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investigating the pre-activation negativity

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Anticipating morphological and syntactic structures
An analysis of the pre-activation negativity (PrAN)

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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

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 (cuing only one type of structure), whereas high tones are less constraining (cuing 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

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

References