LING5702: Lecture Notes 16
Functional Magnetic Resonance Imaging (fMRI)

We've seen latency effects of left-corner parser surprisal. Now let's look at fMRI brain imaging...

Contents

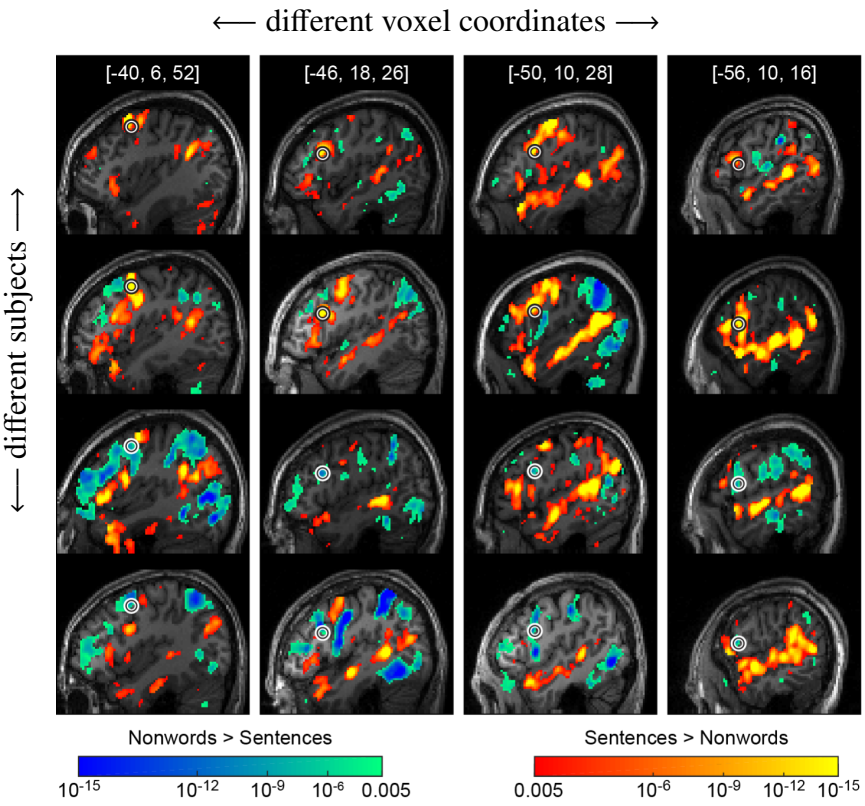
16.1 Localizing a language network in fMRI [Fedorenko et al., 2010]

fMRI measures blood oxygenation (BOLD signal), replenishing neurons after repeated firing.

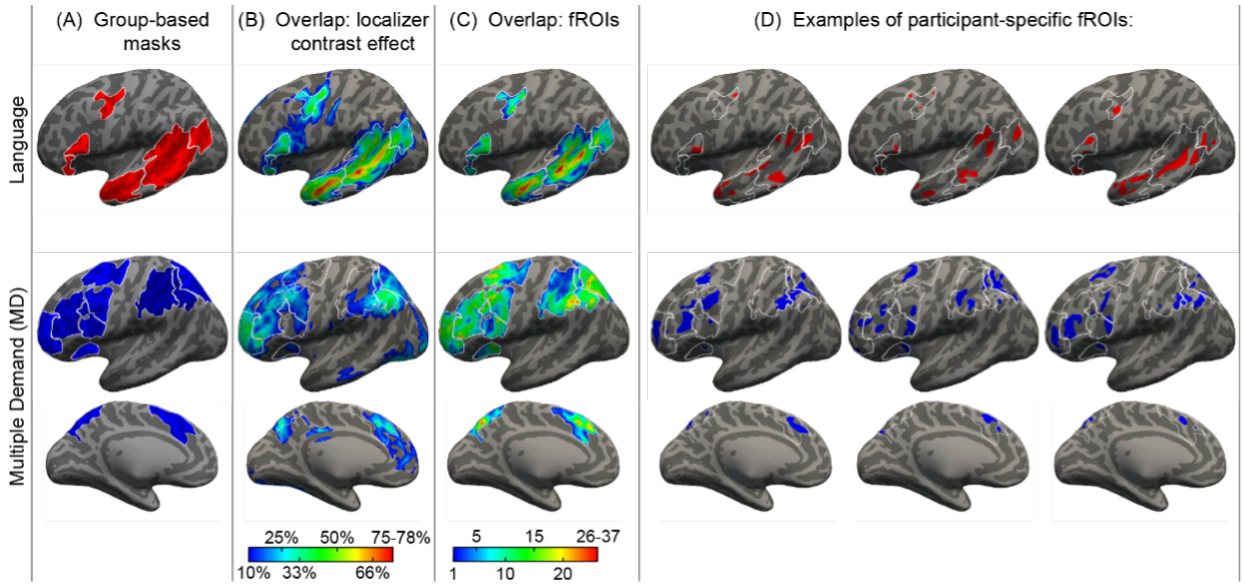
We can distinguish a language network using a localizing task: sentences vs. nonwords.

