

## RESEARCH REPORT

Luke Waites Center for Dyslexia and Learning Disorders

# ***Luke Waites Center Curriculum Efficacy Project***

## **Non-Inferiority of Tech-Assisted Dyslexia Instruction in Remediating Literacy Skills**

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# LWCCEP Interim Findings

## Success and a Challenge

The Luke Waites Center for Dyslexia and Learning Disorders has previously developed and disseminated a successful dyslexia intervention called *Take Flight: A Comprehensive Intervention for Students with Dyslexia* which has been widely adopted in schools across the country since its release in 2006. *Take Flight* is designed to be taught by a certified teacher who has completed an additional two years of advanced dyslexia-specific training to become credentialed as a Certified Academic Language Therapist (CALT). The combined barriers of extensive investment of time and resources necessary for a teacher to attain CALT status and the limited number of qualified CALT training facilities place significant constraints on the number of CALTs available in schools. Yet, as a result of Texas state laws about dyslexia, an increasing number of public-school students are being identified as needing access to high quality dyslexia instruction; hence, the current demand for CALTs exceeds the number available in schools. The current project is designed to address this gap in resources.

## A Promising Solution

In order to increase student access more rapidly to the beneficial *Take Flight* intervention, the Luke Waites Center developed a modified delivery model that is designed to be taught by a certified teacher. The certified teacher, without the advanced CALT training, can deliver the instruction with the help of expert curriculum support. This support includes the use of a 3-D anthropomorphic animated virtual co-teacher whose role is to introduce specific aspects of *Take Flight* content that typically require years of mentored training for a CALT to present with accuracy, consistency, and fidelity. For the technology to fulfill this role, it was necessary to design the virtual co-teacher with natural human-like mouth movement and facial expression. The accuracy of the visual aspects of speech, such as the correspondence of mouth movements to the auditory script is a critical component in language learning and may bolster auditory speech perception in children, particularly those with dyslexia (e.g., Navarra et al., 2012; Ziegler et al., 2009). Furthermore, direct instruction in articulatory phonetics can help students with dyslexia to develop the phonological processing skills needed for reading (Castiglioni-Spalten & Ehri, 2003). The primary goal of the *Bridges* program is to shorten the teacher training time, thereby making effective, evidence-based dyslexia intervention accessible to more children.

Expertise to develop a virtual co-teacher with the necessary anthropomorphic qualities comes from the University of Texas at Dallas Lab for Virtual Humans and Synthetic Societies, which has previously produced award winning 3-D anthropomorphic virtual humans for use in military and medical training settings. The dyslexia intervention using this virtual co-teaching avatar is called *Bridges: A Dyslexia Intervention Connecting Teacher, Avatar, and Student (Bridges)*. Pilot introduction of the *Bridges* program in the controlled Luke Waites Center Dyslexia Laboratory School setting has been well received by students and teachers and also effective for student growth.

## Next Steps

The next step is to determine the efficacy of this promising solution in a less controlled, more typical remedial classroom setting. To evaluate the effectiveness of the *Bridges* program, student outcomes must be compared to outcomes for students receiving both *Take Flight* and other high-quality, validated dyslexia

interventions. All instruction will be provided by school district personnel. SRC is only collecting data to assess outcomes. The next sections of this document describe the study interventions and outcome measures. The following pages present preliminary analysis of student outcome data.

## Comparative Intervention Methods

### *Take Flight: A Comprehensive Intervention for Students with Dyslexia*

*Take Flight* is an extensive, multi-componential dyslexia intervention derived from Orton Gillingham-based instructional principles. It integrates evidence-based best practices for teaching the important components of a comprehensive reading program and has demonstrated efficacy and effectiveness in both laboratory and public-school settings (Avrit et al., 2006; Ring et al., 2017). The curriculum scope and sequence is presented in 230- sessions using two alternating daily lesson types. The first lesson plan (New Learning, 132 lessons) introduces combinations of phonemic awareness, phonics concepts (e.g., grapheme-phoneme correspondences), syllable division rules, morphology, spelling rules, vocabulary, and comprehension strategies. Importantly, each new learning is integrated into each of these daily instructional components to allow for additional practice and consolidation across multiple activities. The alternate lesson plan (Application, 98 lessons) provides an opportunity to consolidate student learning by applying previously learned skills and strategies in repeated reading exercises, spelling, dictation, combined with vocabulary development and comprehension strategy use when reading continuous text.

### *Bridges: A Dyslexia Intervention Connecting Teacher, Avatar, and Student*

The content of the *Bridges* intervention program follows the exact scope and sequence as *Take Flight* but is taught by a certified teacher supported by the virtual co-teacher (the avatar). The virtual co-teacher is designed to introduce new learning concepts with high fidelity and accuracy. These avatar-led lesson activities make up 10-15 minutes of daily lesson time. During the remaining 45-50 minutes of class time, a trained certified teacher uses scripted lesson plans to then lead the students through practice applying new learning.

## Measures

### District Data

Select information was collected from participating school districts for each participating student. Students participating in our LWCCCEP project were identified as having the characteristics of dyslexia by standard school district procedure and referred for dyslexia intervention. Results of each participant's district dyslexia evaluation were collected by the study team to confirm eligibility for the study and to provide a baseline of ability level across various literacy skills. Demographic data received from the district included age, gender, ethnicity, race, free/reduced lunch status, English learner status, related comorbidities, and any special services the participant may be receiving. Additional intervention-related information was also collected as available, including progress monitoring reports, dyslexia homework completion rates, and student attendance rates.

