation' paradigm during sentence production

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[INTRODUCTION] An elusive goal of neurolinguistics is the search for neural networks underlying syntactic operations. The present study investigated this by using a target perturbation technique during sentence production. Perturbation has been used previously to investigate lower levels of speech production. These studies involve auditory feedback perturbation and measure the neural response to perturbation and compensation (Tourville et al., 2008). Here, we adopted a similar approach at the sentence level in which the planned structure is perturbed in a constrained sentence production task. [METHODS] Subjects were instructed to produce simple sentences (active or passive; e.g., 'Mary is pushing Charlie', Kevin is being followed by Susan') through a series of cues. The initial cue denoted the subject, verb, and construction by way of an arrow (arrow pointing right for active, left for passive). Subjects were instructed to begin producing the sentence even though the final argument was not indicated. 250 ms after sentence onset, the cue updated to indicate the final argument, and subjects were trained to produce sentences naturally and incorporate the final information smoothly into their utterances. On 20% of trials, the subject's target syntactic structure shifted mid-utterance (e.g., active to passive), requiring the subjects to update their planned sentence (e.g., planned 'Mary is pushing Charlie', updated to 'Mary is being pushed by Charlie'). Our control condition consisted of identical cues where the subject's task was to produce a list of words rather than a sentence (e.g., 'Mary word left arrow Charlie), including the same proportion of switch trials (e.g., planned 'Mary word left arrow Charlie', updated to 'Mary word right arrow Charlie'). Subjects were trained on the task, during which subjects' production times and errors increased during switch trials, indicating the perturbation was effective. After training, subjects were scanned in fMRI. The sentence and list tasks were presented in separate runs. During scanning, subjects produced the sentences overtly but quietly, with standard fMRI parameters and continuous imaging. [RESULTS] The design produced three key contrasts: (i) active vs. passive (complexity), (ii) sentences vs. word lists (structure), and (iii) switch vs.

non-switch (perturbation). The complexity and structure contrasts revealed activity primarily in sensory-motor networks not implicated in sentence-level processes, unlike previous studies in sentence comprehension that reveal effects in Broca's area and/or the anterior temporal lobe (ATL). Both sentence and list perturbation activated a network previously implicated in go/no-go paradigms, while sentence perturbation showed enhanced activity in the right superior temporal sulcus, right inferior frontal gyrus (IFG), left inferior parietal lobe, and subcortical structures. The right IFG activation has been shown to be a key part of a "stopping" network for inhibition of responses (Aron et al., 2014). [CONCLUSIONS] Our results indicate that sentence production is an automatic process that must be inhibited, while list production is not – suggesting a special role for syntax in speech production. Additionally, regions typically implicated in syntactic processes (Broca's area & the ATL) were not active for any of the contrasts, suggesting that syntactic processing may rely on subcortical or different cortical networks.

E71 Noun/Verb Entropy: an MEG Study of Word-level Syntactic Category Ambiguity

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Some leading theories of Morphology in Linguistics (e.g., "Distributed Morphology," Halle & Marantz, 1993) propose that syntactic categories (noun, verb, adjective) are the result of affixation on a category-neutral root, as opposed to being represented as features of a lexical stem. Given full decomposition accounts of complex word recognition, this predicts a distinction between recognition of noun/verb category ambiguity, which would be parallel to ambiguity in the morphological continuation of a stem, and the recognition of stem ambiguity, e.g., in cases of homophony and polysemy. This study presents findings from an MEG study of visual word recognition, using words that are without overt affixation and ambiguous between noun and verb, investigating whether early (before 500ms) categorization of a word between noun and verb shows neural parallels to meaning and sense disambiguation or brain activity plausibly related to affixal continuation ambiguity. 12 native English-speaking participants (8 female) at NYU Abu Dhabi's Neuroscience of Language Lab participated this visual lexical decision task, using 313 word items without large correlations between noun-verb (N/V) entropy (calculated from relative frequency of the item as noun or verb estimated via CELEX) and variables of interest: inflectional and derivational (continuation) entropy, word frequency, and number of senses. Inverse solutions were computed using MNE on averaged data within each subject, then source activation was computed on individual trials. Three kinds of analyses were run: (1) millisecond by millisecond linear mixed effects regression predicting neural activity in left-temporal anatomical regions of interest (ROIs) from the variables of interest (above); (2) regression over functional ROIs identified by activation peaks in the grand average across items and subjects; and, (3) t-maps of significant correlations at each source with each variable of interest. The results of (1) and (2) were sufficient to rule out the hypothesis that the effects of N/V entropy could be reduced either to homophony (separate, competing representations for noun and verb use) or polysemy (noun, verb representations like related meanings of polysemous stem). In particular, on ROI analyses, activation before 300ms post-stimulus onset displays non-overlapping patterns of significant correlations for the N/V entropy, homophony and polysemy variables. From (3), we see early (near ~200ms) effects of N/V entropy in anterior temporal areas associated in other experiments with lexical decomposition (e.g., Fruchter, Stockall & Marantz, 2013; Linzen, Pylkkänen & Marantz, 2013). The homophony variable exhibits a strong middle temporal effect towards ~250ms in line with previous experiments on the effects of meaning entropy in recognition (Simon, Lewis & Marantz, 2011). Polysemy shows weaker effects distinct from the other two variables. Interestingly, the location of correlations with all three variables seem to converge on the posterior, superior left temporal lobe around ~300ms. Early correlations for syntactic categories during lexical processing suggest that these categories may be determined before syntactic integration (such as proposed in Tyler, et al., 2011). The findings support the decomposition hypothesis about the representation of syntactic categories; further, the current data support an independent effect for the N/V entropy of bare stems.