- measure BOLD given sentence stimuli
- measure BOLD given non-word stimuli
- subtract non-word from sentence and keep top/bottom 10% (language/multiple-demand)

The location of this network varies across subjects, so we have to do this for each person:



The resulting networks are similar but not identical:

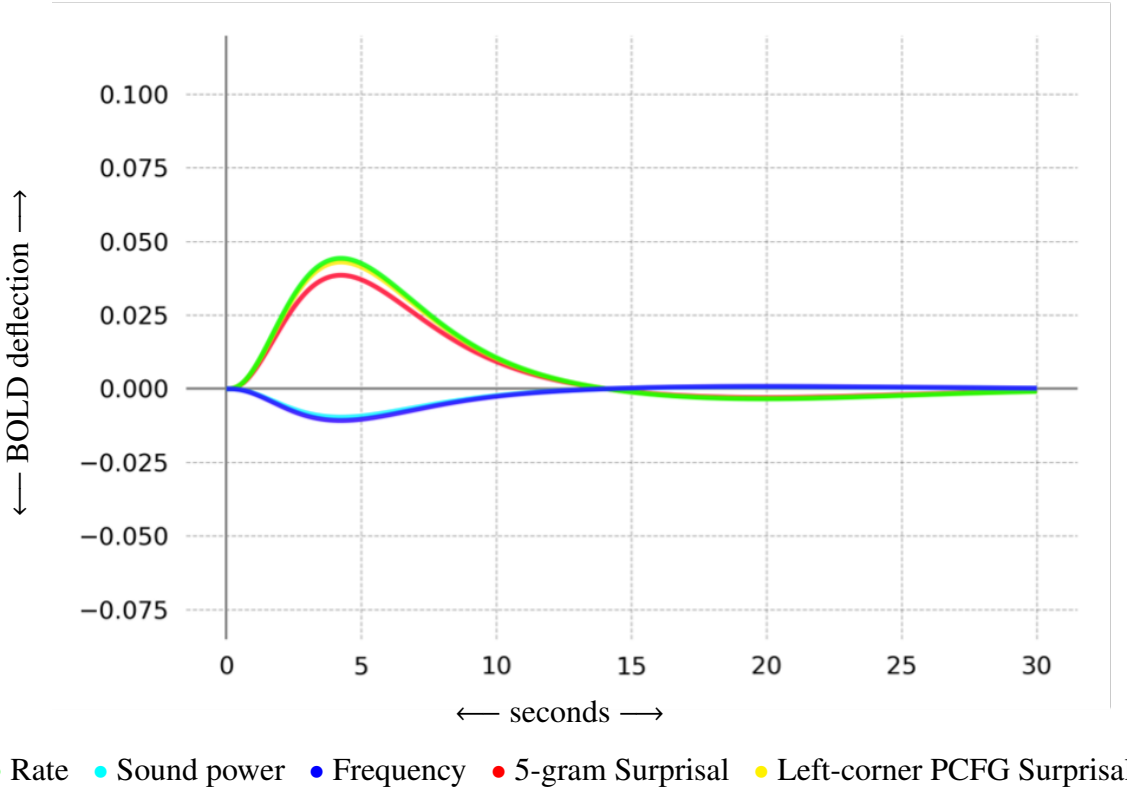


16.2 Left-corner parser surprisal effects in fMRI [Shain et al., 2020]

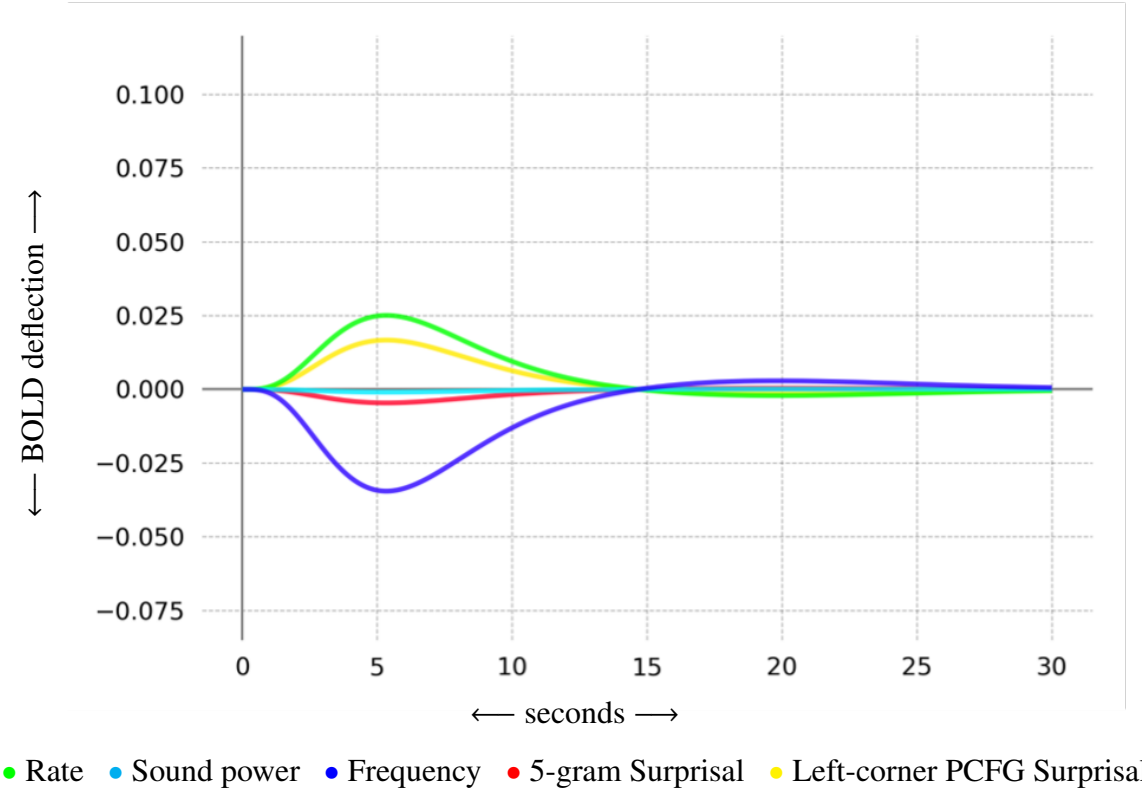
BOLD signals are very slow to peak (5 seconds) and sampling takes time (2 seconds per image).

So we have to convolve (multiply) word surprisals by a hemodynamic response function (HRF).

