From Sounds to Words: Evidence for Lexical Representations Distinct from Nonwords

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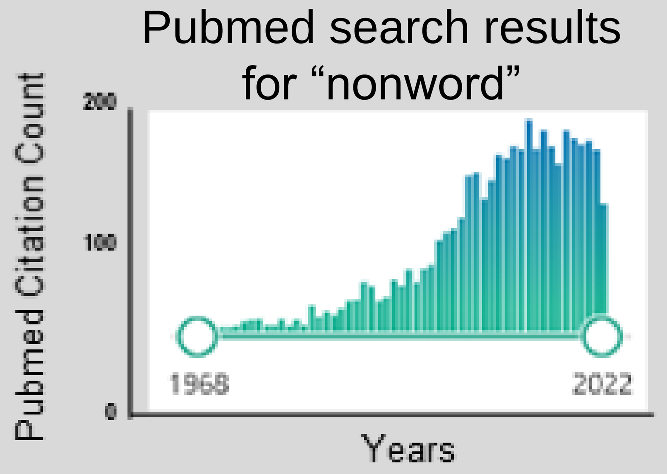
A Critical Gap

- Every level of language processing seems to interface with lexical representation, but there is still a lack of consensus on questions as basic as:
  - How are words represented?
  - In what ways does word-level representation influence downstream processing?

Introduction

- While the neural basis of phonetic representation has been widely explored using neural decoding methods[1], very little is known about the neural basis of lexical representation.
  - Why is nonword processing affected by their similarity to words?
  - What is the nature of nonword representation?
- The representation of nonwords bears on a number of questions/phenomena including:
  - lexical gang effects
  - constraints on phonotactic structure
  - form priming and lexical competition phenomena
  - perception of coarticulated speech



Logic of the study

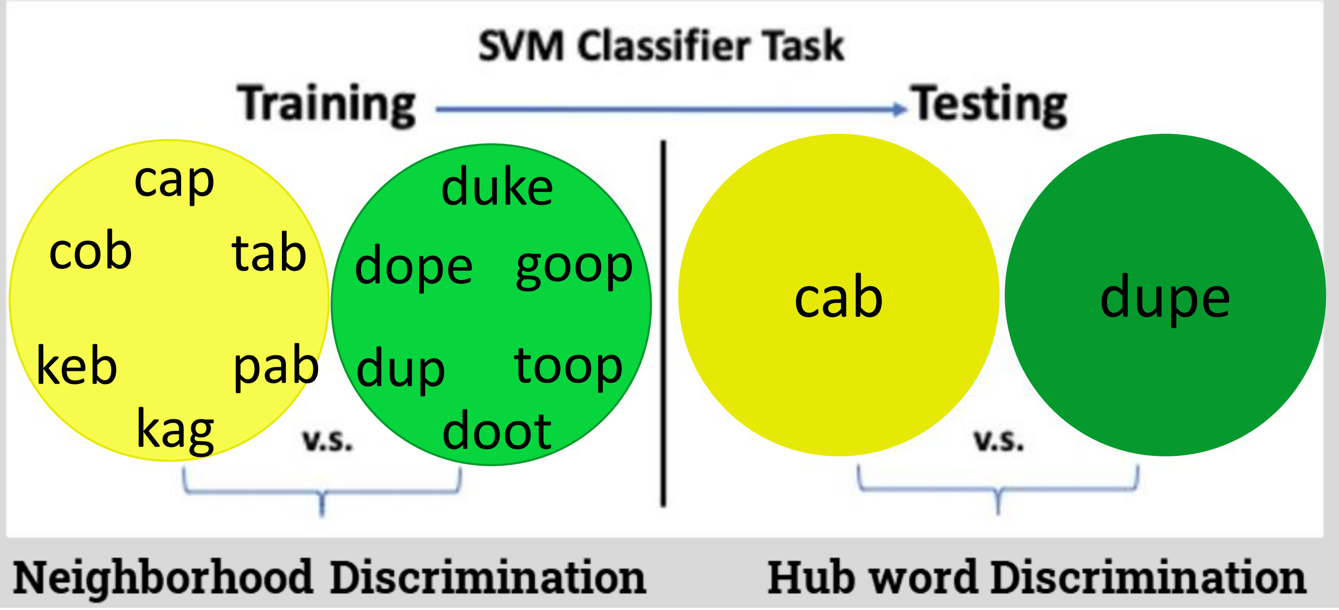
- Words with overlapping phonemes affect each other's processing, suggesting shared representations. We can thus investigate lexical representations by comparing within and between phonological neighborhoods.

