Automatic and recruitable:
MEG evidence for an obligatory but flexible combinatory mechanism in the LATL

Douglas K. Bemis & Liina Pylkkänen (New York University)

doug.bemis@nyu.edu

Basic combinatorial processing; Automaticity; Left ATL; Magnetoencephalography (MEG); English

Short Summary: A major goal for the cognitive science of language is characterizing the domains in which the combinatory rules of language operate. Here we used a cognitive neuroscience approach to investigate the extent to which expressions not conforming to canonical English word order engage the same combinatory mechanisms as canonical expressions. Both intuition and electrophysiological evidence suggest that basic linguistic combinatorial operations are automatic and obligatory, i.e., upon encountering the phrase *red car*, the processor has no option but to construct a complex representation from the constituent elements.[1,2] Given this, a brain mechanism reflecting such combination should behave similarly no matter what the task demands are. Here we show that MEG activity localized to the LATL – a region hypothesized in both the hemodynamic[3] and neuromagnetic[4] literatures to support combinatory linguistic mechanisms – shows a composition effect for adjective-noun combinations whether the task requires composition or not. In contrast, when the noun and adjective are presented in non-canonical English order, e.g. *car red*, combinatory LATL activity is absent in the non-composition task, but present when the task forces composition. These results suggest that the combinatory mechanism reflected by LATL activity is automatically engaged by grammatical expressions and can also be recruited to compose ungrammatical sequences, if the task demands it.

Experiment details: Subjects read adjective-noun combinations (e.g. *red boat*, *boat red*) word by word and indicated if a following picture matched the preceding words. In the composition task, a single colored shape was presented as the test, thus encouraging subjects to construct a single, complex mental representation from the linguistic stimuli. In the non-composition task, the test color and the shape were presented separately, promoting a list-like interpretation. To maximize this contrast, each task was administered as a separate experiment to separate subjects. Within each experiment, canonical and non-canonical orderings were blocked separately and interleaved with complementary one-word trials in which the first word was replaced by a length matched consonant string (*xhl boat, kqzl red*). Thus, both experiments had a 2x2 design with Number of words (one, two) and Order (canonical, reversed) as factors.

Analysis & Results: Our primary dependent measure was MEG activity elicited by the second word that localized to the LATL, which has previously been linked with the mental construction of basic adjective-noun phrases.[4] In our non-composition task, a non-parametric cluster test[5] revealed a significant interaction from 214-255ms ($p = 0.046$) with increased activity during the processing of canonically ordered phrases compared to the one-word control and no difference between the non-canonical conditions. This result suggests that the combinatorial mechanism reflected by the LATL is automatically engaged by canonical phrases, as composition was not only not required by this task but was in fact detrimental (accuracy was significantly impaired in this condition). Contrastingly, in the composition task we observed no interaction in LATL activity but instead found a main effect of number of words (209-269ms; $p = 0.035$) suggesting that this basic combinatorial mechanism can be recruited by non-canonical linguistic processing if the task requires it.

References

1. Hahne, A. & Friederici, A.D. (1999). *Journal of Cognitive Neuroscience,* 11(2), 194-205.
2. Pulvermüller et al. (2008). *Brain and Language,* 104, 244–253.
3. Hickok, G. & Poeppel, D. (2007). *Nature Reviews Neuroscience,* 8, 393-402.
4. Bemis, D.K. & Pylkkänen (2011). *The Journal of Neuroscience,* 31(8), 2801–2814.
5. Maris, E. & Oostenveld, R. (2007) *Journal of Neuroscience Methods,* 164, 177-190.