Representational Similarity Analysis of the Neural Representations of Orthographic, Phonologic, and Semantic Processing: Preliminary Results

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Introduction

- Contemporary reading models propose two word recognition processes: decoding from orthography to phonology (O → P), and whole-word reading from orthography to semantics (O → S).[1]
- Using Representational Similarity Analysis (RSA)[2,3] to examine fMRI activity patterns, we can compare participant data with models of O, P, and S during word reading.
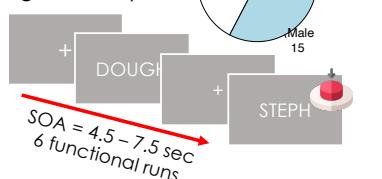
Research Questions:

1. Where are O, P, and S mappings represented in the brain when presented with visual words?
2. Using RSA, how do the strength of these representations influence individual differences in reading skill?
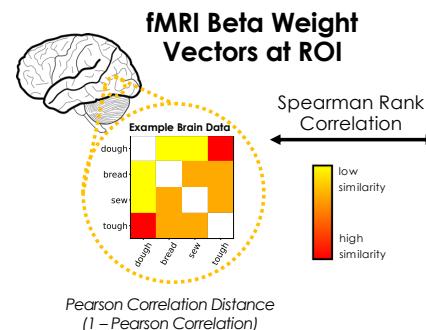
Methods

Participants (N = 50)
- Age: 29.2 ± 13.6 (range: 18 – 67)

Female 33
Non–binary 1
Male 15

SOA = 4.5 – 7.5 sec
6 functional runs

DOUGH
STEPH

Session 1: *Behavioural Session*
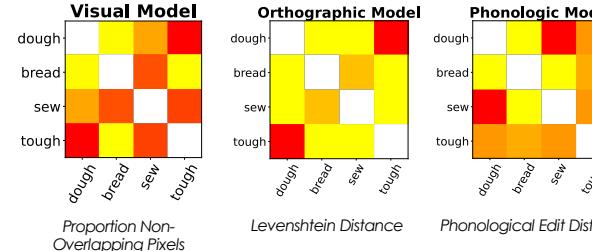- Demographics & Language History Questionnaire
- Word Naming Task: 464 monosyllabic words controlled on sub-lexical dimensions
- Standardized Reading Measures

Session 2: *Neuroimaging Session*
- Silent Word Reading Task (232 words) and Name Detection
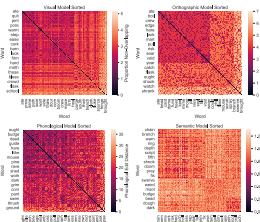- Fast jittered event-related design

Representational Similarity Analysis

fMRI Beta Weight Vectors at ROI

Example Brain Data

Spearman Rank Correlation

low similarity
high similarity

Pearson Correlation Distance (1 – Pearson Correlation)

Example Theoretical Models: word x word representational dissimilarity matrices

Visual Model
Proportion Non-Overlapping Pixels

Orthographic Model
Levenshtein Distance

Phonologic Model
Phonological Edit Distance

GloVe Semantic Model
Cosine Distance of GloVe
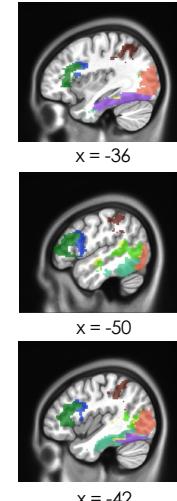
Theoretical Models
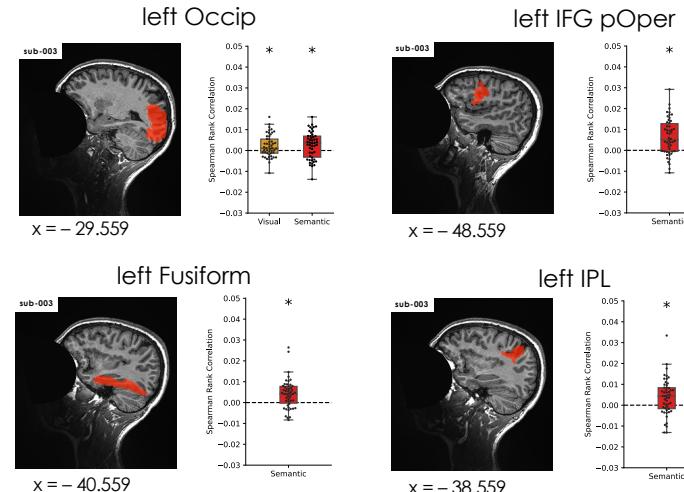
Regions of Interest

- IPL
- OCCIP
- FUS

x = -36

- STG
- MTG
- ITG

x = -50

- IFG pOper
- IFG pTriang

x = -42

Multivariate Results: Similarity to Theoretical Models

left Occip — x = − 29.559

left IFG pOper — x = − 48.559

left IFG pTriang — x = − 48.559

left Fusiform — x = − 40.559

left IPL — x = − 38.559

- *$p < .05$ for one-sample t-test with Bonferroni correction
- Selected univariate activated sub-regions within regions of interest and transformed the regions into subject space
- Distributed patterns of activation along the reading network representing semantic information

Summary

- Spatial patterns of activation across the reading network showed significant correlations with semantic model, suggesting that perhaps the silent reading task is biased towards employing semantic discrimination
- **Next steps:** individual difference analyses to determine whether quality of representations influence reading skill, develop smaller and more focused regions of interest, searchlight analysis within each sub-region of interest, make dataset available to the public

References

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2. Kriegeskorte, N., Mur, M., & Bandettini, P. (2008). Representational similarity analysis—Connecting the branches of systems neuroscience. *Frontiers in Systems Neuroscience*, 2. https://www.frontiersin.org/article/10.3389/neuro.06.004.2008
3. Staples, R., & Graves, W. W. (2020). Neural Components of Reading Revealed by Distributed and Symbolic Computational Models. *Neurobiology of Language*, 1(4), 381–401. https://doi.org/10.1162/nol_a_00018