Our Plan

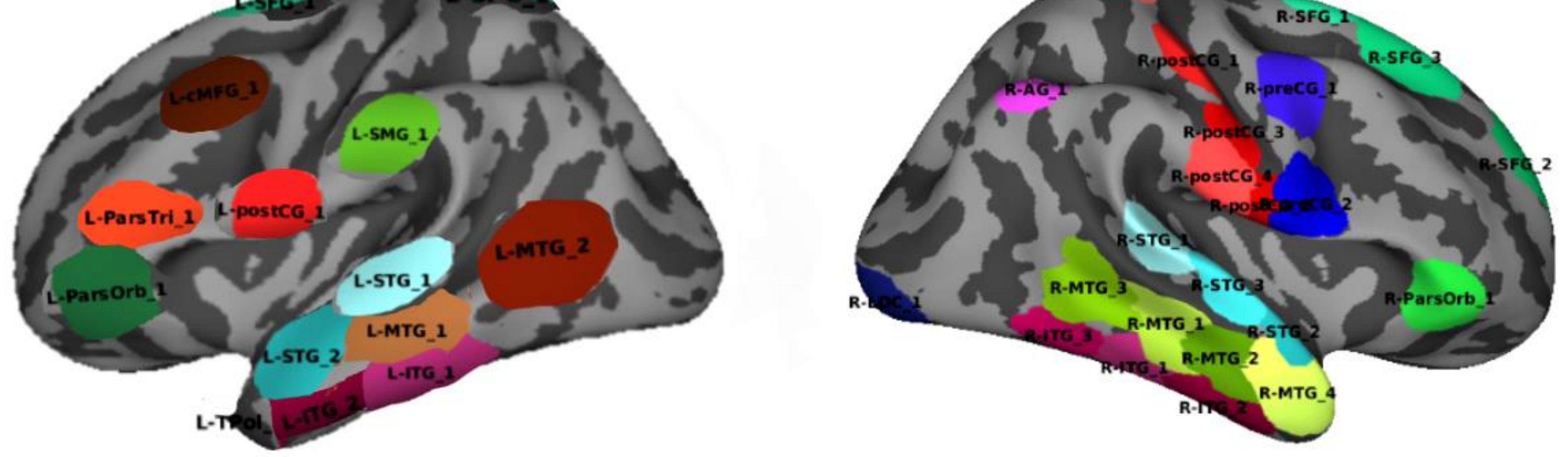
- We ask whether words with shared form have shared neural representation.
- We will assess if nonword vs word patterns are represented in the same way in the brain by using neural decoding techniques, and then viewing how these representations are used by effective connectivity analyses of brain activity.
- By integrating those analyses, we are showing decodable information is causal, not latent.

Stimuli

- Six hub words (CVC) were chosen to define lexical neighborhoods.
- Training and testing were done with 8 different talkers (4 male and 4 female).
- All stimuli were 350 ms long.



