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2019

Document Version:
Publisher's PDF, also known as Version of record

ERP studies of visual and auditory processing of negated sentences

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Introduction

Previous research shows that negation is ignored in initial processing and the event-related potential (ERP) component N400 is insensitive to negation in the presence of semantic priming effects [2-3, 5]. But other evidence has shown that negation can be readily integrated and incongruities in negated sentences can elicit an N400 [6]. Most of this research has focused on negated forms such as *not*, *no* or *any* while little is known about prefixally negated words (e.g. *unauthorized*, *unintentional*) despite their high frequency of occurrence in language use [7].

Aim and research questions

- Two ERP experiments in visual and auditory modalities to investigate affirmatives (*authorized*), prefixal negation *(unauthorized)* and sentential negation *(not authorized)* in sentential contexts such as example (1) :

1) The White House announced that the new Obama biography was ***authorized/unauthorized/not authorized*** *and the details in the book were correct/wrong in actual fact*

- ERPs time-locked to the critical word (underlined), the congruency of which was determined by the adjective (bold) in the first part of the sentence. We asked the following questions:

Visual study:

➢ Is there a delay in the integration of negated meanings?
➢ Is prefixal negation processed similar to the negated form or the affirmative form?

Auditory study:

➢ Is auditory presentation of sentences more natural and easier than visual processing?

Summary of findings

Visual:

- Affirmative: N400-P600: successful detection of incongruities (N400) followed by re-evaluation of content to repair meaning (P600)
- Sentential negation: no N400, but a negativity with a longer latency than the typical N400: negation not entirely ignored in processing but negated meaning not fully present in memory either
- Prefixal negation: sustained anterior negativity: negated meaning needed to be retrieved from working memory, which was taxing

Auditory:

- Affirmative: N400-P600
- Sentential negation: no N400 but a P600: re-evaluation of content
- Prefixal negation: late positivity (P600): re-evaluation of content

