Differentiating Phrase Structure Parsing and Memory Retrieval in the Brain

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Introduction

Natural language comprehension relies on at least two cognitive processes:
- Retrieval of memorized elements
- Structural composition

Question

Where are these two language processing functions localized in the brain?

Data Collection

Participants (n=51) were college-aged, right-handed, native English speakers. Listened to a spoken recitation of The Little Prince for 1 hour and 38 minutes across nine separate sections. Comprehension was confirmed through multiple-choice questions at the end of each section.

Analysis

Preprocessing was carried out with AFNI version 16 and ME-ICA v3.2 (Kundu et al., 2011). MWE predictor and parser action count, convolved with HRF regressed, against observed BOLD signal during passive story listening.

GLM analysis includes four nuisance variables: word offset, frequency, pitch, intensity.

Conclusion

- Memory retrieval for multi-word expressions evokes a pattern of activation that is spatially-distinct from the pattern evoked by compositional structure-building.
- Phrase structure composition involves Anterior Temporal region which is consistent with earlier studies (Bemis and Pykkänen, 2011; Dronkers et al., 2004; Ferstl et al., 2008).
- While the Precuneus Cortex has not been traditionally viewed as part of the language network, it has been implicated in various memory tasks (Andreasen et al., 1995; Fletcher et al., 1995; Halsband et al., 2002; Mashal et al., 2014; Wallentin et al., 2008).

Future Work

- This work: categorical MWE predictor (0/1)
- Future work: gradient MWE predictors (PMI, Loglik, Dice,...)

Acknowledgements

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Predictors

The number of steps that a bottom-up phrase structure parsing algorithm would take at each word indexes structure-building effort, as shown in Fig. 2.

Future Work

- Gradient MWE predictor (PMI, Loglik, Dice,...)
- Future work: categorical MWE predictor (0/1)

Selected References


Mashal, N., Vidane, T., & Lacer, N. (2014). The role of the precuneus in metaphor comprehension: Evidence from an fMRI study in people with schizophrenia and healthy participants. Frontiers in human neuroscience, 8

Result

The results most strongly implicate Anterior Temporal regions for structure-building and Precuneus Cortex for memory retrieval (p < 0.05 FWE), as seen in Fig. 3 and Fig. 4.

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