E72 Agreement Attraction in the Neural Language System

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One of the fundamental processes in language comprehension is the processing of dependencies between grammatical elements such as agreement relations between verbs and their arguments. Understanding the time course and localization of this processing is a central goal of neurobiological investigations of language comprehension. To this end we conducted an experiment which investigated the visual processing of subject-verb agreement dependencies in English with concurrent EEG and MEG recording. We selected stimuli which included an agreement attraction configuration wherein a "distractor" non-subject noun provided the possibility for erroneous grammatical parses assigned to ungrammatical verbs. Virtually no neurolinguistic studies examine agreement dependencies, let alone attraction configurations (especially in the MEG methodology). 19 (of 24 planned) participants read 384 sentences with a prepositional modifier attached to a subject (The key(s) to the cabinet(s) obviously was/were rusty from years of disuse.) in a rapid serial visual presentation paradigm. The grammatical number of the subject noun (key(s)), non-subject distractor noun (cabinet(s)), and target verb (was/were) were fully crossed in a 2x2x2 design. After each sentence, subjects performed an acceptability judgment. The acceptability responses reveal a clear attraction result: compared to wholly unacceptable sentences, acceptability ratings are higher when the two nouns are mismatched, and plural distractor nouns

with singular subjects yield higher error rates than singular distractors with plural subjects. ERP analysis reveals a positive-going deflection in ungrammatical configurations relative to grammatical configurations in the 500-700 ms latency range. This positivity is centro-posterior in distribution and is therefore interpreted as an instance of the P600 effect typically observed for ungrammatical agreement dependencies. Moreover, this P600 is reduced in amplitude under the same conditions driving higher acceptability ratings: the P600 for plural distractors is reduced relative to singular distractors and fully ungrammatical sentences where the verb matches neither noun (the attraction configuration). MEG analysis reveals a decrease in the evoked magnetic response to ungrammatical sentences relative to grammatical ones at the same latency as the observed electrical P600. This decreased activation is higher at occipital sites and is driven by a attraction-configuration change overlaid on top of the M170 to the word immediately following the target region. Additionally, similar patterns of activation are found at the target verb itself in the pars triangularis (BA 45) and superior temporal gyrus (BA 22p/41/42). The results of this study argue for a parsing-mediated interpretation of the P600 given the reduction in amplitude that correlates with behavioral errors indicative of the illusion of ungrammaticality. Furthermore, the MEG results reveal that there are ERF correlates of grammatical dependency violations which can be observed at both occipital and left-temporal locations in the 500-700ms post-stimulus window. Finally, the results here suggest that MEG activation is inversely correlated with the success of dependency processing (and therefore the ERP response), a fact which is consistent with the emerging literature on MEG correlates of grammatical dependency processing.

Control, Selection, Working Memory

E73 Beyond Broca's area: an fMRI study of individual differences in domain-general mechanisms contributing to sentence comprehension

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Successful sentence comprehension requires rapidly integrating relevant phonological, prosodic, syntactic and contextual information. There is ample evidence that this complex process recruits large-scale networks including domain-general processes such as working memory, attention, semantic memory and cognitive control. However, there is much debate regarding how these processes are contributing to sentence comprehension, and the neuroanatomy supporting these contributions. This debate has largely focused on Broca's area. For example, separate previous studies indicate that portions of Broca's area responding to increased complexity in syntactic structure overlap with regions engaged by working memory (i.e. articulatory rehearsal) and cognitive control (i.e. the classic visual Stroop task) (Rogalsky et al. 2008; January et al. 2009). However, no previous studies have investigated both of these processes within the same subjects in relation to sentence comprehension. A further complication is that the impact of input modality (listening versus reading) has not typically been taken into account. In addition, previous work has focused on group-averaged results, which may be masking the involvement of other areas that support domain-general processes, due to individual differences in anatomical variability and functional organization. To begin to address these issues, the current fMRI study examines the neuroanatomy of sentence comprehension in relation to verbal working memory and cognitive control processes, using auditory stimuli and individual subject analyses (in addition to standard group analyses for comparison). Healthy adult control subjects engaged in three different paradigms during fMRI acquisition: (i) listening to sentences and making plausibility judgments, (ii) a verbal working memory task, i.e. articulatory rehearsal of nonwords, and (iv) an auditory Stroop task (Christensen et al. 2011). Our group-level analyses indicate that the Stroop and working memory tasks activate highly overlapping areas in Broca's area (in both left pars opercularis and triangularis; $p < .05$ FDR corrected). These results would seemingly suggest that the contribution of Broca's area to sentence comprehension may be via a domain-general process evoked during both the working memory and auditory Stroop tasks. However, preliminary individual subject analyses provide a more complicated picture: In each individual subject, there was overlap between the working memory and Stroop tasks in either pars opercularis or pars triangularis, but there were also distinct pars opercularis regions responding to articulatory rehearsal, and distinct pars triangularis regions for the Stroop task. Whole-brain individual subject analyses indicated that canonical sentences, articulatory rehearsal, and the congruent Stroop trials activated similar networks including Broca's area, Spt, and STS. The noncanonical sentences and the incongruent Stroop trials also activated this network, in addition to inferior parietal lobule (IPL) regions. There was significantly greater inter-subject variability for the latter conditions, particularly regarding Spt, STS and IPL involvement. These findings suggest that the neural computations of sentence comprehension are supported by multiple distinct domain general processes, which may be best characterized by exploring beyond Broca's area.

