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Anticipating morphological and syntactic structures

investigating the pre-activation negativity

Söderström, Pelle; Horne, Merle; Mannfolk, Peter; van Westen, Danielle; Roll, Mikael

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PO Box 117
221 00 Lund
+46 46-222 00 00

Anticipating morphological and syntactic structures

An analysis of the pre-activation negativity (PrAN)

Vetenskapsrådet

Knut and Alice Wallenberg Foundation

Pelle Söderström, Merle Horne, Peter Mannfolk, Danielle van Westen & Mikael Roll

Department of Linguistics, Centre for Languages and Literature

Lund University, Sweden

MARCUS AND AMALIA WALLENBERG FOUNDATION

Introduction

- Listeners constantly try to predict upcoming words when processing speech
- A brain potential – the 'pre-activation negativity' (PrAN) – has been suggested to reflect morphological pre-activation of likely word endings [1-4]
- We tested whether PrAN could be found in syntactically predictive contexts as well

PrAN

bå-… -ten/-tar/-t-hus…

boat-…-the/-s/-house

The present study

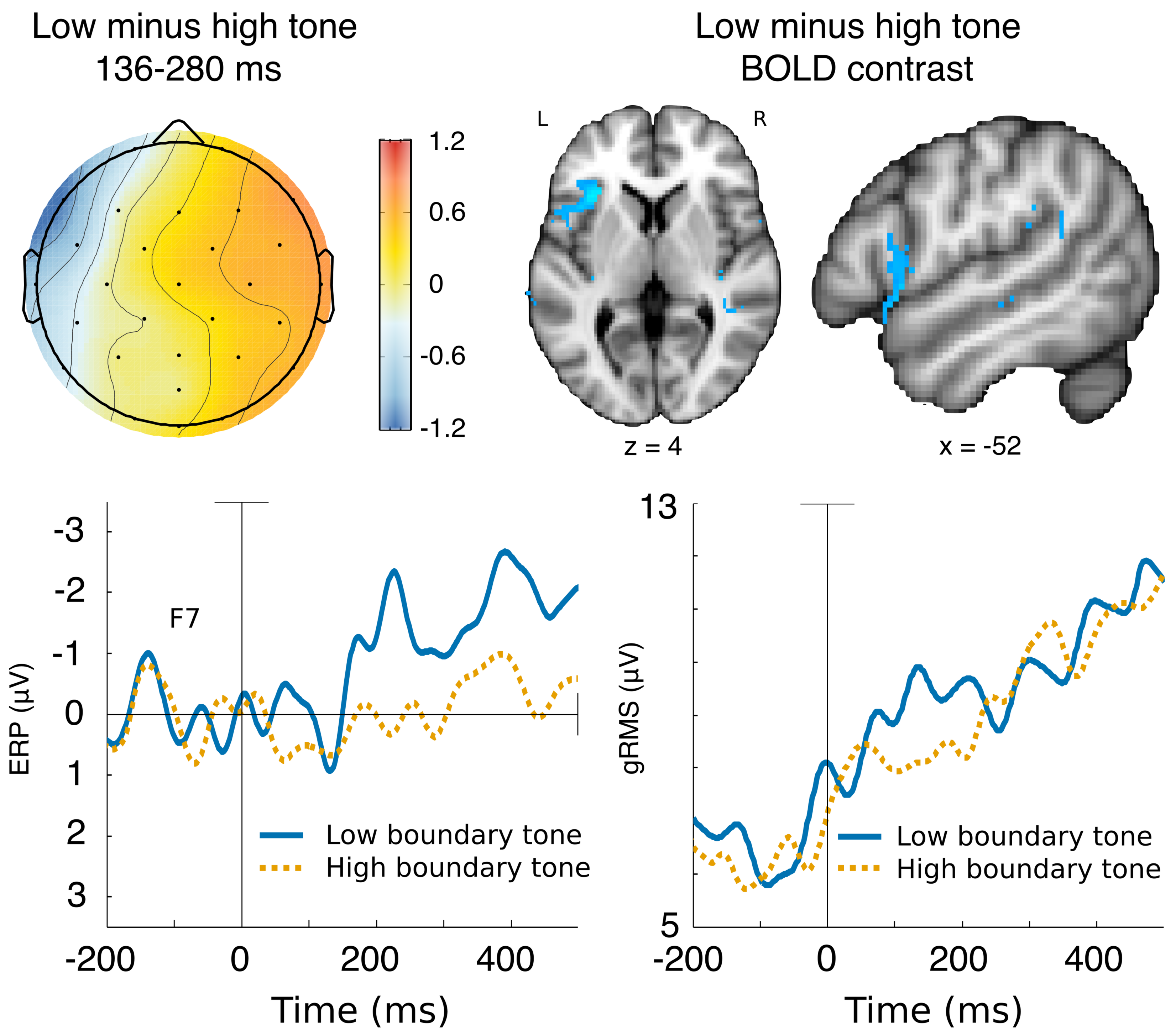
- Using a concurrent fMRI/ERP paradigm, we tested whether syntactic structure could be pre-activated based on strongly constraining tonal cues
- In Swedish, clause-initial tones (low/high) function as cues to syntactic structure
- Low tones are more predictively constraining (cueing only one type of structure), whereas high tones are less constraining (cueing a larger class of structures)

