Brain responses to continuous speech with MEG: acoustics to comprehension

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Introduction

Reverse correlation of EEG and MEG data has been used to analyze neural processing of continuous stimuli such as speech, but the analysis is typically restricted to sensor space. We show that reverse correlation can be combined with source localization of MEG data to estimate the neural response to continuous speech in time as well as anatomical location. This allows us to distinguish different levels of processing in the brain response to continuous speech by identifying components that are sensitive to acoustic, lexical and semantic information in the speech signal.

Right: Speech signal and continuously coded predictor variables.
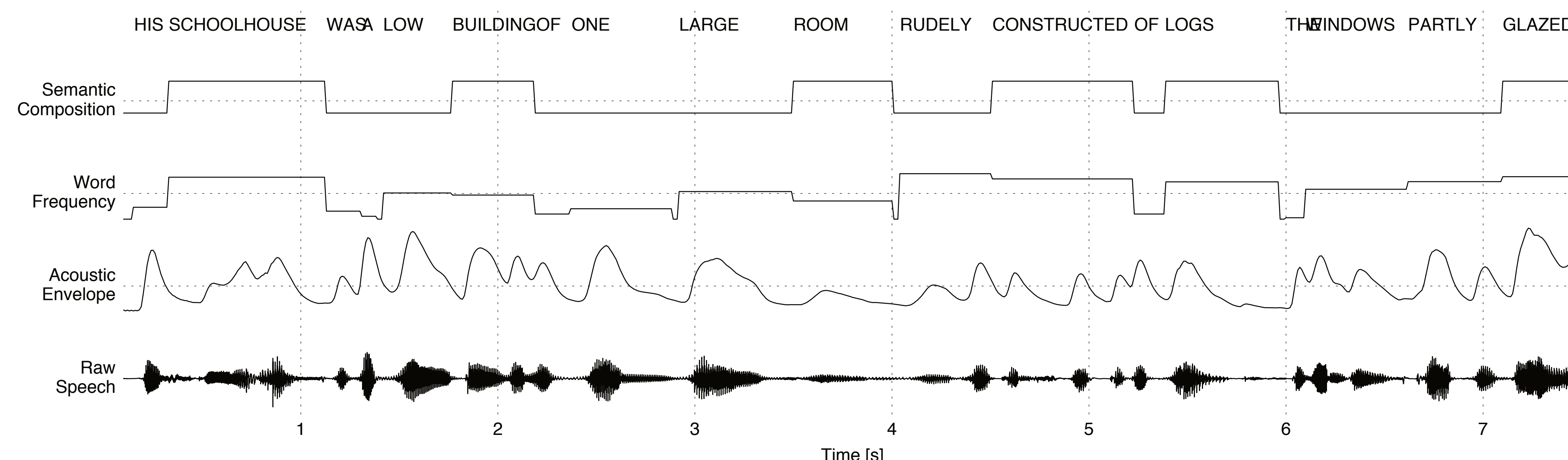