E74 Memory retrieval during pronoun processing relies on coherent theta oscillations between frontal and posterior cortex

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Pronoun processing during sentence comprehension requires retrieval of specific items from a sentence-level working-memory representation. Successful retrieval requires the processing of the temporal order of items. Because neural oscillations in the theta band are crucial for the processing of the temporal order of items in working memory, we hypothesized that

working-memory retrieval during pronoun processing should be associated with increasing theta power. Such an increase should be observed over prefrontal cortex, known to support the processing of item order. Moreover, prefrontal cortex should synchronize with posterior cortex, assumed to support item retention. In our electroencephalography experiment, we manipulated retrieval demands by contrasting the processing of pronouns requiring antecedent retrieval from either a simple, non-embedded, or complex, embedded sentence. We combined scalp-level time–frequency analysis, source localization, and source-level coherence analysis. Results showed a frontal-midline and broad left-hemispheric theta-power increase for embedded-noun as compared to non-embedded-noun retrieval, which was predictive of retrieval performance. Neural generators were localized to the left-prefrontal cortex, alongside left-parietal and bilateral-inferior-temporal cortices. Source-level coherence analysis revealed increased synchronicity between left-frontal and left-parietal and between left-frontal and right-inferior-temporal cortices. Our results suggest that increasing synchronicity between left-prefrontal and left-parietal cortices may reflect the selection of the appropriate antecedent noun inside the sentence-level working-memory representation. Increasing synchronicity between left-prefrontal and right-inferior-temporal cortices may reflect the selection of the noun's lexical-semantic long-term-memory representation. Our results provide evidence for a functional role of network-level theta coherence, concerting the interplay of brain regions subserving temporal-order processing, working memory, and long-term memory, during pronoun processing.

E75 Re-arrangement of functional networks when listening to auditory inputs with differing artificial grammars

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Introduction: The degree to which the brain's functional networks rearrange or maintain their structure in relation to input features is a pivotal topic in neuroimaging research, carrying particular weight for the neurobiology of language and auditory processing. Specifically, it is unclear whether specific properties of a given grammar themselves impact functional network organization during auditory processing. We used fMRI and a network modeling approach to understand whether functional sub-network ("modular") organization is stable in the face of changes to grammar properties. We find that the nature of grammar fundamentally alters modular arrangement, with weakest effects in the DMN and sensory networks, and strongest effects in lateral temporal and lateral prefrontal regions. Method: We presented 19 participants with auditory streams (100 sec) constructed from regular grammars (4 tones presented with repetition), varying in strength of transition constraints. We focus here on the "Random" condition—where the grammar lacked any transition constraints (Markov Entropy = 2bit)—and the "Highly ordered" condition, for which the grammar contained such constraints (Markov Entropy = 0.8bit). For every participant in each condition, we cross-correlated each voxel's time series against those of all other voxels. Connectivity matrices were then thresholded at 5% connection density, and the thresholded matrices submitted to a modularity-partitioning algorithm (Blondel, Guillaume, Lambiotte, & Lefebvre, 2008), which returns the most modular partition of the data. We then quantified, for each voxel (node) the proportion of within-module connections in the Random condition that were also within-module connections in the Highly Ordered condition. This measure (single-node sent consistency; SNSC) indexes similarity of modular organization between conditions, with the advantage of offering data at the single-node level. These SNSC values were then averaged across participants to create a group map. Appropriate null (sampling) distributions were constructed to account for the stochastic nature of the partitioning algorithm itself. Results: The distribution of SNSC values, quantifying for each node the proportion of preserved within-module connections across the Random and Highly Ordered conditions, centered around 0.2, with few voxels having values above 0.5. This distribution of values was dramatically lower than that of the null distribution, which had a median SNSC value of 0.91. Furthermore, SNSC values clustered spatially, consistent with the topography of known functional networks. SNSC was highest in areas within the DMN, but also bilateral insula, and visual and motor regions. In contrast, SNSC values were low in areas such as the superior temporal sulci, and middle frontal gyri. Interestingly, SNSC magnitudes were low in the right inferior frontal gyrus but high in the left. Conclusion: Our results show that functional networks reorganize depending on input regularity, but not uniformly. Some networks tend to maintain their modular structure, whereas others re-arrange depending on input features. These findings indicate that there is no single network that processes features of regular grammars. Rather, differing transition constraints within the grammar itself alter the way in which functional brain networks instantiate.

E76 Recasting the eLAN as an Attentional Efficiency-dependent Enhancement of the N100

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Researchers have long been interested in the nature/extent of the language system's interfaces with domain-general cognitive systems. The current study was designed to investigate the relationship between language and attention, neglected due to an emphasis on the language/working memory interface [1]. We investigate this relationship using the eLAN, an early (100-300 msec) left-anterior negativity originally elicited [2] by comparing "word-category violations" (WCVs) to their controls, and interpreted as indexing first-pass structure-building operations [3]. ["The man admired {sketches/*Don's} OF sketches the landscape."] Rather than a response indexing linguistic [3] or low-level sensory processes [4], we hypothesized that eLAN is ontologically an attentional response. While we agree with the latter interpretation [4], it lacks a mechanistic

