Cognitive Factors Influence Individual Differences in Semantic Processing: Evidence from MEG

Previous studies have assumed homogeneity in individual native language (L1) processing — both in terms of proficiency and the brain networks involved (Chomsky, 1966). However, recent studies show that both proficiency and brain organization vary between individuals, and variation in brain activity may be linked to cognitive factors (Moreno et al., 2008; Pakulak and Neville, 2010; Newman et al., 2012; Tanner and Van Hell, 2014). Processing word meanings (lexical semantics) in sentence context is one aspect of language for which this has been shown: the size of the N400 EEG effect elicited by semantically anomalous words in sentences correlates with standardized measures of language proficiency. The present study extended these findings in two ways: we used magnetoencephalography (MEG) and investigated processing lexical semantics at the individual word, rather than sentence, level. As well, language proficiency was assessed using several subtests of the Test of Adult and Adolescent Language 3 (TOAL-3).

On a series of trials, participants were presented with pictures each paired with an auditory word, which was either congruent or incongruent with the picture (e.g., a picture of a mitten followed by either the word “mitten” or “fence”). Mismatched words elicited an enhanced N400m (the MEG equivalent of the N400) relative to matched words, which was left lateralized and greatest over both anterior and posterior regions between 350-500 ms post-stimulus. The relationship between N400m amplitudes and individual differences in language proficiency were assessed using stepwise linear mixed effects (LME) modelling.

The LME analysis yielded a significant Condition x ROI interaction, $F(1, 41222) = 231.772$, $p < 0.0001$, confirming the maximal N400m effect at left anterior and posterior sensor sites. Additionally, there was a significant 3-way Condition x ROI x LV interaction, $F(3, 41222) = 39.518$, $p < 0.0001$. This indicated that scores on the Listening Vocabulary subset of the TOAL-3 correlated with N400m amplitude. These findings show that, like the N400 EEG effect, the N400m varies considerably among individuals, and a significant amount of this variance can be attributed to people's vocabulary size. This suggests that previous studies on semantic processing may have oversimplified and overgeneralized native language processing. Further results will be discussed, including source localization of the listening vocabulary-related differences in the brain, and relationship with other linguistic and cognitive predictor variables.

References

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