A Neurocomputational Model of the N400 and the P600

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Background: The "Semantic Illusion" (or "Semantic P600") phenomenon

Semantically anomalous, but otherwise well-formed sentences (1b) did not affect the *meaning*-related N400 component, but increased the amplitude of the *structure*-related P600 component instead (relative to control (1a); Hoeks et al., 2004):

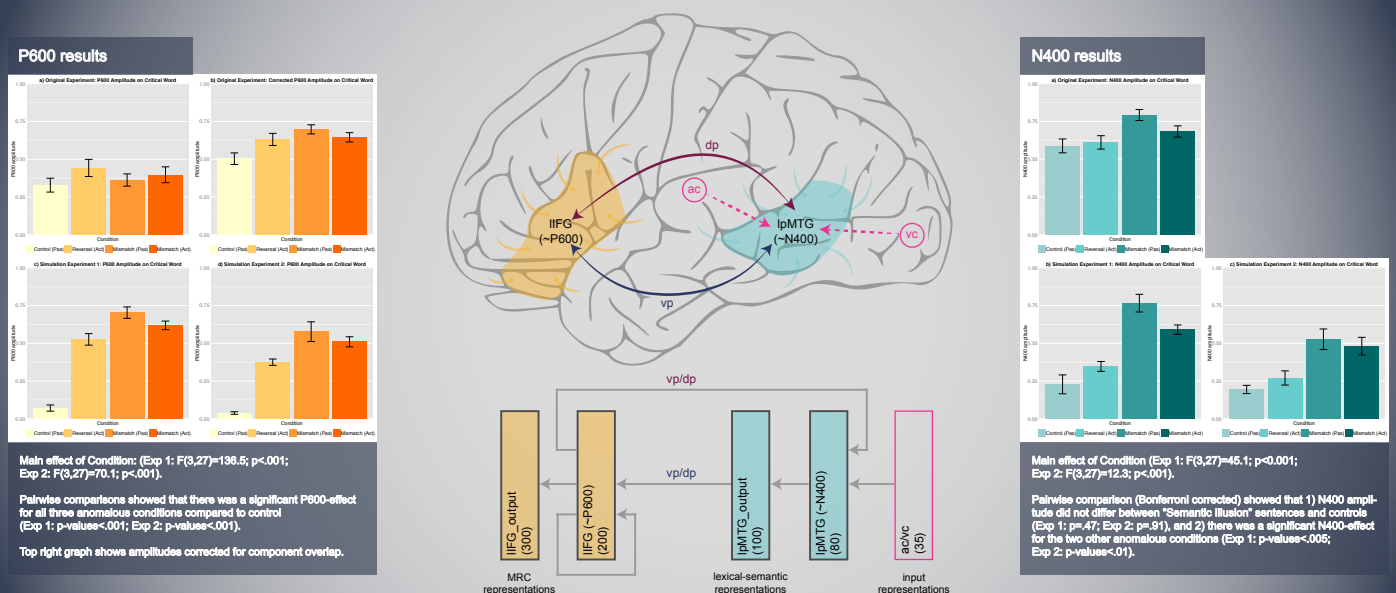| Sentence (literal translation from Dutch)	Condition	ERP-Effect
1a) 'The javelin was by the athletes thrown'	Control (passive)	—
1b) 'The javelin has the athletes thrown'	Reversal (active)	P600
1c) 'The javelin was by the athletes summarized'	Mismatch (passive)	N400 / P600
1d) 'The javelin has the athletes summarized'	Mismatch (active)	N400 / P600

This finding has spawned five complex models of language comprehension, but none of these seems capable of explaining the full range of relevant findings in the literature (Brouwer et al., 2012).

A simpler perspective—the Retrieval-Integration account (cf. Brouwer et al., 2012; Brouwer & Hoeks, 2013)

N400 is ~~semantic integration~~ > **lexical retrieval** (~lpMTG)   **P600 is** ~~syntactic processing~~ > **semantic integration** (~lIFG)

P600 results

Main effect of Condition: (Exp 1: F(3,27)=136.5; p<.001; Exp 2: F(3,27)=70.1; p<.001).

Pairwise comparisons showed that there was a significant P600-effect for all three anomalous conditions compared to control (Exp 1: p-values<.001; Exp 2: p-values<.001).

Top right graph shows amplitudes corrected for component overlap.

N400 results

Main effect of Condition (Exp 1: F(3,27)=45.1; p<0.001; Exp 2: F(3,27)=12.3; p<.001).

Pairwise comparison (Bonferroni corrected) showed that 1) N400 amplitude did not differ between "Semantic Illusion" sentences and controls (Exp 1: p=.47; Exp 2: p=.91), and 2) there was a significant N400-effect for the two other anomalous conditions (Exp 1: p-values<.005; Exp 2: p-values<.01).

A neurocomputational model of the Retrieval-Integration account (Brouwer, 2014; Brouwer & Hoeks, in prep.)

The model constructs a thematic-role assigment representation (MRC representation) of a sentence on a word-by-word basis.

The model is taught that any combination of *agent*, *action*, and *patient* is possible, but that some are more likely than others (~world knowledge; cf. Mayberry et al., 2009).

Acoustic/orthographic input representations are mapped onto lexical-semantic representations (corpus-derived semantic feature vectors; cf. Rohde. et al., 2009) in the lpMTG, while taking the unfolding MRC into account.
> N400 amplitude is estimated as the amount of change (cosine dissimilarity) in the lpMTG layer from one word to the next.

The retrieved lexical-semantic representations are integrated with the current MRC into an updated MRC in the lIFG layer.
> P600 amplitude is estimated as the amount of change in the lIFG layer from one word to the next (cf. Crocker et al., 2010).

Conclusions

Simulations show that the model accounts for the two most salient patterns of ERPs: P600-effects and biphasic N400/P600-effects.

The model provides a 'proof-of-concept' of the Retrieval-Integration account, and a starting point for a more comprehensive model.

References: Hoeks et al. (2004). *Cogn. Brain Res.*; Brouwer et al. (2012). *Brain Res.*; Brouwer & Hoeks (2013). *Front. Hum. Neurosci.*; Brouwer (2014), *PhD thesis*; Brouwer & Hoeks (in prep.); Rohde et al. (2009). *Cogn. Sci.*; Mayberry et al., (2009). *Cogn. Sci.*; Crocker et al. (2010). *Brain & Lang.*

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