explanation as to why WCVs elicit eLAN – which we believe an attentional account provides. WCVs by hypothesis engage the executive attentional system when comprehenders monitor for ungrammaticality, orienting them to unexpected, task-relevant stimuli [6], resulting in selective attention to WCVs, enhanced sensory processing, and an increase in N100 amplitude [7]. The efficiency of these attentional processes is highly variable across individuals, as demonstrated more generally by performance on the Attention Network Task (ANT) [8], which yields estimates of the efficiency of the brain's attentional alerting, orienting, and executive networks [6]. We hypothesize that the efficiency with which the brain processes linguistic input, here indexed by eLAN, depends on the efficiency of these attention systems, and that, if so, the physical parameters of the eLAN will co-vary with the efficiency of executive and/or orienting networks. METHODS: We recorded ERPs and behavioral responses while 32 participants completed the ANT and a sentence processing experiment containing WCVs and their controls (40 per condition), embedded in 240 fillers as in [2]. RESULTS: Behavioral ANT results were consistent with the literature, demonstrating independence of an individual's attention networks (all $R2 < .23$), and variability in attentional network efficiency within and across participants. eLAN effects were also highly variable across individuals. We divided participants into high- and low-efficiency (alerting, orienting, and executive) groups based on a median split of ANT performance. Significant eLAN effects were observed only in those with low-efficiency orienting systems ($p < .05$) and those with low-efficiency executive systems ($p < .05$), but not in their high-efficiency counterparts (all $p > .5$). Moreover, eLAN effects were either present or absent across attentional efficiency groups, whereas LAN, N400, and P600 effects were present in all groups, and showed only minimal differences in latency, amplitude, and distribution across groups. Correlational analyses are ongoing. CONCLUSION: These data suggest eLAN effects may be mere attentional modulations of the N100. We hypothesize that while comprehenders with high-efficiency attentional systems possess adequate resources to accommodate WCVs, low-efficiency comprehenders must recruit additional selective attentional resources to process WCVs, thereby increasing N100 amplitude. This finding highlights the importance of investigating cognitive systems beyond working memory in sentence processing research. References:[1] Münte et al.(1997), [2] Neville et al.(1991), [3] Friederici(2002), [4] Dikker et al.(2009), [5] Chomsky(1965), [6] Corbetta&Shulman(2002), [7] Hillyard et al.(1973), [8] Fan et al.(2002)

E77 The Role of the Right Hemisphere in Langauge Comprehension: A Dynamic Causal Modeling Investigation

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Although the language network is predominantly left-lateralized, the fact that the right hemisphere (RH) contributes significantly to language is uncontroversial. In particular, neuroimaging experiments and patients studies have provided significant evidence of RH contributions to complex tasks such as irony, metaphor, and inferencing. Despite increasing amounts of research, however, the nature of the RH contributions and the mechanisms by which they are integrated into the stream of LH language processing are still debatable. One contemporary theory of RH language contributions, the Spillover Theory (e.g., Prat, Mason, & Just, 2011) proposes that the RH provides additional processing capacity to the LH, which can be exploited on an as-needed basis when task difficulty temporarily overloads the dedicated LH language regions. The Spillover Theory makes specific predictions about when and why integration between hemispheres occurs. However, it is difficult to determine the mechanisms underlying RH Spillover using conventional brain imaging analyses, which are primarily correlational. To examine potential mechanisms underpinning RH Spillover, we used Dynamic Causal Modeling (DCM), a neuroimaging analysis technique that allows users to directly compare how well alternative network-level models of brain function explain fMRI data. DCM was applied to an existing dataset (Prat & Just, 2011) in which participants performed a sentence comprehension task under varying intrinsic (syntactic complexity) and extrinsic (addition of a secondary working memory load) demands. Specifically, four models were generated, which covered a range of possible mechanisms by which LH and RH language processes might be integrated, and how task difficulty might influence this integration. In the LH-directed spillover model, additional processing demands modulate the pathways from Broca's area to its RH homologue, thus generating a "spillover" of neural activity in which the LH would influence the RH increasingly as task difficulty increased. In the bidirectional spillover model, the integration of information increases bi-directionally as difficulty increases, thus giving the LH language regions the opportunity to both influence and be influenced by RH contributions. In the RH-direct model, on the other hand, additional demands only modulate pathways from the RH to the LH, assuming that as demands increase, the RH's influence on LH language processes increases, but the LHs influence on the RH reserve does not change. Finally, in the parallel processing model, additional demands directly affect the RH parallel to the LH, but the degree to which the two hemispheres influence one another does not change. The four models were compared using a Bayesian Model Selection random effects procedure, where subjects were the random factor. The results show uncontroversial support for the RH-directed model, whose exceedance probability was 0.55, while the exceedance probability of the other three models in combination was barely 0.45. Thus, our results suggest that, while the LH hemisphere remains in control of language processing, the influence of the RH on LH language processes dynamically increases as the processing demands of a task increase. These findings

support the Spillover theory by suggesting that RH language contributions become more important as the demands of a task increase.

Language Disorders

E78 Cognitive development in dyslexia

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Introduction. The Bergen Longitudinal Dyslexia Study is a population based study that has followed a group of children from the age of 5 until the age of 12. The children were individually assessed with an extensive test battery when they were 5, 6, 7, 8 and 11 years old. Results have been published on early prediction, intervention, and functional brain imaging. Here we present cognitive benchmark scores on the background of literacy scores in L1 (Norwegian) and L2 (English) from the children who developed dyslexia and the children who did not develop dyslexia. In accordance with our earlier published data, we expected to see significant group differences. However, literacy and cognitive skills have shown to be reciprocal, and we therefore expected to see a gradual decrease in cognitive group differences by age. Hence, also the correlation between literacy scores and cognitive scores should decrease by age. Since emergent literacy in L1 and L2 typically take different steps of development, we hypothesized that a correlational decrease might not be seen between the L2 scores and the cognitive scores. As dyslexia is defined as a multifactorial impairment, it was expected that individual cognitive mapping would exhibit a substantial degree of variation in cognitive benchmark scores in the dyslexia group. Method. The subjects (Dyslexia, n = 13; Typical, n = 28) were all from the population based cohort of 109 five year old children at project start. Longitudinal cognitive data were on phonological awareness, short term memory, working memory, rapid naming, visuo-spatial skills, long term memory and language comprehension. All longitudinal literacy scores showed significant group differences. Here we report from the age 11 scoring only. The cognitive data were analysed by repeated measures ANOVA in a group by age design, and by correlating them with L1 and L2 scores. Finally, individual dyslexia cognitive scores were mapped for a closer insight into the variability in dyslexia. Results. First, although group differences in literacy scores were highly significant, the group differences in cognitive scores decreased by age. Second, the correlation between the L1 literacy scores and the cognitive scores became weaker by age, while the opposite was seen with the L2 scores. Third, the individual variations in cognitive scores within the dyslexia group were substantial, with a higher number of low scores in the boys compared to the girls. Discussion. The diverging development of literacy skills (stable significant group differences) and cognitive skills (group differences gradually decreasing) may explain some of the inconsistencies seen in dyslexia research. However, the strong correlation between the early age benchmark cognitive scores (especially rapid naming and visuo-spatial scores) and later literacy scores indicates how basic these skills are to L1 literacy development. Another pattern was seen in L2, with higher correlation by age, especially as to phonological awareness, short and long term memory, rapid naming and language comprehension. The variations seen in cognitive skills in the dyslexia group indicate the importance of individual assessment to find efficient methods of intervention.

