Relationships between phonological working memory and language processing in adults with dyslexia

Terri L. Scott[1*], Yaminah Carter[2], Ja Young Choi[2,3], Tyler K. Perrachione[2]

[1]Graduate Program for Neuroscience, Boston University, *Correspondence: **tlscott@bu.edu**, [2]Department of Speech, Language & Hearing Sciences, Boston University, [3]Program in Speech and Hearing Bioscience and Technology, Harvard University ; PDF of this poster can be found at **http://sites.bu.edu/cnrlab/publications/conference-presentations-abstracts/**

Summary

- **Phonological working memory (PWM)** is the process of maintaining sounds important for **speech** and **language** in short term memory.
- Individuals with **dyslexia** often show a specific deficit in PWM, as measured by **nonword repetition (NWR)** tasks.
- We measured brain activation using fMRI while individuals with dyslexia and age-matched controls performed **NWR** (including control conditions with real words), as well as two functional localizers for the **language processing** and **multiple demand (MD)** networks.
- Though **the dyslexia group performed significantly less accurately on NWR**, traditional group averaging did not reveal any significant differences in brain activation.
- We tested for differences during **NWR** in functionally defined regions of interest in PWM, language processing, and MD networks, and **only found group differences in MD regions**.

Methods

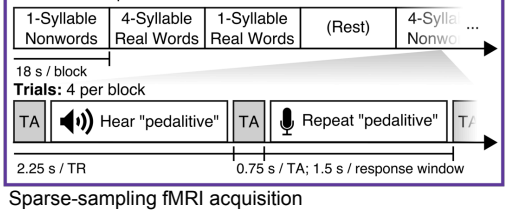
Participants

- 23 adults with dyslexia (19 female, 4 male; age *M* = 23.34 ± 2.93) and 22 controls (12 female, 10 male; age *M* = 23.73 ± 4.13)
- Inclusion criteria for the dyslexic group: Standard scores of ≤ 85 without a diagnosis of dyslexia (<= 90 with diagnosis) on at least 2 subtests from the WRMT and TOWRE

Task

Nonword Repetition Design

fMRI Runs: 3 per session

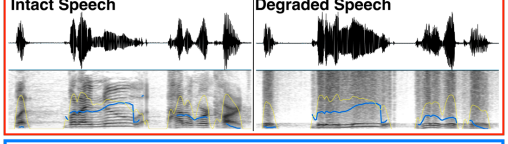


Sparse-sampling fMRI acquisition

Functional Localizers

Language/Speech Task Design

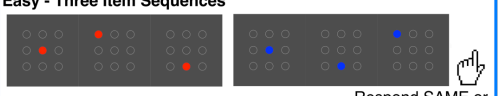
fMRI Runs: 2 per session, 16 blocks per run + rest, one 18-second audio clip per block



Spatial Working Memory: Corsi Blocks

fMRI Runs: 2 per session, 8 blocks per run + rest, 4 trials per block, Easy blocks lasted 18 seconds, Hard blocks lasted 27 seconds

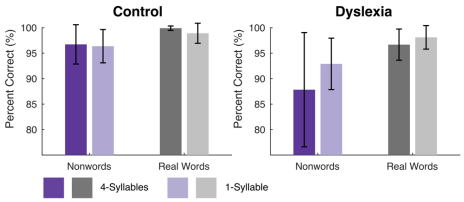
Easy - Three Item Sequences



Continuous-sampling fMRI acquisition

Analyses and Results

Nonword Repetition: In-Scanner Behavior and Group Average Comparison



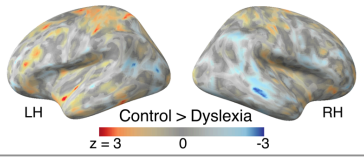
Generalized Linear Mixed Effects Model

*Accuracy ~ Word Type * Number of Syllables * Group + (1 + Word Type + Number of Syllables | Subject) + (1 | Item)*

Significant **main** effects of:
Word Type ($p << 0.001$)
Group ($p << 0.001$)
Significant **interactions** between:
Number of Syllables and *Group* ($p = 0.001$)
Word Type, *Number of Syllables* and *Group* ($p = 0.04$)

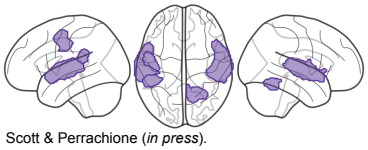
Nonwords (4-Syl. > 1-Syl.) Between Group Comparison

- No clusters survive correction at FWER = 0.05, $p = 0.01$.



