

Testing the Efficacy and Mechanism of a Glass Analysis Method Reading Intervention

1. PI and Co-PIs

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2. Proposed Research Activity

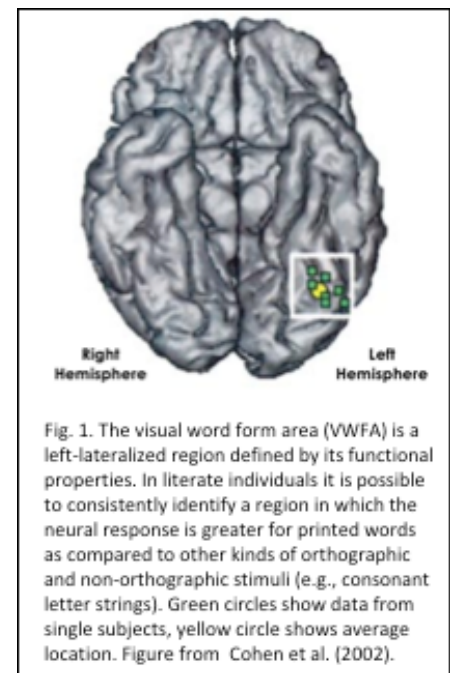
We will test the effectiveness and mechanism of a reading intervention based on the Glass Analysis method (Glass, 1973). Participants will be 6th grade struggling readers assigned to an intervention (N=24) or a wait-list control (N=24) group. The intervention effectiveness will be measured by comparing gains in basic reading skill for the intervention versus control group. Neuroimaging data will be used to test for a predicted relationship between the intervention and increased neural activity within a right hemisphere brain region associated with orthographic processing (the r-VWFA).

Rationale

This project builds from a line of basic cognitive neuroscience work led by the proposal PI (Fiez). This past work has sought to understand the role of a particular brain region, the visual word form area (VWFA) (Figure 1). The VWFA is functionally specialized through reading experience, so that after an individual acquires literacy this region begins to respond more selectively to printed words as compared to non-pronounceable letter-like stimuli (e.g., strings of consonant letters) or non-orthographic visual stimuli (e.g., images of faces) (Cohen et al., 2002), and the strength of this response is linked to individual differences in reading skill (McCandliss et al., 2003).

In some individuals a similarly located region in the right hemisphere (r-VWFA) also responds to printed words, though usually less robustly (Cohen et al., 2002). Our past work has asked: 1) what properties guide the lateralization of visual word processing to the left hemisphere? and 2) why do some readers exhibit a more bilateral (both VWFA and r-VWFA) pattern of activation?

To answer these questions, we have considered whether the left-lateralization of the VWFA is driven by the visual properties that are characteristic of printed scripts, or whether it reflects how an individual analyzes the visual word forms and their subcomponents to recognize not