ROI Set

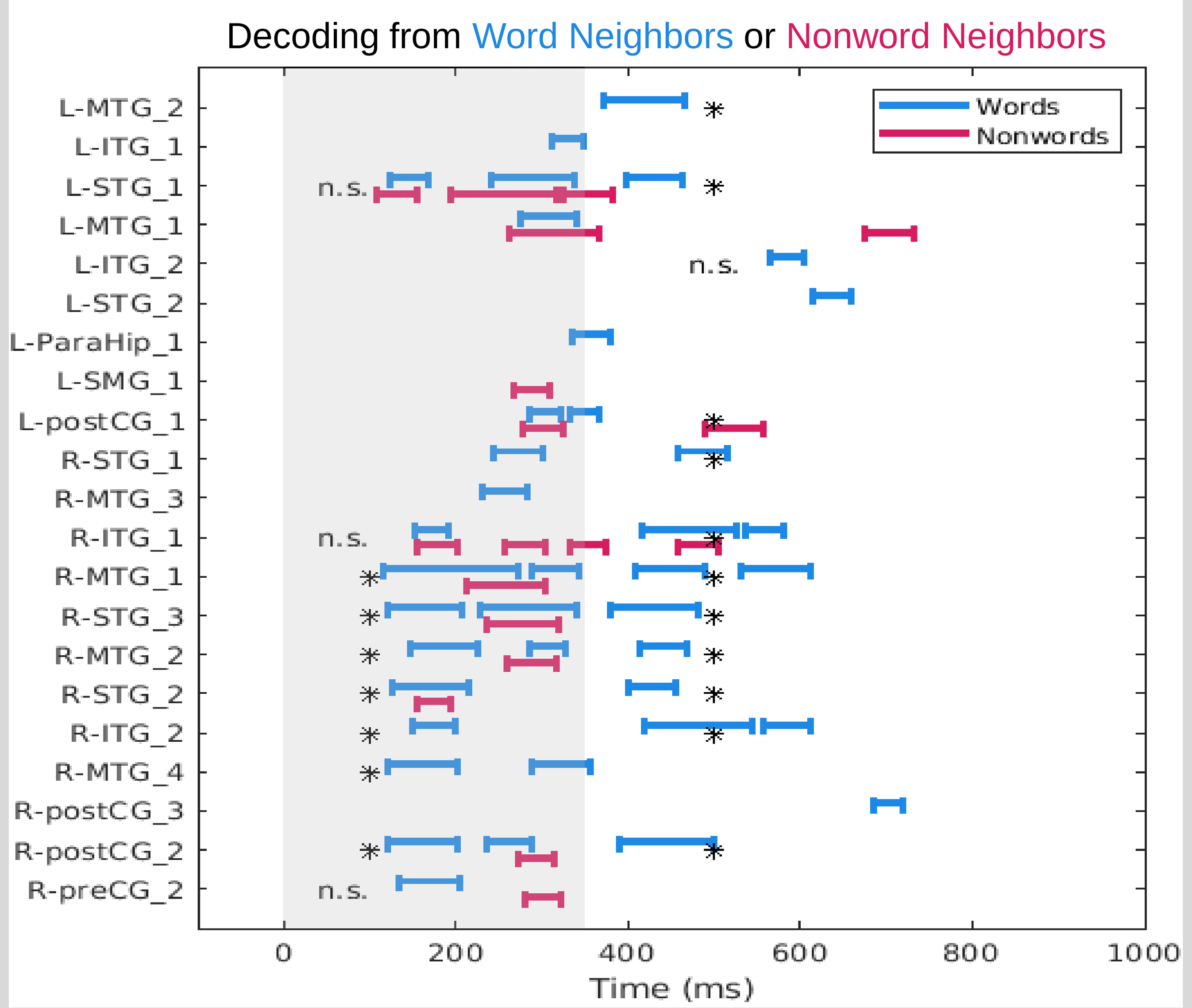


Methods

- Collect MEG and EEG data during a lexical decision task
- Calculate structural MRI constrained source reconstruction of MEG and EEG data
- Identify ROIs in data-driven manner based on activation[2]
- Perform SVM classification based on ROI subdivision timecourses
- Use **transfer learning task** rather than leave-n-out
- Train support vector machines using epochs from neighbors
- Test ability to discriminate the hub word epochs
- Average across all neighborhood pairs to produce single accuracy timecourse
- Conduct analyses with subsets of neighbors: words and nonwords
- Analyze effective connectivity using Granger causality, incorporating lexicality-sensitive subdivision activity and classification accuracy