Can we find differences if we look in individual subjects' regions of interest within the PWM, language processing, and multiple demand networks?

Do control and dyslexia groups have different magnitude responses in core phonological working memory regions?



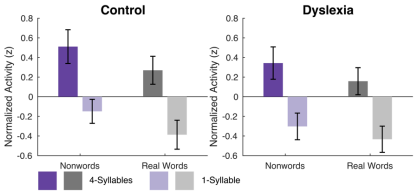
Scott & Perrachione (*in press*).

Linear Mixed Effects Model

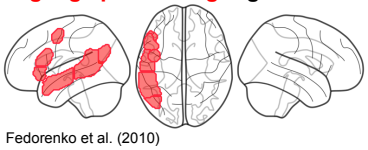
*Mean Activity ~ Word Type * Number of Syllables * Group + (1 + Word Type + Number of Syllables | Subject) + (1 | Brain Area)*

Significant **main** effects of:
Word Type ($p << 0.001$)
Number of Syllables ($p << 0.001$)

We measured brain activation in functional regions of interest (fROIs) defined as the top 10% of voxels from each subject's 4-syllable > 1-syllable nonwords contrast map. Responses were measured in left-out (independent) data. Broad regions of interest were derived from a group of 20 control subjects, some of which overlapped with the subjects in this analysis.



Do control and dyslexia groups have different magnitude responses in language processing regions?



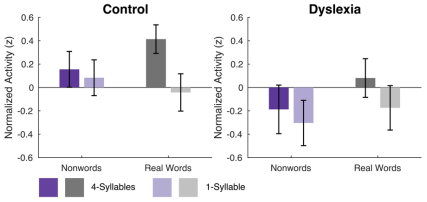
Fedorenko et al. (2010)

Linear Mixed Effects Model

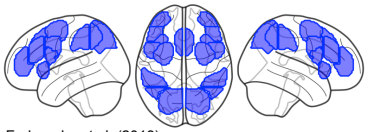
*Mean Activity ~ Word Type * Number of Syllables * Group + (1 + Word Type + Number of Syllables | Subject) + (1 | Brain Area)*

Significant **main** effect of:
Number of Syllables ($p << 0.001$)
Significant **interaction** between:
Word Type and *Number of Syllables* ($p = 0.04$)

This set of language regions was derived using 220 control subjects from separate studies by Fedorenko et al. We derived fROIs using the top 10% of voxels from each subject's intact speech > degraded speech contrast (Scott et al. 2017). We then measured responses to nonword and real word repetition within these language regions.



Do control and dyslexia groups have different magnitude responses in multiple demand regions?



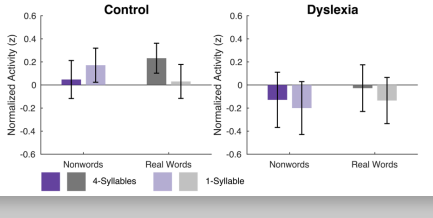
Fedorenko et al. (2013)

Linear Mixed Effects Model

*Mean Activity ~ Word Type * Number of Syllables * Group + (1 + Word Type + Number of Syllables | Subject) + (1 | Brain Area)*

Significant **interactions** between:
Word Type and *Number of Syllables* ($p << 0.001$)
***Word Type, Number of Syllables* and *Group* ($p = 0.002$)**

This set of MD regions was derived using 197 control subjects from separate studies by Fedorenko et al. We derived fROIs using the top 10% of voxels from each subject's hard > easy spatial working memory contrast. We then measured responses to nonword and real word repetition within these MD regions.



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