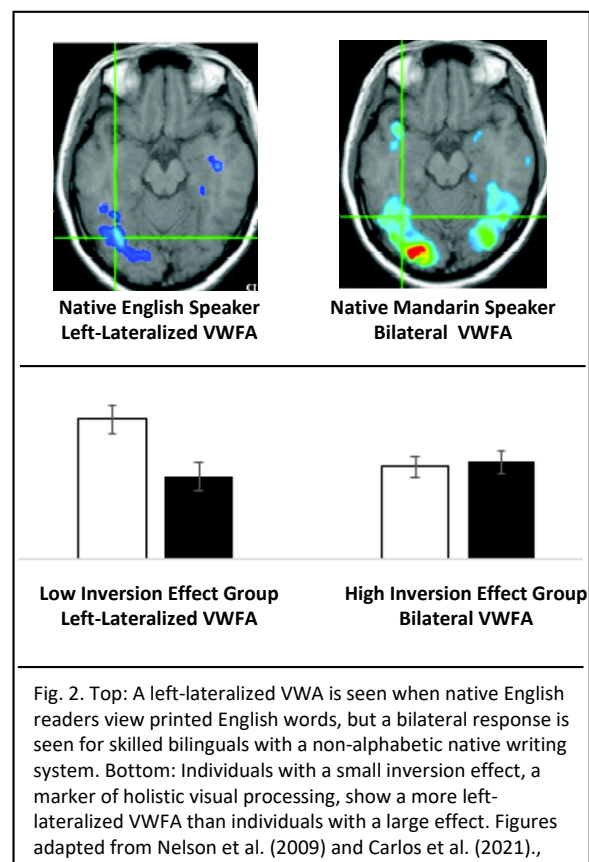


just the printed word forms themselves, but also their corresponding sound and meaning (i.e., to engage in *word identification*). In a series of neuroimaging experiments we contrasted different natural writing systems (English, Korean, and Chinese) (Ben-Yehudah et al., 2019; Carlos et al., 2019; Hirshorn et al., 2020; Nelson et al., 2009), as well as artificial writing systems designed to manipulate the visual forms of words and their mapping to phonology (Hirshorn et al., 2016; Martin et al., 2019; Moore et al., 2014a; Moore et al., 2014b).

We found that learning to read an alphabetic writing system is likely to induce a left-lateralized VWFA response (Martin et al., 2019; Moore et al., 2014b). Further, readers of English who are most skilled at using letter-sound correspondences to sound out (or decode) unknown English words tend to have a more left-lateralized VWFA response (Carlos et al., 2019). In contrast, learning to read a non-alphabetic writing system (such as Chinese (Nelson et al., 2009)) or an artificial writing system based on printed word subcomponents representing English syllables (Hirshorn et al., 2016) seems to induce a bilateral pattern of visual word processing, with activation of both the VWFA and the r-VWFA (Figure 2, top).

Further, skilled readers of English who seem to rely more upon the visual analysis of whole words or syllabic subunits, and their connection with semantic knowledge, tend to have a more bilateral VWFA and r-VWFA activation pattern. This includes native readers of Chinese who are skilled second-language English readers (Ben-Yehudah et al., 2019; Nelson et al., 2009), and monolingual English readers who are particularly sensitive to a manipulation thought to disrupt right-hemisphere holistic visual analysis (Hirshorn et al., 2020) (Figure 2, bottom). Importantly, these individual differences can be observed in the context of similar performance on composite measures of reading ability, which suggests that the neural and behavioral signatures of reading skill can have more than one profile.

The fact that some readers of English attain a high level of skill that is accompanied by a bilateral VWFA/r-VWFA neural pattern strongly motivates the present work. Specifically, we hypothesize that adolescents who have struggled to become skilled readers of English using common instructional strategies – many of which rest upon a foundation of letter-sound analysis and printed word decoding (Gaias et al., 2020) – might especially benefit from a reading intervention that rests upon larger units of visual analysis and the connections of these units to syllable and word-level pronunciations. We reason that such an instructional approach might help to build the kind of bilateral system for orthographic processing and reading style that we have seen in some skilled readers of English. While this might not be the prototypical or most efficient pathway for success for most readers, for some it might be the better alternative (Hirshorn et al., 2014; Moore et al., 2014).



This line of thinking has led us to be specifically interested in the Glass Analysis method for reading instruction (Glass, 1973). The method has similarities to phonics-based reading programs, in that its primary goal is to support the skilled recognition of printed words, a foundational skill that supports higher level reading abilities such as comprehension (Perfetti, 2007). However, it focuses on 119 multi-letter clusters that are most commonly used in the English writing system, instead of individual letter-sound correspondences. The clusters are introduced in the context of “service words” and students work to visually analyze the clusters within them instead of assembling word sounds to yield a pronunciation. For example, one cluster pack introduces the ‘ar’ letter combination through a sequence of increasingly complex words (bar, hard, cars, star, park, harder, chart, sharp, starting, army, sparkle, march, yard, harbor, marketing). Following about 20-40 minutes of working with the cluster packs, the student engages in oral reading of follow-on phrase and sentence material with the tutor providing reading assistance and attention to learned clusters.

