

MEG reveals early sensitivity to phrase-structure violations in visual cortex

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Introduction

EEG-studies have demonstrated that syntactic operations can take effect as early as 150-200ms post-stimulus onset, at which point the presence of an unpredicted word category elicits an early left anterior negativity (ELAN; e.g., Friederici 2002). The ELAN is modulated not only by the strength of structural expectations (Lau et al 2006), but also by purely physical aspects of the stimulus. Gunter et al (1999) found no ELAN when stimuli were presented against a low-contrast background. They concluded that fast and automatic structure building is dependent upon good signal quality. An alternative hypothesis, however, is that the ELAN is sensitive to physical stimulus properties because it is itself a sensory response, perhaps generated via top-down modulation of sensory cortices. EEG's spatial resolution is too low to address this issue, so we examined the contribution of sensory cortices to early effects of word category identification with magnetoencephalography (MEG). In addition, we investigated whether overtly perceivable category-marking morphology is a prerequisite for early effects of structural prediction.

Method/Design

15 subjects read sentences word-by-word (300ms on, 300ms off) with either an expected or unexpected target word. In two conditions, the target contained overt category-marking morphology: (1) prepositions, i.e., free closed-class morphemes (from Neville et al); and (2) participles, containing a bound closed-class morpheme (adapted from German; Friederici et al). A third condition (3) contained an unexpected bare stem (i.e., no overt category-marking).

Results

We found that expectedness modulates activity already at ~100ms, in visual cortex (visual M100). This early effect was limited to prepositions and participles only, showing that it is not a result of just any mismatch between prediction and visual input. Rather, the visual cortex seems to identify only a limited set of closed class morphemes, which can be compared against the predicted input. In addition to the visual M100 effect, prepositions elicited a fronto-lateral effect at 135-149ms, consistent with previous ELAN findings. Participles showed no anterior effects in this time-window. Rather, a slightly later, left-temporal effect of unexpectedness was observed at 238-267ms. No early effects were found for the bare stems. The expected and unexpected conditions only separated at 356-369ms in the left temporal gyrus.

Conclusion

These results show that (a) syntactic predictions modulate activity already in the occipital cortex and (b) early effects of unexpectedness are only obtained when the unanticipated element is overtly perceivable. Together, the visual M100 findings and the slightly later fronto-lateral effect for the prepositions raise the possibility that the ELAN response found in prior studies may have reflected a combination of sensory cortex modulation and effects in more traditional language areas. In summary, our findings suggest that physical features of upcoming words are anticipated by the parser as a function of their syntactic environment, and that this information is made available to the occipital cortex at a very early stage of visual analysis. The finding that the visual cortex monitors syntactic properties of linguistic input may provide a crucial key for understanding how language processing can be so remarkably fast.

References

- Friederici, A.D. Trends Cogn Sci 6, 78-84 (2002)
Friederici, A.D., Pfeifer, E. & Hahne, A. Cogn Brain Res 1, 183-92 (1993)
Gunter, T.C., Friederici, A.D. & Hahne, A. Neuroreport 10, 3175-8 (1999)
Lau, E., Stroud, C., Plesch, S. & Phillips, C. Brain Lang 98, 74-88 (2006).
Neville, H., Nicol, J., Barss, A., Forster, K. & Garrett, M. J Cogn Neurosci 3, 151-165 (1991)

Materials

- (1) a. The boys heard Joe's stories about Africa.
b. The boys heard Joe's about stories Africa
- (2) a. The discovery was reported.
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- (3) a. The discovery was in the report.
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