Methods

Magnetic fields were recorded while 17 young adults listened to one-minute long segments of a narration of *The Legend of Sleepy Hollow* (2 segments, 3 repetitions each). MEG data were projected to an average brain model (scaled to each subject's head size) with distributed minimum norm current estimates. For each source element, reverse correlation with boosting using ℓ_1 norm was performed with three predictors: (1) The envelope of the acoustic signal, estimated based on an auditory brainstem model; (2) The log of the word frequency, coded as a constant value for the duration of each word (higher values for less frequent words); (3) Semantic composition, coded as a binary value with 1 on words which can be semantically composed with previous words. Response functions were evaluated statistically using permutation tests, testing for responses that differed significantly from zero.
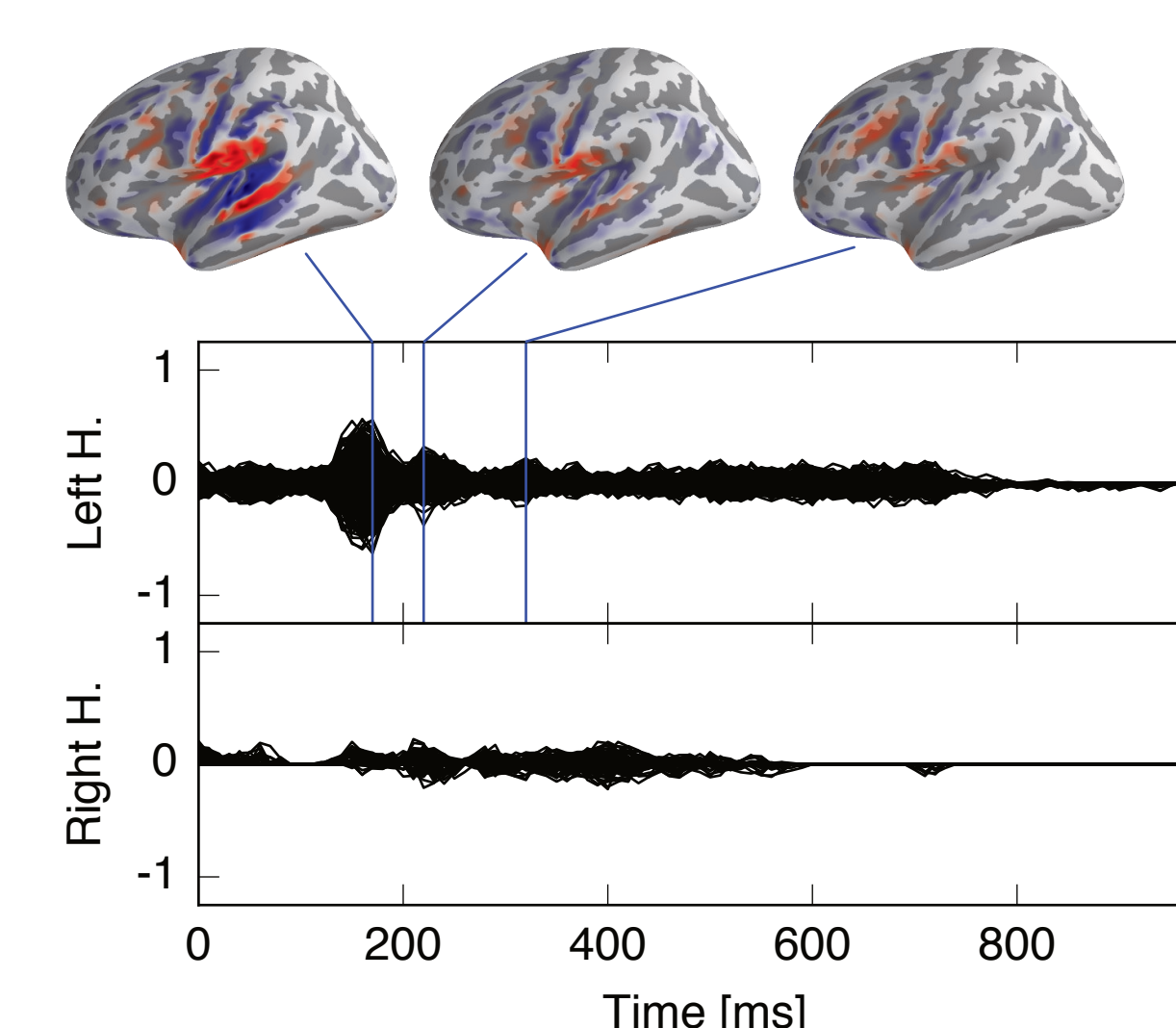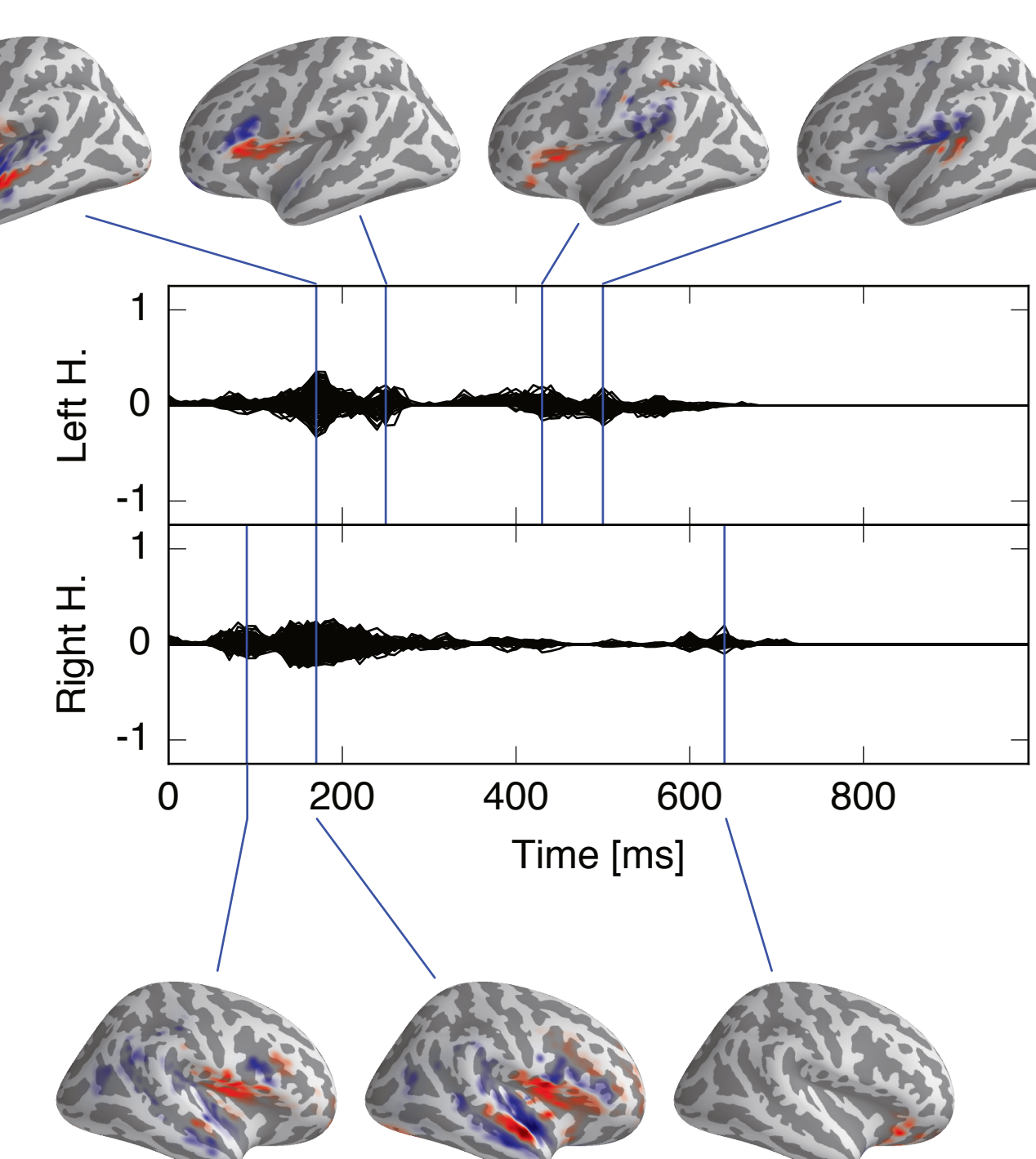
Right: the MEG acquisition chamber
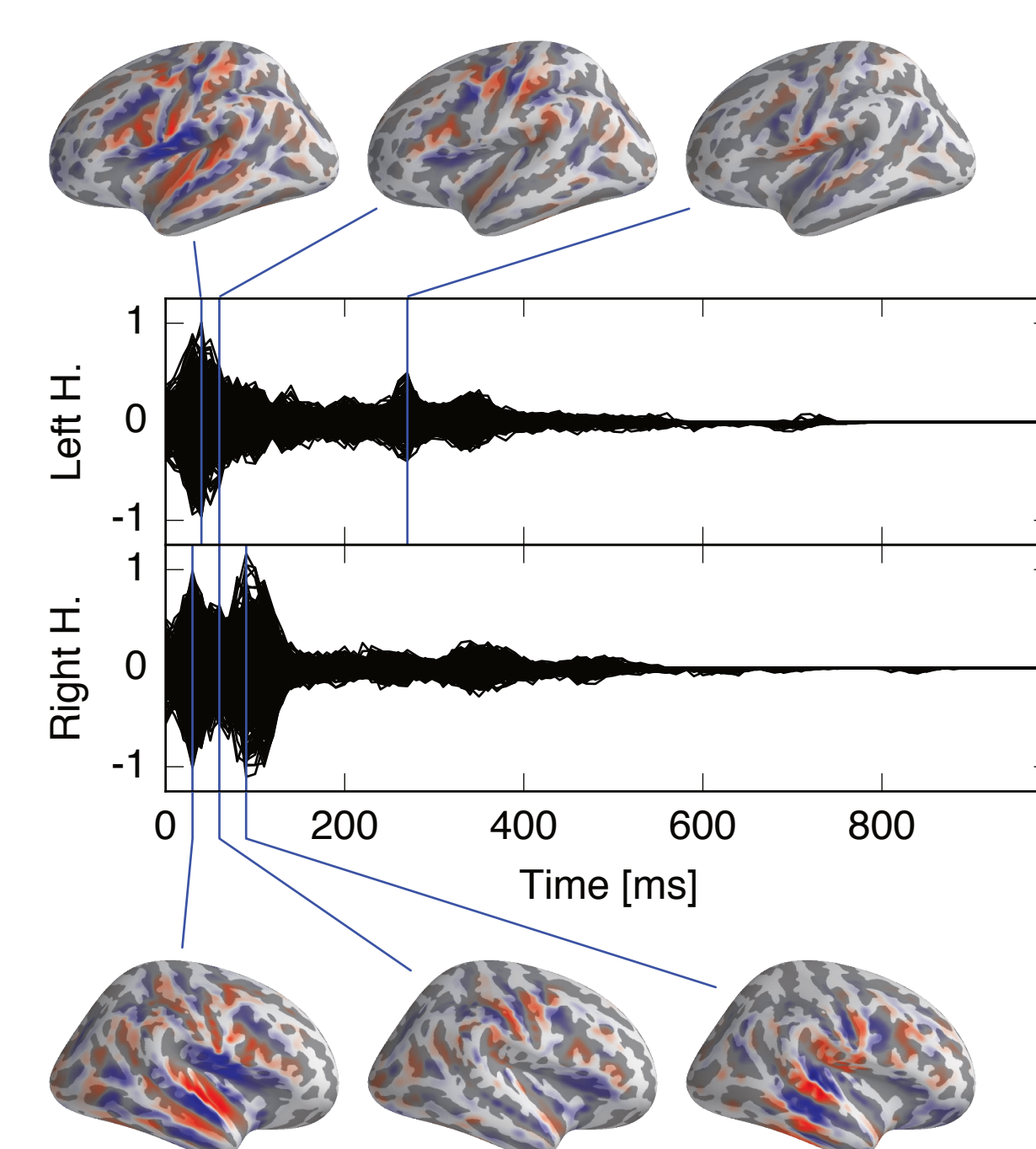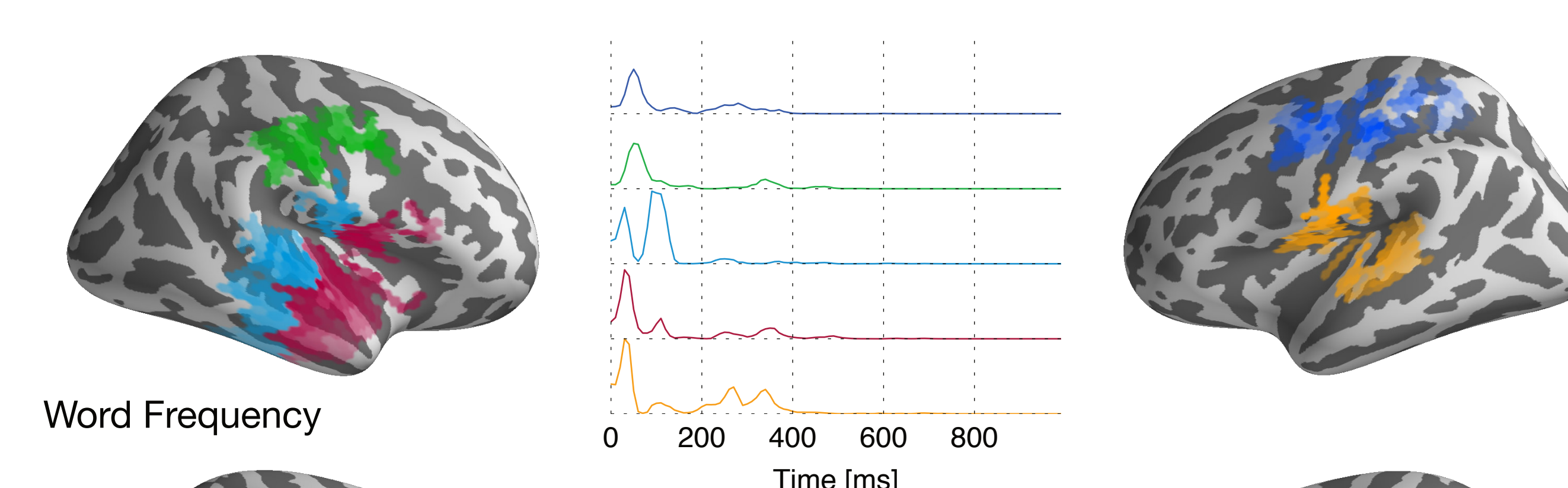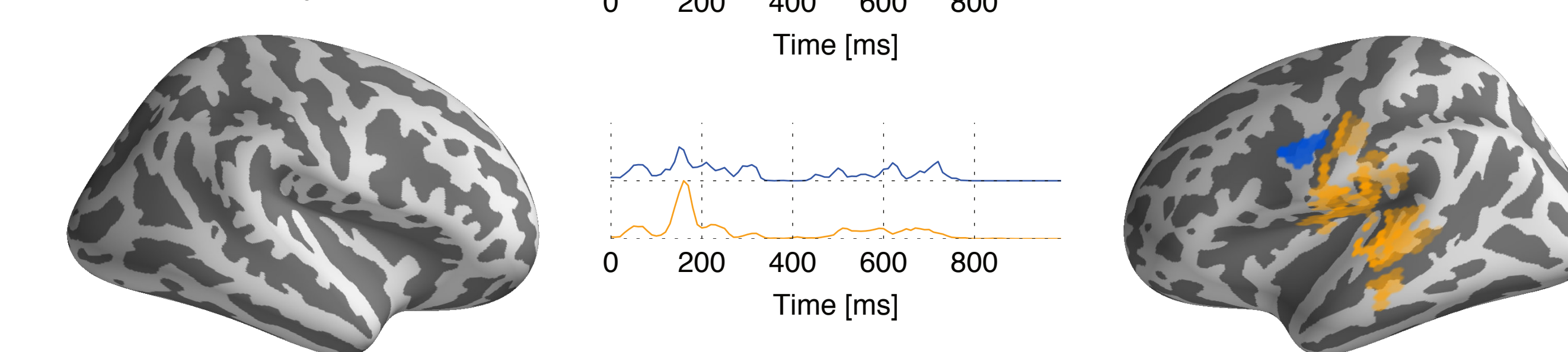