The Glass Analysis Method has been available for decades, but there is little published research on its effectiveness. One published study appeared as a PhD thesis (Bernowsky, 1999) and it involved a convenience sample of eight second and third grade students from a suburban school district in New Jersey. Assessments of reading skill were conducted before and after five months of instruction. Intervention outcomes were not analyzed statistically, but a majority of the students showed improvements on the reading assessment measures. Penny (2002) reported results from a larger and higher quality study. The participants were students enrolled in a reading course for high school students with long-standing difficulties in reading. For an experimental group, 21 students completed approximately 18 tutoring sessions. A control group of 12 students remained in their class. Students who received the tutoring sessions showed greater relative improvement on standardized reading measures as compared to those in the control condition. Our primary goal is to expand this past work through a high-quality test of a reading intervention based on the Glass Analysis method, adapted for virtual administration by relatively inexperienced tutors. Our secondary goal is to investigate its underlying neural mechanism of change.

Methods

Participants and group assignment. We will recruit adolescents enrolled in 6th grade within the Pittsburgh Public School System (PPSS) whose 5th-grade score on the Pennsylvania System of School Assessment (PSSA) for English Language Arts fell within the below-basic category.

Participants will be randomly assigned to an intervention group or a wait-list (later intervention) control group. Those in the intervention group will complete the reading intervention during a 6-week period that will immediately follow a pre-assessment and group assignment period. Those in the control group will have the opportunity to complete the intervention during a 6-week period that will commence after their post-assessment session. A total of 48 individuals will be recruited into the study, with 24 enrolled into the study in the fall term of 2022 (12 intervention, 12 control) and 24 enrolled into the study in the spring term of 2023 (12 intervention, 12 control) (see Table 1 for more details).

Table 1: Study Design and Timeline

	7/22	8/22	9/22	10/2 2	11/2 2	12/22	1/23	2/23	3/2 3	4/23	5/23	6/2 3	7/23
Ramp up	Prepare study materials												
Cohort 1 (N=24)		Recruit	Pre-Assess	Intervention		Post-assess							
				Wait period			Intervention						
Cohort 2 (N=24)							Recruit	Pre-Assess	Intervention		Post-Asses		
									Wait period			Intervention	

Reading intervention. The intervention will be delivered online in ~ 45 min sessions held five times per week. The Fiez lab has extensive experience with online assessment and training, which most recently has included adults with dyslexia. Each session will comprise ~ 20 minutes of instruction involving progression through a set of cluster packs, followed by ~ 20 minutes of oral reading practice with texts that will follow the recommended principles for the Glass-Analysis method (e.g., sentences in which multiple words contain the target cluster) (Glass, 1973). The cluster packs and oral reading material will be specified in advance for each session and a tutor will work with their assigned student to progress through the materials. Tutors will be expected to work with their students to reschedule missed sessions, to stay on track to complete 30 sessions by the end of the 6-week intervention period.

Pre- and Post-Study Assessment. Participants will complete a ~ 45 min reading assessment up to a month before (pre-assessment) and no more than two weeks after (post-assessment) a 6-week intervention/wait period. The assessment will involve administration of eight subtests from the Woodcock Reading Mastery Test-III (WRMT3; Woodcock, 2011): the listening comprehension subtest as a measure of oral language ability; the phonological awareness and rapid automatic naming subtests as a measure reading readiness; the word identification, word attack, and oral reading fluency subtests as measures of basic reading skill; and the word comprehension and passage comprehension subtests as measures of reading comprehension.

All participants will be invited to participate in an additional neuroimaging assessment. This will be optional so as to avoid any sense of coercion related to eligibility for the intervention. Funds will be separately solicited from the Pitt-CMU BRIDGE Center. This would allow for the collection of pre- and post-study neuroimaging data that will follow the pre- and post-assessment of reading skill. In each session we will acquire neuroanatomical brain images, and functional brain images. These data will allow us to measure intervention-related changes in the response properties and neural connectivity of the VWFA and r-VWFA.

