Intervention-Driven Changes in the Visual Word Form Area of Struggling Readers

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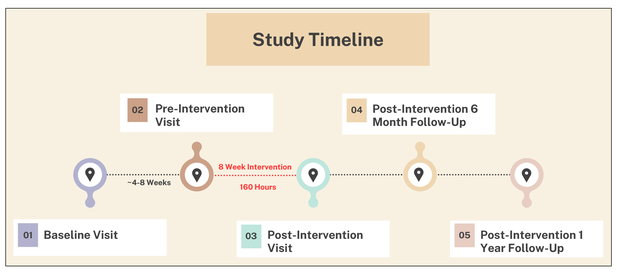
Background

- The Visual Word Form Area (VWFA) is a region in Ventral Occipitotemporal Cortex (VTC) that selectively responds to text over other visual stimuli[1]
- VWFA is comprised of sub-regions that respond more to different features of text - VWFA1 is primarily responsible for the processing of visual properties of text whereas VWFA2 is primarily responsible for the processing of linguistic properties of text[2]
- VWFA develops over time as individuals gain reading proficiency[3]
- Dyslexia is related to abnormal functional and spatial organization of VTC[4] , especially the VWFA

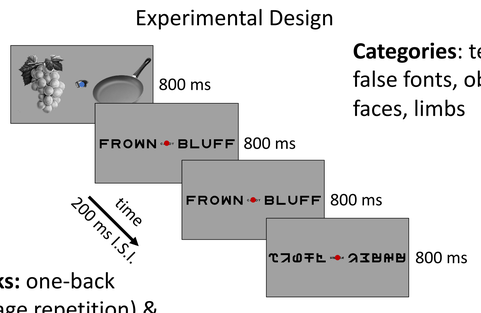
How does an intensive reading intervention change the functional landscape of text-selective cortex in struggling readers?

Methods

- **27** children (age 8-12) with reading difficulties received the intervention over the summer and completed reading assessments and MRI scans over the course of a year



- **12 children** (4 struggling readers, 8 typical readers; n=35 planned) who did not participate in the intervention, underwent the same assessment and scanning protocol
- Children completed 2 runs of a 2 functional localizer tasks:



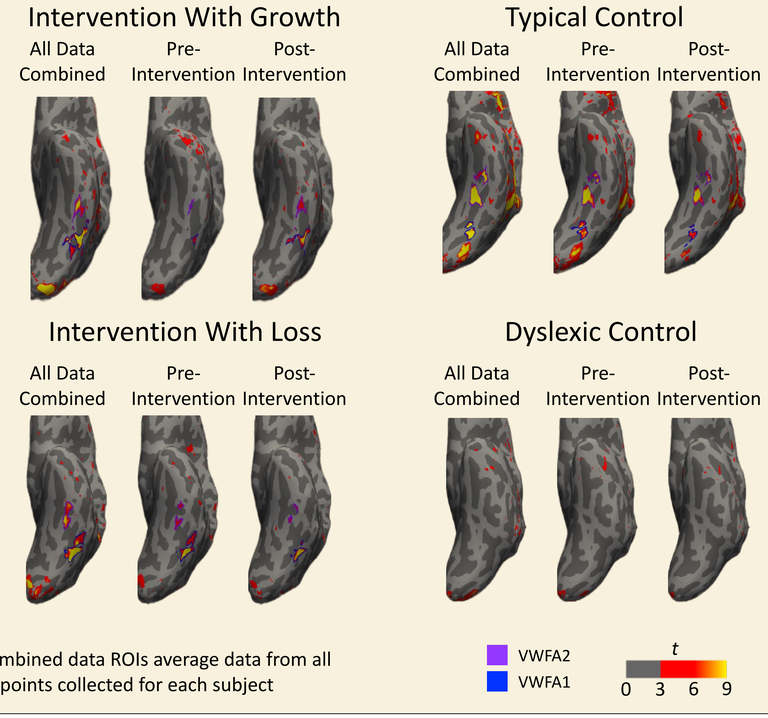
Categories: text, false fonts, objects, faces, limbs

Tasks: one-back (image repetition) & fixation (color change)

*Experimental design and stimuli adapted from White et al., 2023[5]

- MRI data were preprocessed with fMRIPrep and analyzed with Nilearn
- ROIs were drawn on the cortical surface of individual participants in native space using the contrast Text > all other categories (threshold: t>3)

