

Predictive Coding Across Levels of Language

Research Question

Predictive processing of language is well supported

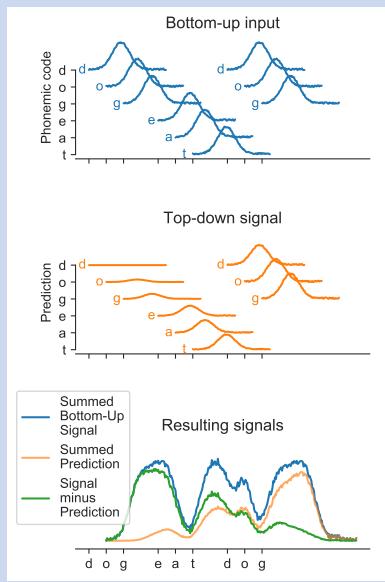
- well known neurocognitive correlates (e.g., N400; [5])
- ... typically *within* one level: i.e., from word meaning to word meaning

Predictive Coding theory [1] suggests *hierarchical predictions*

- e.g., lower levels influenced by higher levels (word *forms* predicted by word *meanings*)
- levels play out on different time scales
- some previous research has been questioned [6] [2]
- Predictive coding suggests lower-level (e.g., phonemic) representations should be less strong for more higher-level (e.g., semantically) predictable words

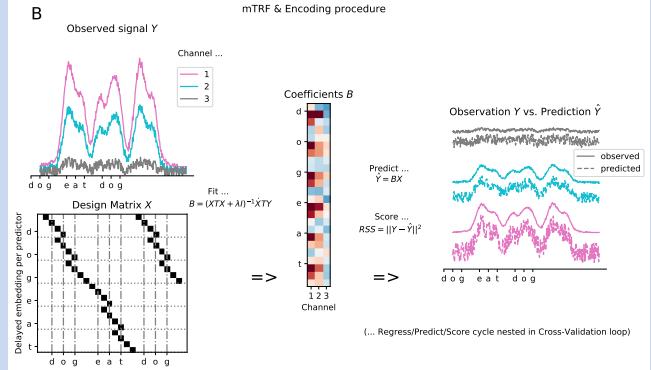
References

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- [5] M. Kutas and K. D. Federmeier. Thirty years and counting: finding meaning in the N400 component of the event-related brain potential (ERP). *Annual review of psychology*, 62:621–647, 2011.
- [6] M. E. A. Nieuwland. Limits on prediction in language comprehension: A multi-lab failure to replicate evidence for probabilistic pre-activation of phonology. *BioRxiv*, 2017.



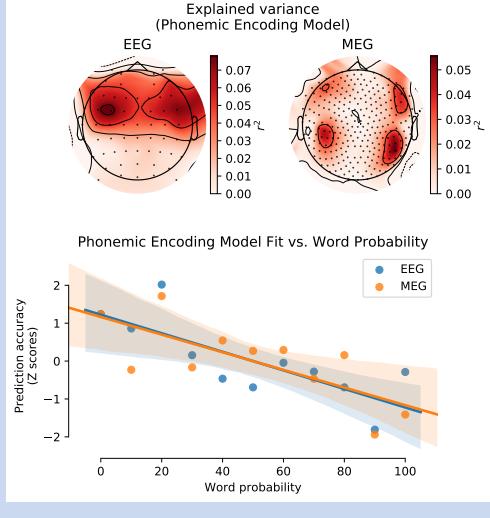
Methods

- Potsdam Sentence Corpus (144 German sentences, with cloze ratings for each word; [4])
- MEG (n=25) and EEG (n=35) data
- compute strength of phonemic representations
 - fit a phoneme continuous encoding model [3] to MEG and EEG data
 - calculate absolute (cross-validated) residuals per time point and channel (roughly: how similar is the neural activity induced by each phoneme token to the idealized template for that phoneme?)
- compute correlation between *word* predictability and *phoneme* representation strength
 - first approach: fit second-level *cloze* continuous encoding model to *squared residuals* from first level
 - second approach: for each word, calculate similarity between template (first-level model coefficients) and actual neural activity, and bin by cloze word

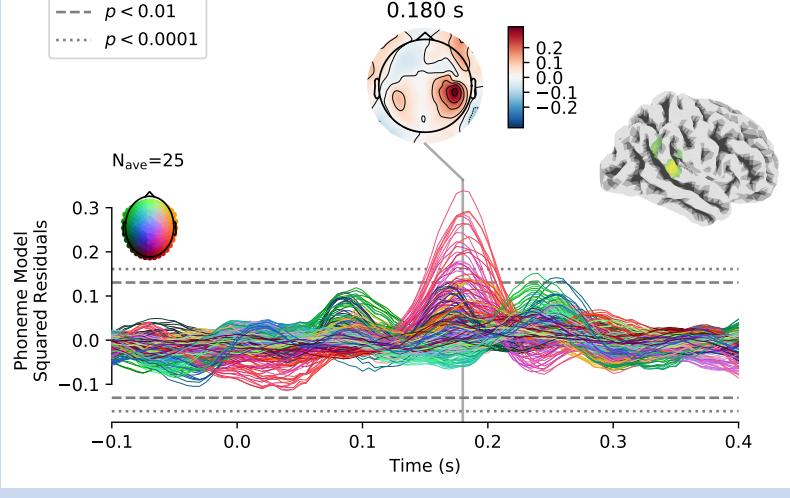


Results

Approach 1: Brain responses to less predictable words are more similar to the template



Approach 2: Regression coefficients from second level (cloze on phonemic encoding residual) encoding indicate at the beginning of words, the phonemic model fits less well for predictable compared to unpredictable words. (MEG & EEG; only MEG shown)



Discussion Results are in accordance with the hierarchical version of Predictive Coding theory: when processing continuous, congruent speech, phoneme-level representational pattern strength covaries with word-level predictability.