Planned analyses. To measure the effectiveness of the intervention, we will use the total reading cluster score (a composite of basic reading skill and comprehension subtests) as the dependent measure. An ANOVA will compare the pre- versus post intervention/wait assessment scores for the intervention and control groups, with study term (fall, spring) as an additional factor. Most critically, an interaction is predicted between assessment timepoint (pre vs. post) and group (intervention vs. control), with the intervention group exhibiting significantly greater gains in reading skills as compared to the control group.

To investigate the underlying mechanisms, *a priori* spherical regions of interest will be placed on the prototypical location of the VWFA and r-VWFA based on our past work. The strength of the functional response in each region will be extracted for orthographic as compared to non-orthographic stimuli and serve as the dependent measures for a subsequent ANOVA. The ANOVA will include neuroimaging session (pre vs. post intervention/wait), group (intervention vs. control), study term (fall vs. spring), and hemisphere (left vs. right) as factors. Most critically, an interaction is predicted between neuroimaging session, group, and hemisphere, with the intervention group exhibiting significantly larger neural responses to orthographic stimuli in the second session, especially in the right hemisphere region (i.e., the r-VWFA).

3. Research Team

This project represents a significant new direction for all of the primary investigators. For Fiez, it represents her first attempt to use basic findings on the neurobiology of reading to inform an educational intervention that meets the standards of a clinical trial. It would also be her first experience leading a project involving adolescent participants. For Matsumura and Sandora, it represents their first engagement in an “educational neuroscience” project. Additionally, while Matsumura and Sandora have extensive educational research experience with a literacy focus, these efforts have been primarily directed towards developing comprehension and other high-level reading skills.

Together, the team has the combination of skills and disciplinary expertise needed to execute the project with credibility across the psychological, neuroscience, and educational disciplines. Fiez will have overall responsibility for project design, execution, and dissemination, with scholarly contributions especially related to psycholinguistic and neural theories of reading skill and reading development. Sandora, Matsumura, and Beck will serve as project advisors. In particular, the education researchers will work with Fiez and her lab to finetune the intervention materials, train the tutors and monitor fidelity of implementation of the intervention.

4. Aspects of the work that make it intellectually exciting with federal funding potential

This project focuses on an underserved group, adolescent struggling readers from an urban school district, and it brings to the forefront a reading intervention that is distinct from the predominant interventions for building basic reading skill (Denton and Madsen, 2016; Herrera, 2016; Gaias et al., 2020). If successful it could provide the rare example (Bowers, 2016) of neuroscience that motivates effective teaching methods and informs debates about whether instruction should target impaired or nonimpaired skills. We can readily imagine future work that would build upon this initial proof-of-concept feasibility test, such as a larger scale trial that could test and compare the effectiveness both the Glass Analysis Method and a more traditional approach implemented online (such as a variant of Beck’s world building approach implemented by McCandliss et al. (2003)).

We are also excited by the potential to create broader access to reading intervention services for children enrolled in schools with limited resources. We have deliberately chosen an intervention approach that does not involve a traditional school setting or highly trained interventionists. If our implementation is found to be effective, it could open up exciting new community and caregiver-based opportunities to improve reading skill for many children. We

are excited to have team connections to the Institute for Learning as a way to facilitate dissemination of our results beyond the academic research literature.

We see multiple avenues for future funding. Fiez's basic work has been supported by the National Institute for Child Health and Development, which would be a natural source of support for a larger-scale clinical trial. Fiez has also received NSF funding, including current support for a project in which the data collection efforts are enfolded into an undergraduate advanced psychology lab course. The same model could be used to develop a proposal that combines continued study of the intervention with undergraduate STEM engagement. Finally, the work would also seem to be appropriate for IES funding, and the engagement of Matsumura, Beck, and Sandora could help to grow the work towards this funding direction.

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