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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 (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

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 (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

PrAN
bå…-ten/-tar/-t-}
boat…-the/-s/-house
Jim hävdar att Caesar...
Jim claims that Caesar not conquered Gaul
Jim hävdar att Caesar...
Jim claims that Caesar not conquered Gaul

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].

Low minus high tone
136-280 ms
Low minus high tone
BOLD contrast

Jim hävdar att Caesar
Low tone inte intog Gallien Jim claims that Caesar not conquered Gaul
Jim hävdar att Caesar
High tone intog inte Gallien Jim claims that Caesar conquered not Gaul