E79 Dysgraphia in Patients with the Behavioral Variant of Frontotemporal Degeneration and Primary Progressive Aphasia.

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Patients with primary progressive aphasia (PPA) demonstrate language production difficulties in spoken communication, including errors of grammatical structure as well as speech-sound errors. Patients with behavioral variant frontotemporal degeneration (bvFTD) also have speech production deficits. However, studies of written production in PPA and bvFTD have been rare. We analyzed production of a written sentence about the weather in 65 patients, including nonfluent/agrammatic PPA (naPPA, n=8), logopenic variant PPA (lvPPA, n=16), semantic variant PPA (svPPA, n=6) and bvFTD (n=35). Patient groups were matched for MMSE and education ($p>0.05$). Two independent raters, blind to patient diagnosis, analyzed written sentences for grammatical errors. We also analyzed other writing errors, including: Real word errors, subdivided into phonologically-related and semantically-related substitution errors; and Non-word errors, subdivided into phonologically-plausible and phonologically-implausible substitution errors. Groups were matched for the number of words they attempted to write ($p=0.432$). A chi-square test showed a significant group difference for grammatical errors, [$X2(4)=10.59$, $p=0.032$]. Relative to one control subject (6.3%) who made a grammatical error, 5 naPPA patients (62.5%), and 4 svPPA patients (66.7%), 8 lvPPA patients (50%), and 12 bvFTD patients (34.3%) produced grammatical errors in written sentences. We also observed a trend for producing other writing errors [$X2(4)=9.16$, $p=0.057$]. Although no control subjects committed other writing errors, 8 bvFTD patients (22.9%), 2 svPPA patients (33.3%), 2 naPPA patients (25%), and 6 lvPPA patients (37.5%) committed other writing errors. The majority of other writing errors were phonologically plausible non-words (46.9%), followed by phonologically implausible non-words (25%). Errors in written expression are common among patients with bvFTD, svPPA, naPPA, and lvPPA. The presence of grammatical and other writing errors occurred despite the presence of a written record and the opportunity to correct production. Grammatical errors thus cannot be attributed entirely to a short-term memory deficit, and letter substitutions cannot be easily attributed to motor speech abnormalities. Study Supported By: NIH (AG017586, AG032953, NS044266, AG38490, NS053488, and the Wyncote Foundation)

E80 Computer-based rehabilitation for central alexia

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Central alexia is the broad category of acquired reading disorders that occur with aphasia, including specific disorders such as phonological dyslexia, surface dyslexia and deep dyslexia. Examination of a local database of 114 aphasic patients suggests the prevalence of central alexia is around 67%, and yet rehabilitation of the disorder is underreported in the existing literature. However, reading disorders are ideally suited to computer-based interventions as an adjunct to conventional speech and language therapy, as they can be practiced at home without the need for a conversation partner, freeing up therapists' time to focus on other aspects of speech and language. In this poster, we will describe the development of an Android App for reading training called 'iReadMore', which aims to improve single word reading speed and accuracy in central alexia. This software follows similar principles to that described by Woodhead and colleagues1, using repeated presentations of written to spoken word pairings to strengthen the association between orthographic and phonological representations. The redeveloped App now incorporates semantic support for word recognition using word-picture pairings as well as written-spoken word pairings. The usability of the App has been enhanced through 'gamification', with the aim of encouraging intensive and long-term use by making it more game-like and engaging. Furthermore, the software features improved adaptability by progressing through difficultly levels varying in written words exposure duration and accuracy criterion according to performance. Initial beta testing of iReadMore has been conducted with a group of 6 users with central alexia. User feedback highlighted the importance of personalisation of the difficulty parameters to allow for the large variability in severity in this heterogeneous patient population. Technical considerations of the Google Nexus platform were also examined. The lightweight tablet and intuitive software design enhanced the accessibility of the therapy for the testing group who varied in motor dexterity and previous computer experience, but some issues were observed with the fine motor control required for touch screen 'tapping'. Feedback from the test group will be used to further develop the App prior to a baseline-controlled trial with 24 patients. A within-subjects crossover design will be employed to test the efficacy of the software, and also whether the application of anodal transcranial direct current stimulation to the left inferior frontal gyrus may enhance the behavioural improvements in reading speed and accuracy. 1 Woodhead, ZVJ, Penny W, Barnes GR, Crewes H, Wise RJS, Price CJ, Leff AP (2013). Reading therapy strengthens top-down connectivity in patients with pure alexia. Brain, 136, 2579-2591.