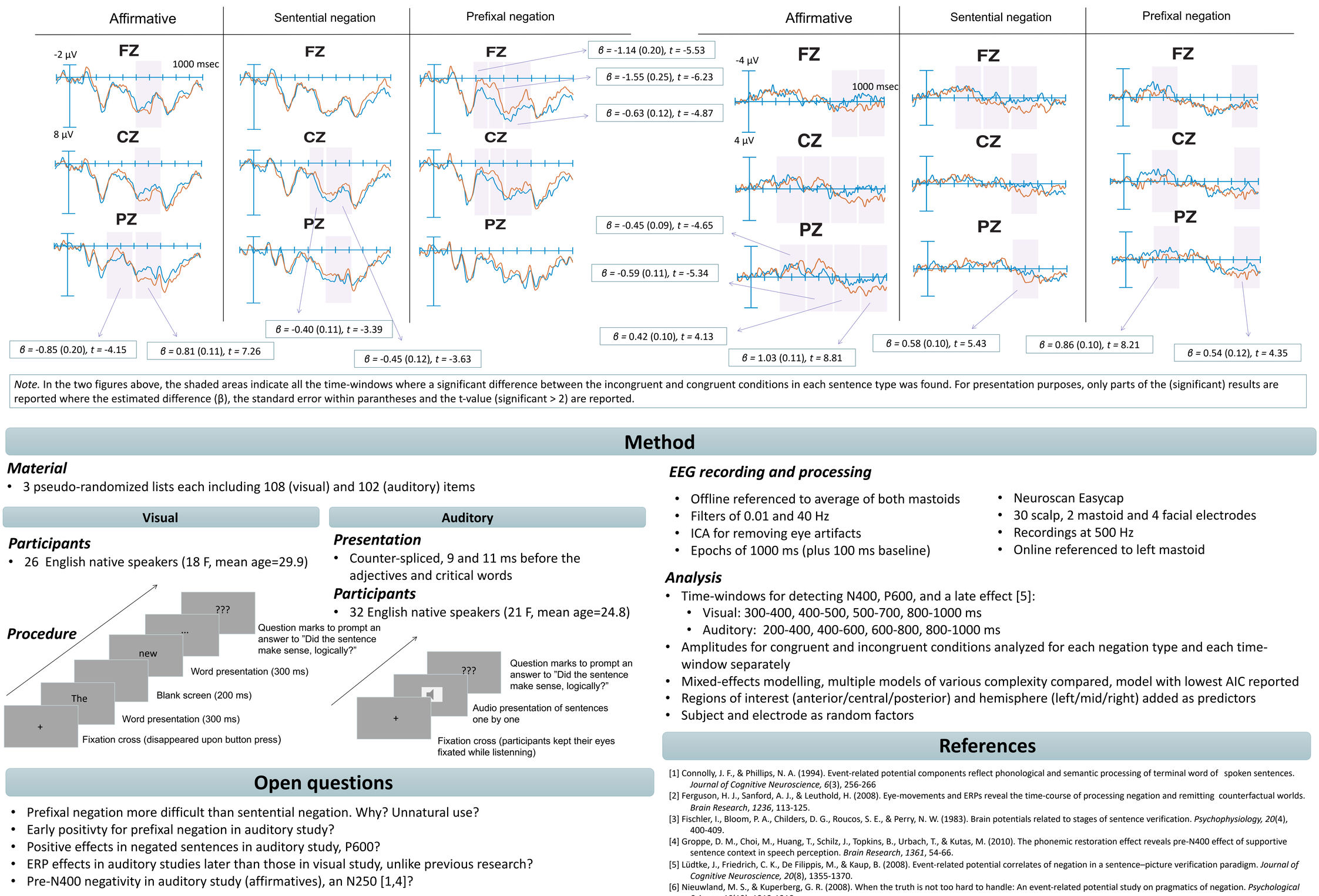
Conclusions

- Negated sentences were not ignored in early processing [unlike 2-3, 5], nor were they processed the same way as affirmative sentences [unlike 6].
- We found evidence for a more nuanced processing of negation suggesting that incongruities in negated sentences involved different processing mechanisms than those in affirmative sentences.
- Prefixal negation was the most difficult form to process in both studies, hence was not likely to be processed the same way as affirmative forms.
- Auditory processing of negated sentences was easier (clearer ERP effects) than word-by-word visual processing.

Results

Affirmative — *The White House announced that the new Obama biography was authorized and the details in the book were correct/wrong in actual fact*
Sentential negation — *The White House announced that the new Obama biography was not authorized and the details in the book were correct/wrong in actual fact*
Prefixal negation — *The White House announced that the new Obama biography was unauthorized and the details in the book were correct/wrong in actual fact*

Congruent
Incongruent



Note. In the two figures above, the shaded areas indicate all the time-windows where a significant difference between the incongruent and congruent conditions in each sentence type was found. For presentation purposes, only parts of the (significant) results are reported where the estimated difference (β), the standard error within parantheses and the t-value (significant > 2) are reported.

Method

Material

- 3 pseudo-randomized lists each including 108 (visual) and 102 (auditory) items

Visual

Participants

- 26 English native speakers (18 F, mean age=29.9)

Procedure

Auditory

Presentation

- Counter-spliced, 9 and 11 ms before the adjectives and critical words

Participants

- 32 English native speakers (21 F, mean age=24.8)

EEG recording and processing

- Offline referenced to average of both mastoids
- Filters of 0.01 and 40 Hz
- ICA for removing eye artifacts
- Epochs of 1000 ms (plus 100 ms baseline)
- Neuroscan Easycap
- 30 scalp, 2 mastoid and 4 facial electrodes
- Recordings at 500 Hz
- Online referenced to left mastoid

Analysis

- Time-windows for detecting N400, P600, and a late effect [5]:
  - Visual: 300-400, 400-500, 500-700, 800-1000 ms
  - Auditory: 200-400, 400-600, 600-800, 800-1000 ms
- Amplitudes for congruent and incongruent conditions analyzed for each negation type and each time-window separately
- Mixed-effects modelling, multiple models of various complexity compared, model with lowest AIC reported
- Regions of interest (anterior/central/posterior) and hemisphere (left/mid/right) added as predictors
- Subject and electrode as random factors

Open questions

- Prefixal negation more difficult than sentential negation. Why? Unnatural use?
- Early positivty for prefixal negation in auditory study?
- Positive effects in negated sentences in auditory study, P600?
- ERP effects in auditory studies later than those in visual study, unlike previous research?
- Pre-N400 negativity in auditory study (affirmatives), an N250 [1,4]?

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Presented at the XIV International Symposium of Psycholinguistics in Tarragona, Spain, on 11, April, 2019