Response Functions

Averages of the estimated response functions were calculated for the three levels of speech processing, masked for significance with permutation tests. Butterfly plots show all potential sources, separately for the left and right hemisphere. Peak time points are illustrated with brain maps.
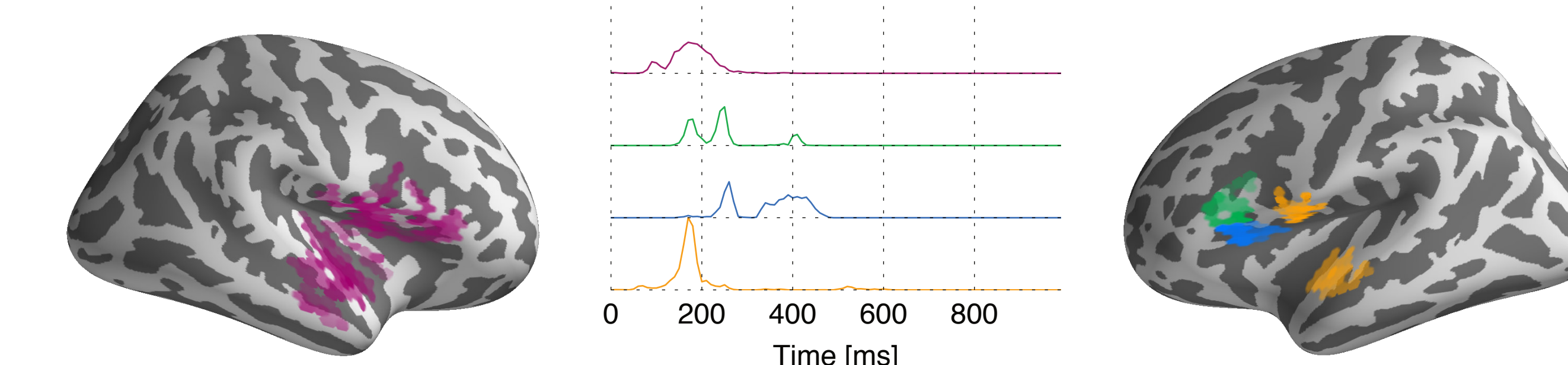

Acoustic Envelope

Word Frequency

Semantic Composition

Clustered Responses

Response function sources were determined using hierarchical clustering with the Ward criterion and a spatial adjacency constraint. Absolute values of responses were used for clustering, and clusters with high correlation were merged to account for discontinuities due to anatomy.

Acoustic Envelope

Word Frequency

Semantic Composition