E81 Single word reading after left hemisphere stroke: a VLSM analysis

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Studies of acquired language disorders have provided much of the fuel for debate over whether different areas of the brain subserve reading of different word types. Reports of patients who read real words more accurately than pseudowords offer evidence for the existence of a system in the brain that allows mapping of orthography to phonology without semantics. Part of what is debated is whether this system is independent, or is inextricable from the system used for reading real words with lexical-semantic value. The technique known as voxel-based lesion symptom mapping (VLSM) can inform this debate by relating brain damage to behavior on a voxel-by-voxel basis. In previous studies, VLSM has revealed areas critical to aspects of language such as picture naming (Baldo et al., 2013), repetition (Fridriksson et al., 2010), and number vs. word reading (Piras & Marangolo, 2009). In the current study, we used VLSM to examine reading of specific types of single words. We gathered high resolution scans for twenty-four people with chronic left hemisphere strokes and traced each lesion manually. All but 2 participants met the Western Aphasia Battery criteria for diagnosis of aphasia. Within a few days of the scan, participants read 6 lists of words aloud: 3-4 letter pseudowords, a list of real words matched to the pseudowords by altering a single letter, a list of abstract and concrete words matched for length and frequency, and the PALPA list of exception/regular words. Participants were given 10 seconds to respond to each word. We then used MRIcron to create VLSMs for each reading test. On all tests, higher scores indicated better performance. Lesion density threshold was set at 10%. Lesion maps for pseudoword reading vs. real word reading were surprisingly distinct. Though we did not correct for multiple comparisons in this preliminary analysis, there were almost no areas of overlap. VLSMs for real word reading yielded superior temporal sites, while pseudoword reading scores yielded inferior frontal sites. It is unclear what aspect of oral reading the pseudoword maps reflect. However, the results from the other word types provided some insight. VLSMs for abstract and concrete word reading revealed that abstract word reading score was related to lesions in frontal areas similar to those that were related to pseudoword reading score, while concrete words, with their greater semantic content, were associated with superior temporal areas. Assessment of the maps for reading of exception vs. regular words, which do not differ in terms of semantics, revealed no frontal/temporal distinction and, in fact, showed near complete overlap of the two maps in inferior frontal/parietal areas. These results suggest that the distinct difference in the maps for PW vs. word reading in this sample is more likely due to the lack of semantics in PWs than to the more difficult phonological decoding needed to produce them aloud. More subjects and more stringent thresholds are needed to solidify these results.

E82 The Role of Subcortical Structures in Language: Evidence from Lesion Data

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Introduction. Recent psycholinguistic and neurolinguistic models of language have postulated that the subcortical basal ganglia nuclei have a functional role in the 'rule system or the mental grammar of language' (Mouthon,

Annoni, & Khateb, 2013; Lieberman, 2002). However, clinical investigations of cases of aphasia following basal ganglia lesions did not yield results supporting a clear role for these structures in language. Most studies of aphasia following basal ganglia lesions characterize it as a transient one (Fabbro, 1997).The transient nature of subcortical (BG) aphasia was thought to be the result of cortical hypoperfusion and the subsequent recovery in cortical perfusion results in improved language functions in cases with BG lesions (Hillis et al, 2004; Olsen, Bruhn, & Oberg, 1986).On the other hand, a few studies of subcortical (BG) aphasia have reported on persistent aphasia in a few cases (Robin & Schienberg, 1990; Sapir, Kokmen & Rogers, 1986). There are very few longitudinal studies of functional recovery of subcortical aphasia. No longitudinal follow up studies of patients with crossed subcortical aphasia (Della Rosa et. al, 2014). Longitudinal studies of aphasia related to BG lesions will offer support for the non-transient nature of language impairments in such cases. Method. A longitudinal case study was undertaken to document the persistence of symptoms of an adult with subcortical aphasia. Subject. SE, a 69-year-old right-handed female had a sudden onset of speechlessness and left-sided hemiplegia. A repeat CT scan revealed hemorrhagic cerebrovascular accident that damaged right frontal lobe under the anterior horn of the lateral ventricle, the head of caudate and putamen of the right hemisphere (Figure 1). The left hemisphere was spared. In the acute stage, SE's communication status was characterized by global aphasia. In the sub-acute stage, global aphasia began to resolve. At one month post-onset, SE's language deficits resembled the profile of Broca's aphasia. In addition, SE's speech was characterized by moderate to severe apraxia of speech. Testing at six year and 11 year post-onset involved the use of Apraxia Battery for Adults (ABA), Boston Diagnostic Aphasia Examination (BDAE), Discourse analyses (Conversation & narrative), Discourse Comprehension Test, Psycholinguistic Assessment of Language Performance in Aphasia (PALPA), Reversible Sentence Comprehension Test, Linguistic Ambiguity Comprehension Test, Grammaticality and Semantic acceptability assessment. Results and Discussion. Subcortical aphasia associated with basal ganglia lesion can persist for a long period, as in the case of SE. The occurrence of symptoms related to phonologic-articulatory production and Word production deficits can be accounted for by the modified version of Crosson's model (Fabbro, 2002).However, this model does not account for the occurrence of agrammatic Broca's aphasia. The notion of mental grammar associated with the procedural memory system which is reportedly neurologically rooted in the basal ganglia can account for agrammatic symptoms of SE. The cortical hypoperfusion-related explanation for the occurrence of subcortical aphasia may not be applicable for every single case with BG lesions. The persistent subcortical aphasia conditions reported in the literature further points to the need for more systematic longitudinal studies of cases with BG lesions (Robin & Scheinberg, 1990).