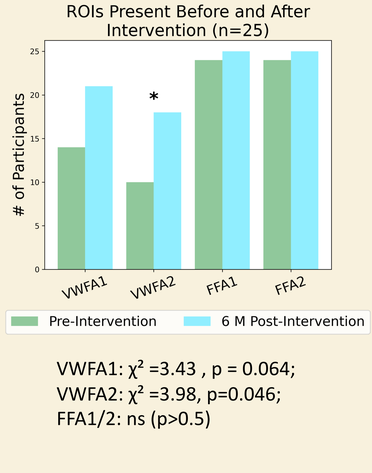
Finding the VWFA in Individual Subjects



* Combined data ROIs average data from all timepoints collected for each subject

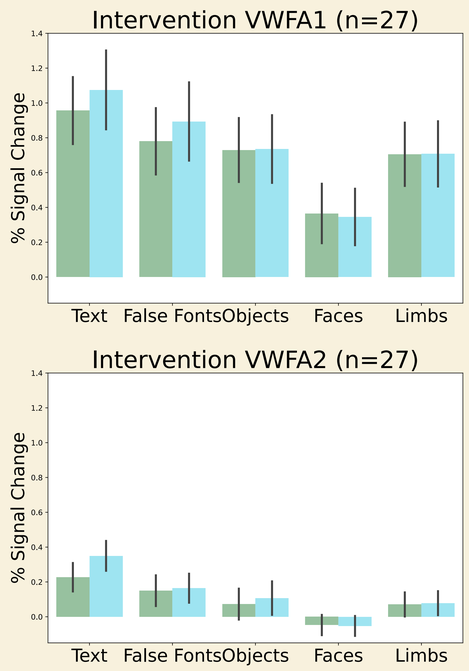
Reading Intervention Drives VWFA Emergence

Children who did not have VWFAs[6] developed them 6 months later after reading skills improved. Face-selective regions did not change.



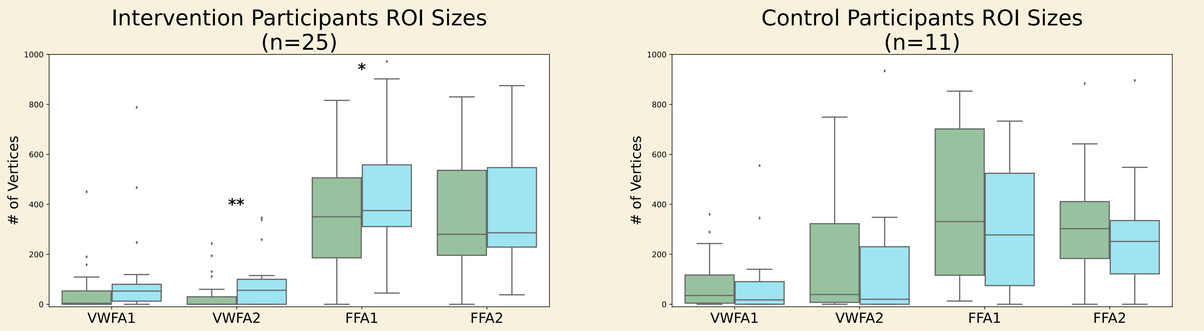
VWFA1: χ^2 =3.43 , p = 0.064;
VWFA2: χ^2 =3.98, p=0.046;
FFA1/2: ns (p>0.5)

Text-Selectivity Remains Stable Despite ROI Emergence



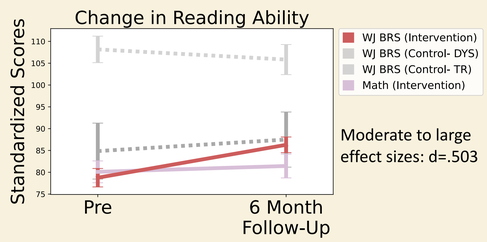
Preliminary data suggests intervention participants experience an increase (p<0.1) in text-selectivity in VWFA2. Data collection is ongoing and future research is needed to determine if this trend reaches a level of significance.

ROI Emergence Drives Size Increase



Intervention participants only display significant gains in VWFA2 (p=0.009) and FFA1 (p=0.022) only when including all participants in an LME. When participants who did not have an ROI pre-intervention are excluded from the analysis, there are no significant changes in either ROI.

Reading Scores Increase



Moderate to large effect sizes: d=.503

Conclusions

- Previous research suggests that struggling readers may not have developed VWFAs[6]. However, our results indicate that with sufficient intervention, these readers may indeed develop VWFAs.
- Notably, VWFA2 exhibited a higher sensitivity to changes in size compared to VWFA1 post-intervention.
- Interestingly, participants who initially had text-selective ROIs displayed less growth compared to those without such regions at the study's outset.
- Mean text selectivity increased specifically for struggling readers, and this growth was observed exclusively in VWFA2.
- In conclusion, the distinct responsiveness of changes observed in VWFA2 were more pronounced than in VWFA1. These results suggest that the reading intervention tapped in to primarily the linguistic processing mechanisms associated with VWFA2 more than VWFA1.

Want to learn more about this project? Visit poster 1-I-73 for information on intervention driven changes in frontal regions and poster 2-B-7 for information on functional connectivity. Or visit https://edneuro.stanford.edu/.

References

1. Cohen, L., & Dehaene, S. (2004). Specialization within the ventral stream: The case for the visual word form area. *NeuroImage*
2. Yeatman, J. D., & White, A. L. (2021). Reading: The Confluence of Vision and Language. *Annual Review of Vision Science*
3. Baker, et al., (2007). Visual word processing and experiential origins of functional selectivity in human extrastriate cortex. *Proceedings of the National Academy of Sciences*
4. van der Mark, et al., (2009). Children with dyslexia lack multiple specializations along the visual word-form (VWF) system. *NeuroImage*
5. White, et al., (2023). Engaging in word recognition elicits highly specific modulations in visual cortex. *Current Biology*,
6. Kubota, et al., (2019). Word selectivity in high-level visual cortex and reading skill. *Developmental Cognitive Neurosience*

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