Grammatical anticipation? Neural dynamics of noun and verb processing

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Introduction

• A wealth of evidence highlights (partially) dissociable neural systems responsible for processing nouns and verbs
• Noun processing recruits more strongly temporal brain areas and verb processing frontal brain areas (e.g., Vigliocco et al., 2011)
• This could reflect differences in action versus object semantics (e.g., Pulvermüller, 2013) or, alternatively, differences in lexical categories and syntactic operations (e.g., Shapiro et al., 2006).
• Much less research has been dedicated to the time-course of the cortical area activations between nouns and verbs and on the neural correlates elicited by the function words which typically precede an upcoming noun or verb.

The current study

In the current study, several goals are pursued:

1. To characterize when an anterior-posterior cortical dissociation would be observed between noun and verb processing
2. To explore whether minimal sentential context, i.e. single function words, might influence such time-course
3. To use the evidence to constrain theoretical proposals concerning the organization of grammatical class in the brain.

Work in progress: We present advanced data analysis and preliminary conclusions

Experimental protocol

Design and procedure

Native speakers of French were asked to read covertly a pair of words per trial. Each word (prime or target) was presented for 600 ms.

We contrasted nouns vs. verbs, in predictive vs. non-predictive contexts, plus catch trials.

The task required detecting pseudo-words in the catch trials only.

Stimulus selection procedure (lexique.org)

1. Words between 3 and 8 letters long filtered for frequency, absence of homographs, profanity
2. Filtered out incorrect word transitions (*ta allure, *sa erreur, *je essaie), misplaced imperatives (je brille / brille [imp 2e])
3. Matched verbs to closed-class words for gender, number (place into bins), nouns to verbs for length, frequency, orthographic distance (old20), bigram frequency, number of phonemes
4. Check subjective naturalness ratings from 6 native speakers
5. Finally, 350 pairs with best naturalness ratings and closest lexical frequency match chosen
6. Additionally, 140 pseudowords generated using lexique.org toolbox to match orthographic and phonological properties of stimulus words. Used as catch trials, paired with closed-class words at random in proportion to normal stimuli.

Conditions

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<th>Prime</th>
<th>Targets</th>
<th>No. of trials</th>
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<td>Catch</td>
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MEG data analysis

MEG and MRI preprocessing

1. Cortical surface reconstructed using FreeSurfer software for each individual from high-resolution 3D T1-weighted MRI structural image
2. Cortical surface sampled to 15000 dipole locations using Brainstorm. This cortical surface served as the solution space for the estimated current generators (i.e. orientation constrained dipoles on gray matter)
3. Forward solution was calculated using a weighted minimum norm estimates approach.

Anatomical ROI analysis

1. Subdivision of individual anatomy into regions of interest (ROI) based on the anatomical atlases of Desikan and Killiany (68 + 4).
2. For each subject and experimental condition, absolute average ROI time series extracted
3. Mass univariate analyses (with no a priori knowledge of effect location and latency): 2000 non-parametrical permutation tests (EEGLAB toolbox, Delorme & Makeig, 2004) on each time point followed by corrections for multiple comparisons (False Discovery Rate, FDR; Bejamini & Yekutieli, 2001).

Preliminary results

Main effect of predictability

Interaction of predictability and grammatical category

Preliminary conclusions

• Grammatical predictability has a reliable effect
• Grammatical category reveals meaningful significant contrasts, but in an unexpected direction: Noun conditions more active than verb conditions in frontal areas.
• Further explorations of temporal lobe activity in progress.

References

Data analysis was performed with Brainstorm (Tadel et al. 2011), which is documented and freely available for download online under the GNU general public license (http://neuroimage.usc.edu/brainstorm).