E83 Statistical learning and overnight consolidation of an artificial grammar: Evidence from adults with and without aphasia

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Human adults have a remarkable capacity for discovering structure based solely on statistical properties of the input, and this statistical learning is proposed to play an important role in language learning. However, few studies have examined statistical learning in individuals with aphasia or tested long-term retention of this type of learning. The present study investigated statistical learning and next-day retention of an artificial grammar in healthy young and older adults and individuals with aphasia in two experiments. Both experiments used an artificial grammar in which pseudowords are ordered in short sentences according to phrase structure rules (Saffran, 2002). Experiment 1 examined the effects of amount and type of training in statistical learning. 75 monolingual young adults were randomly assigned to one of four training groups or to an untrained control group. The four training protocols consisted of either exposure training (i.e., listening to grammatical sentences) or active training (i.e., deciding which sentences are grammatical and receiving feedback on the accuracy of their answers) with either a short (i.e., 200 sentences) or long (i.e., 400 sentences) amount of input. All participants completed a grammaticality judgment test at the end of the first day and again the next day. Experiment 2 examined statistical learning in adults with and without aphasia. Nine individuals with stroke-induced agrammatic aphasia and 12 age-matched healthy adults listened to grammatical sentences in the artificial language for 30 minutes, completed a grammaticality judgment test, and returned the next day to complete the judgment test again. An additional 10 age-matched healthy participants served as an untrained control group by completing the two judgment tests without receiving the exposure training. Results from Experiment 1 showed that the long exposure and long active training groups performed significantly better than the control group immediately following training, but only the long active group performed significantly better than the control group the next day. Additionally, a significant time by type of training interaction effect indicates that individuals who received short or long active training tended to increase in grammaticality judgment scores on the second day compared to the first day, whereas individuals who received short or long exposure training tended to decrease. Results from Experiment 2 indicated significant statistical learning of the artificial grammar immediately following training in trained healthy and aphasic adults. Trained healthy individuals tended to decrease slightly in their grammaticality judgment scores the next day, but they remained significantly above chance performance. Participants with aphasia showed greater individual variability in overnight consolidation and as a group did not remain above chance performance on the second day. The findings from this study suggest that individuals with agrammatic aphasia, as well as healthy young and older adults, demonstrate statistical

learning based solely on exposure to grammatical structures. However, overnight consolidation of grammar learning may be compromised in some individuals with aphasia. Additionally, in healthy young adults, active training methods incorporating task practice and feedback promote better overnight consolidation of grammar learning compared to purely exposure-based training.

E84 LONGITUDINAL DECLINE IN SENTENCE COMPREHENSION IN PRIMARY PROGRESSIVE APHASIA AND BEHAVIORAL VARIANT FRONTOTEMPORAL DEGENERATION

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INTRODUCTION: A subset of patients with frontotemporal degeneration (FTD) have primary progressive aphasia (PPA), characterized primarily by declining speech and language but minimal change in other areas of cognition. In addition to non-fluent speech, patients with the non-fluent/agrammatic variant of PPA (naPPA) have grammatical difficulty in their speech production and may also have impaired grammatical comprehension. Patients with the logopenic variant of PPA (lvPPA) may overlap in part with the speech characteristics of naPPA since they both have reduced speech fluency, although we are unaware of comparative studies of grammatical comprehension lvPPA and naPPA, nor comparative studies examining the decline of grammatical processing in PPA. Finally, non-aphasic patients with a behavioral variant of FTD (bvFTD) also appear to have some language difficulties. METHODS: We examined profiles of declining grammatical comprehension in patients with naPPA (n=5), lvPPA (n=9) and bvFTD (n=10). These patients were diagnosed according to published criteria. The PPA groups and healthy controls (n=22) were matched for age and education. Patients were not demented at first assessment, with average MMSE scores >25, but patients differed from controls in MMSE at $p<0.01$. Patients were assessed at two times, separated on average by 20.2 months, and the duration between assessments did not differ between patient groups. MMSE declined between the two assessments (range 2-6 points), but this did not differ between patient groups. We assessed grammatical comprehension with a two-alternative, forced-choice, sentence picture-matching task. Sentences had two semantically-unbiased actors interacting with a reciprocal action, and pairs of pictures associated with each sentence exchanged the roles of the actors. We used a fully penetrated design where sentences were manipulated to have a cleft structure or a center-embedded structure, were subject-relative or object-relative, and included a three-word prepositional phrase between the subject of the main clause and the trace in the subordinate clause or the phrase was placed at the end of the sentence. We also assessed, digit span forward and reverse, Boston naming test, letter-guided category naming fluency. RESULTS: At baseline, overall comprehension performance differed between groups ($F[3,45]=11.34$; $p<0.001$). Both naPPA and lvPPA differed significantly from controls ($p<0.001$). At the second assessment, all groups – including patients with bvFTD – differed significantly from controls ($p<0.001$). The rate of decline in performance was equivalent across groups ($p>0.50$). We correlated the difference score between Time 1 and Time 2 grammatical comprehension assessments with neuropsychological performance, and found that bvFTD patients' decline was significantly correlated ($p<0.01$) with digit span forward and digit span reverse. CONCLUSION: PPA and bvFTD patients' grammatical comprehension declined at an equivalent rate over about 20 months, but progressive comprehension deficits appeared to be due to different sources of impairment. Decline in bvFTD patients' performance was related to limited short-term memory resources, consistent with our previous cross-sectional findings, but decline in PPA appeared to be related to progressive grammatical processing difficulty. Progressive disease thus compromises multiple aspects of a large-scale language processing system, leading to declining sentence comprehension over time. Future work can establish the anatomic basis for these longitudinal changes.

E85 Aphasia rehabilitation from a linguistic perspective and the role of tDCS

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Background. Aphasia therapy that focuses on abstract properties of language improves aphasic disorders. Neuromodulation with transcranial Direct Current Stimulation (tDCS) increases effect size of aphasia therapy. In this study, we combine both strategies by administering tDCS while treating inflected verb production at the sentence level, using cues that promote knowledge and realization of argument structure and tense morphology (the Italian ACTION, adapted from Bastiaanse et al., 1997). We assess the role of tDCS and behavioral training in promoting improvement, and evaluate whether it affects not only trained, but also untrained verbs. Method. Five patients with post-stroke aphasia participated in this study. All presented with deficits in the phonological output lexicon and phonological output buffer. They made errors in thematic role assignment during sentence comprehension and in realization of predicate argument structure during speech. A mild semantic deficit was present in two patients. Twenty daily, 1-hour treatment sessions were provided over two phases, in a double-blind study. In each phase, patients received 20 minutes of tDCS or sham per session. Stimulation site was determined individually, based on MRI scans. Production of infinitives (henceforth, VInfinitive), finite verbs (henceforth, VFinite) and sentence construction (henceforth, VSentence) was assessed over three days before and after each treatment phase. The sum of lexical accuracy across the three test days of each phase was used to detect consistent improvement following treatment. Results. All patients showed stable behavior prior to treatment. The first patients (P1 and P2) received sham in phase 1 and tDCS in phase 2. Improved production of trained verbs was observed in VInfinitive (for P1 only after phase 2), VFinite

