I. What parsing mechanism correlates best with observed BOLD signals?

There is a growing consensus that the left anterior temporal lobe (blue arrows, right) implements some sort of basic syntactic processing (Friederici and Gierhan 2013; see e.g. Dreron et al. 2004; Humphries et al. 2005; Bemis and Pykkänen 2013).

But what is this processing? No consensus exists, so we consider four alternative formalizations using a correlational method. We hypothesize that basic syntactic processing reflects the traversal of syntactic structures, and thus higher node counts should correlate with stronger BOLD signals in the left anterior temporal lobe.

II. Correlational method

We derived time series predictors from the first chapter of Alice in Wonderland, and fit them to preprocessed fMRI data from 11 right-handed, college-age participants. One of these predictors, speech rate, marks the offset of words. This predictor localized participant-specific regions in the temporal lobe.

We then evaluated the ability of different syntactic predictors to account for mean BOLD signal in a 10mm spherical region around these participant-specific peaks. Predictors derived from the text and audio were convolved with a canonical hemodynamic response function and summed together to yield predictions about activation in anterior temporal regions of interest (cf. Just and Verman 2007, fig. 11).

III. Alternative syntactic structures

We followed Van Wagenen et al. (2012) in calculating node counts using two different types of syntactic structure. One type adheres to the Penn Treebank (Marcus et al. 1993) annotation guidelines. A second type is based on X-bar theory in the sense of Chomsky (1970) and Jackendoff (1974,1977). We used Minimalist Grammars (e.g. Stabler 2013) to generate these X-bar structures.

IV. Deriving predictors

Predictors came from the text of the narrative as well as the audio that participants heard.

V. Analysis and Results

For each of the four combinations of syntactic analysis and parsing strategy, we fit a regression model with syntactic node count as a predictor. Each model also included three other predictors: speech rate, unigram log frequency, and prosodic break strength (ToBI; Beckman et al. 2005).

These dots correspond to coefficients on syntactic predictors. The best-fitting predictors are based on X-bar structures and top-down parsing (e.g. blue numbers in the trees above).

Node count is a significant predictor of anterior temporal lobe activation. Prosodic break strength and unigram (log) frequency are not. This is also the case for the right anterior temporal lobe.

Conclusions

Simple formalization of parser effort in terms of node count predicts BOLD time series in left anterior temporal region. X-bar node count correlates better than Penn Treebank node count. The result persists even with prosodic breaks as a co-predictor.