Results for left-corner parser surprisal and baselines in language network:



Results for left-corner parser surprisal and baselines in multiple-demand network:



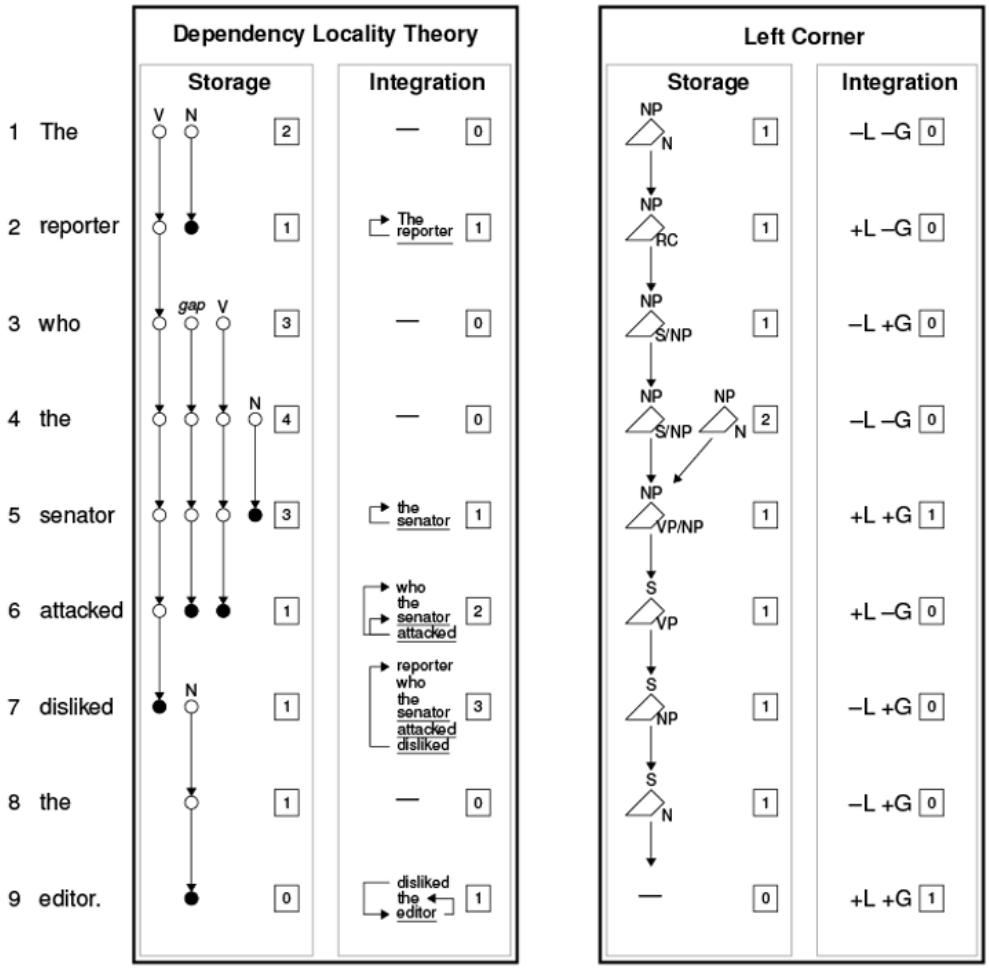
16.3 Memory effects in fMRI [Shain et al., 2022]

It seems expectation plays a role in BOLD.