and in 3-day accuracy. Production of untrained verbs improved only in phase 1, in 3-day lexical accuracy for both patients. P3, P4, and P5 received tDCS in phase 1 and sham in phase 2. After tDCS all patients improved in the production of trained verbs in the three tests and in 3-day accuracy. For untrained items, improvement was present for VFinite (P4) and 3-day accuracy (P3, P 4 and P5). After sham, patients improved for treated verbs in VInfinitive (P4), VFinite (P4 and P5), and 3-day accuracy (P3, P4 and P5). For untreated verbs, improvement was observed in VFinite (P5), VSentence (P4) and 3-day accuracy (P4 and P5). Overall, effects for trained verbs were larger after tDCS (irrespective of phase) and effects for untrained verbs were larger after phase 1 (irrespective of stimulation condition). Generalization in phase 2 was only observed in two patients treated with tDCS in phase 1. Non-word repetition, everyday language ability and mood did not change significantly. Conclusion. Our preliminary data indicate that tDCS increases therapy effect size for trained items. The role of tDCS in promoting generalization will have to be answered with a larger sample. Our data suggest that (1) improvement for untrained items is larger in early stages of treatment and (2) tDCS in early stages of treatment may increase the potential for generalization in later stages. Increasing our sample will allow further testing of these hypotheses.

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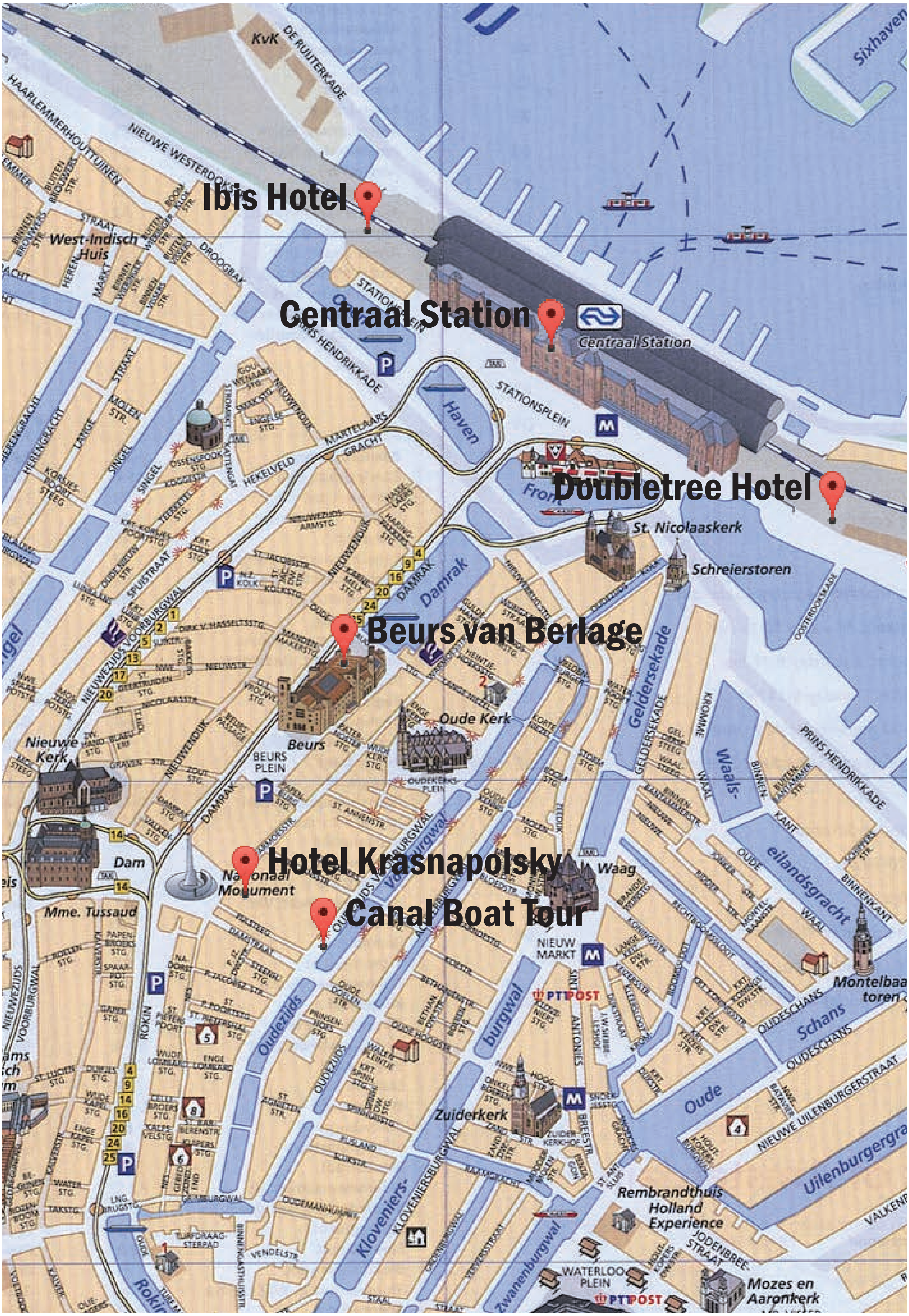
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