Results

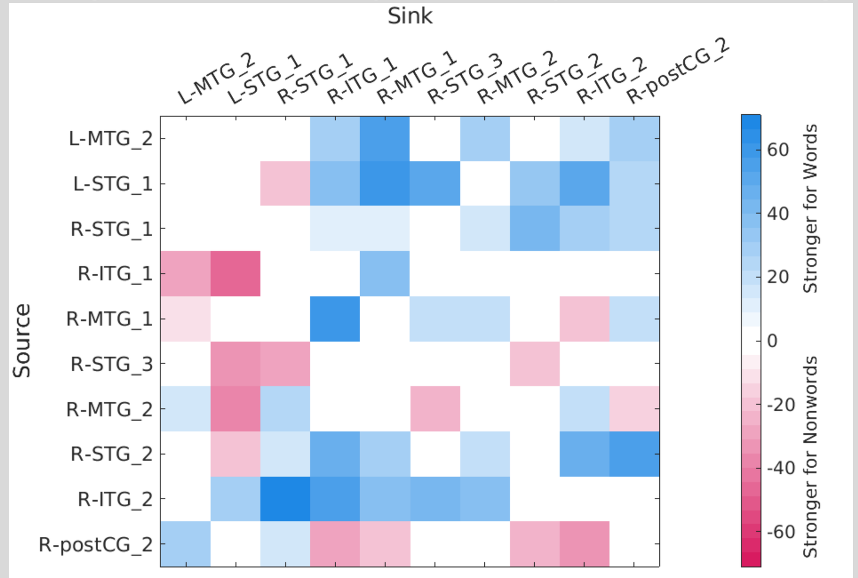
Neural Decoding



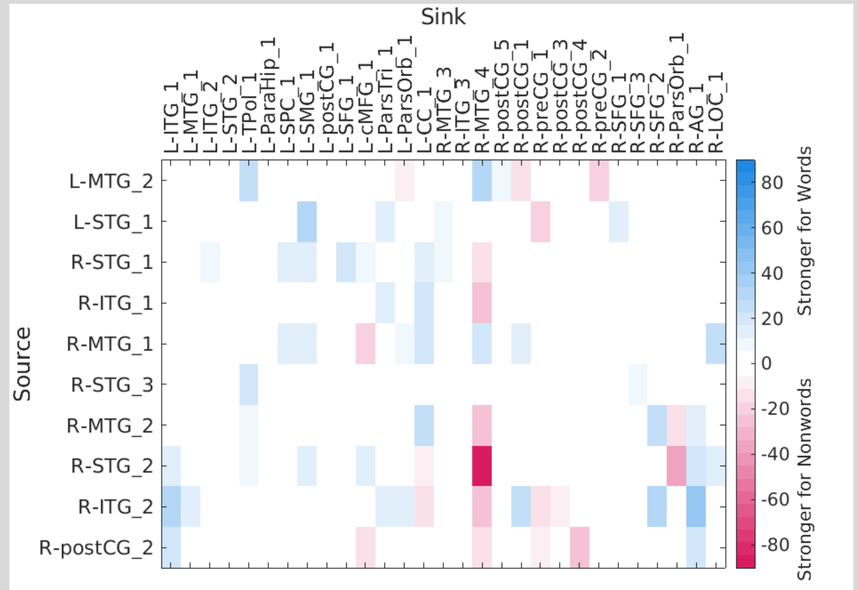
Bars represent periods of significant transfer decoding. Asterisks and n.s. are results of tests between conditions. Shaded region is the period of stimulus presentation.

Effective Connectivity

Granger Causation by Lexicality Sensitive Regions



Influences between lexicality-sensitive regions



External influences from lexicality-sensitive regions

Discussion

- In a difficult, transfer-learning task, source reconstructions of MEG/EEG data produced significant decoding of phonological neighborhood
  - Decoding regions located where words are represented in Hickok and Poeppel[3] model
- **Once stimulus presentation is completed, words are distinct from nonwords, despite previous overlap:**
  - Word-evoked activity produces transfer decoding in the 400-600 ms window; nonword-evoked activity does not
  - During this time period, representation includes **both phonological and lexicality information**
- Lexicality-based representations influence a distributed network of regions identified in Hickok and Poeppel's language model as well as regions specific to task activity
  - Words and nonwords affect different regions within the network
  - Words influence anterior temporal regions associated with semantic representation

References

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