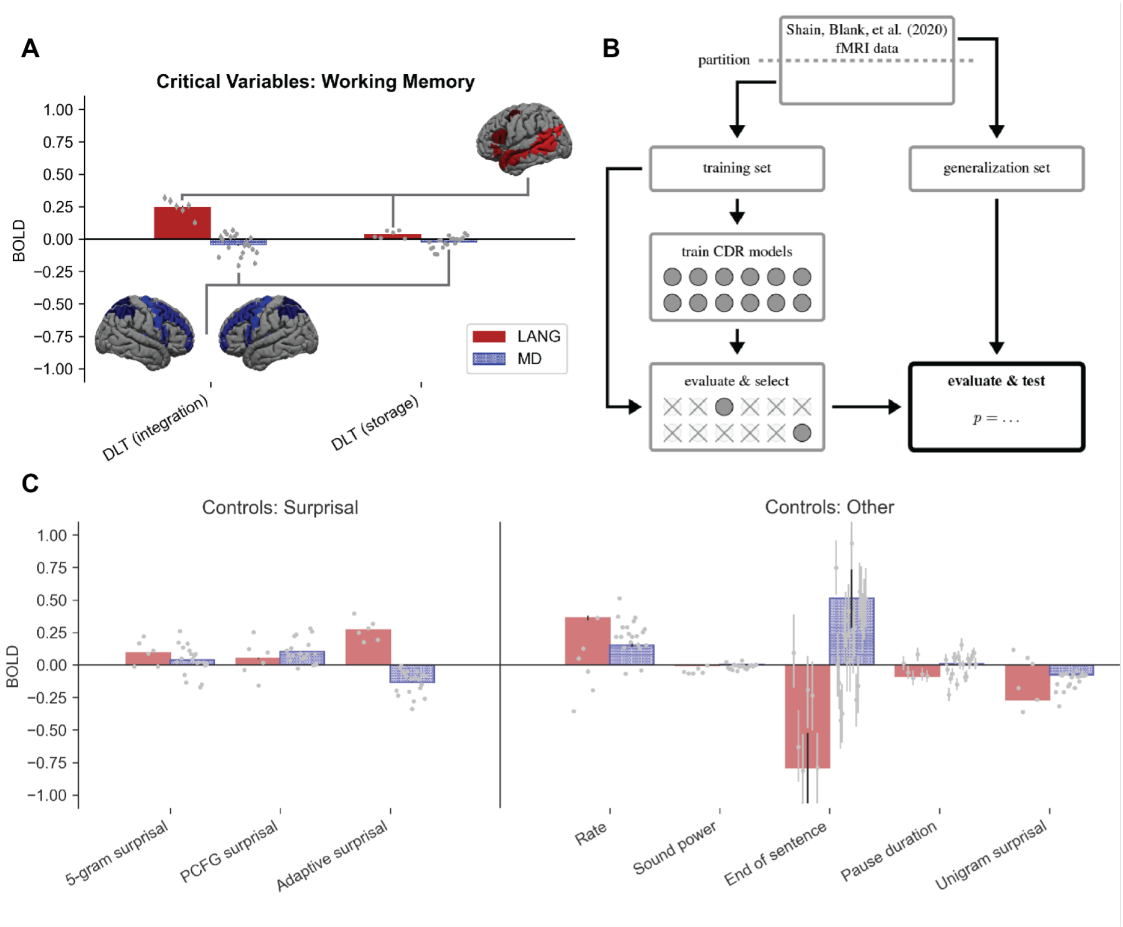
Let's see if there are separate effects for memory:

1. Dependency Locality Theory (DLT) [Gibson, 2000]: count open deps / bypassed distractors
2. Left-corner parsing: number / change in number of derivation fragments

For example, in processing '*The reporter who the senator attacked disliked the editor*':



Results show large independent effect for DLT integration (distractors to bypass):



References

[Fedorenko et al., 2010] Fedorenko, E., Hsieh, P.-J., Nieto-Castañón, A., Whitfield-Gabrieli, S., & Kanwisher, N. (2010). New method for fMRI investigations of language: defining ROIs functionally in individual subjects. *Journal of Neurophysiology*, 104(2), 1177–1194.

[Gibson, 2000] Gibson, E. (2000). The dependency locality theory: A distance-based theory of linguistic complexity. In *Image, language, brain: Papers from the first mind articulation project symposium* (pp. 95–126). Cambridge, MA: MIT Press.

[Shain et al., 2022] Shain, C., Blank, I. A., Fedorenko, E., Gibson, E., & Schuler, W. (2022). Robust effects of working memory demand during naturalistic language comprehension in language-selective cortex. *Journal of Neuroscience*, 42(39), 7412–7430.

[Shain et al., 2020] Shain, C., Blank, I. A., van Schijndel, M., Schuler, W., & Fedorenko, E. (2020). fMRI reveals language-specific predictive coding during naturalistic sentence comprehension. *Neuropsychologia*, 138.