- More predictively useful tones gave rise to **left frontal ERP negativity (PrAN)** 140 ms after tone onset, as well as activity in **left insula and inferior frontal gyrus**
- Invalidly cued word orders elicited **P600** after low – but not high – tones, suggesting the disconfirmation of a syntactic prediction

PrAN

Jim hävdar att Cae**sar**$_{\textbf{Low tone}}$ inte intog Gallien 'Jim claims that Caesar **not conquered** Gaul'

Jim hävdar att Cae**sar**$_{\textbf{High tone}}$ intog inte Gallien 'Jim claims that Caesar **conquered not** Gaul'


Low minus high tone
136-280 ms
1.2
0.6
0
-0.6
-1.2
Low minus high tone
BOLD contrast
L
R
z = 4
x = -52
-3
-2
-1
0
1
2
3
F7
ERP (µV)
Low boundary tone
High boundary tone
-200
0
200
400
Time (ms)
13
5
gRMS (µV)
Low boundary tone
High boundary tone
-200
0
200
400
Time (ms)

Top left: ERP topography (left frontal) for the ERP negativity found for more predictively constraining (low) tones. Top right: The low minus high tone contrast gave rise to activity in left insula and IFG. Bottom left: ERPs revealed a negativity for low tones beginning at 136 ms. Bottom right: A gRMS analysis suggested more neural activity for low tones in the same time window [5].

Method and results

- 19 native speakers of Swedish (11 female, mean age 24.5 years)
- Concurrent event-related fMRI/ERP (Brain Products GmbH)
- 50% of sentences had invalid word orders based on tonal cue (LoInvalid/HiInvalid)
- ERP data from 16 participants analysed
- Two time points: predictive tone onset, and word order disambiguation point
- Low tones gave rise to ERP negativity in 136-280 ms time window (cf. [3]) over left-lateralised electrodes ($F(1,15) = 7.252$, $p = 0.017$)
- A gRMS analysis revealed two peaks of neural activity at 100-150 ms ($F(1,15) = 5.691$, $p = 0.031$) and 150-230 ms ($F(1,15) = 5.264$, $p = 0.037$) for low tones
- P600 over left electrodes for LoInvalid ($F(1,15) = 5.354$, $p = 0.035$)
- Slower response times for LoInvalid as well ($F(1,15) = 5.944$, $p = 0.028$)
- A conjunction analysis (to isolate effects of tone) was performed on fMRI data (z threshold = 3.2, $p = 0.001$, GRF statistics)
- Largest cluster for the low minus high tone contrast spanned the left anterior insula and left inferior frontal gyrus
- Subject variability correlation between BOLD in prefrontal cluster and gRMS ($r = 0.609$, $p = 0.024$)

Conclusions

- Strong cues to syntactic structure elicited ERP negativity (PrAN) as early as 140 ms after cue onset
- Disconfirmed predictions gave rise to P600
- PrAN was found to mainly be underpinned by activity in left insula and IFG (cf. [6-9])
- Syntactic structures can be pre-activated based on a strongly constraining cue

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