### Study Specific Outcome Measures

Participating students were evaluated three times over the course of two academic years by SRC diagnosticians: once at the start of the school year (pre-test), at the end of the first school year (mid-test),

Table 1. Study Specific Outcome Measures

Assessment Name	Subtests/Domains	Reliability Metric
Comprehensive Test of Phonological Processing	Phonological Awareness	$\alpha = .92$
Gray Oral Reading Test	Oral Reading Fluency	$\alpha > .91$
Peabody Picture Vocabulary Test	Receptive Vocabulary	$\alpha = .89$
Woodcock Reading Mastery Tests	Passage Comprehension	$r > .85$
Word Identification and Spelling Test	Word Reading, Spelling	$\alpha = .98$

and again at the end of the second school year (post-test). The assessments administered included norm-referenced tests of language and literacy achievement and provide information regarding student ability as they progress through their intervention program (see Table 1).

## Participants

The current study aims to evaluate growth in reading ability for students receiving routine dyslexia intervention services in public-school settings. To be eligible for participation, students must have had a school-based identification of dyslexia and must have been enrolled in their first year of school-based intervention services. Families of all eligible students at 27 participating elementary campuses were provided with study information and offered the opportunity to participate. Those who provided consent were enrolled and scheduled for study evaluations and data collection. The final sample includes 137 students (73 female) in Grades 2 through 5 (Median: Grade 3). Demographic and baseline characteristics of the full sample are presented in Figure 1 and Table 2.

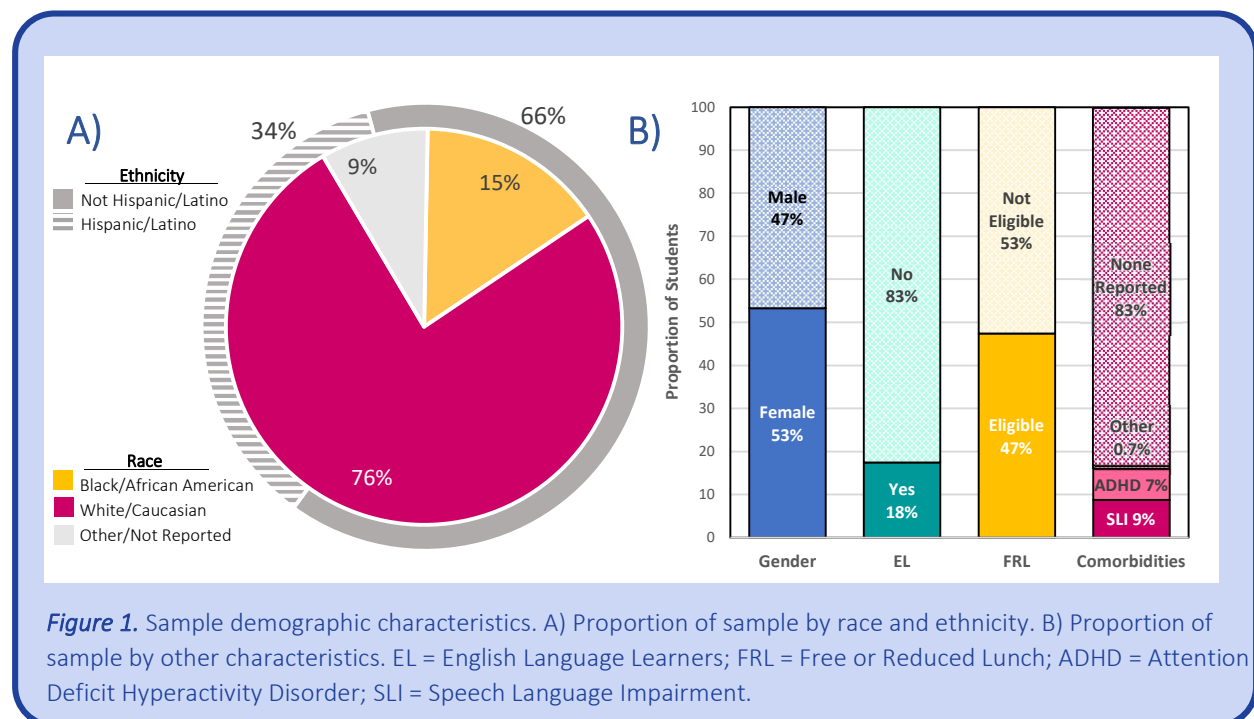


Figure 1. Sample demographic characteristics. A) Proportion of sample by race and ethnicity. B) Proportion of sample by other characteristics. EL = English Language Learners; FRL = Free or Reduced Lunch; ADHD = Attention Deficit Hyperactivity Disorder; SLI = Speech Language Impairment.

Table 2. Demographic Characteristics of the Aggregate Sample.

	Aggregate Sample <i>n</i> = 137	<i>Take Flight</i> <i>n</i> = 69	Bridges <i>n</i> = 68	Test Values
Age in Years; Months [M(SD)]	8y;5m (1y;1m)	8y;6m (1y;1m)	8y;4m (1y;0m)	$F(1,135) = 0.82$
Grade [Median]	3	3	3	
Sex (% F)	53.3	52.2	54.4	$\chi^2(1)=0.79$
Race (%)				$\chi^2(2)=2.56$
Black/ African American	15.3	11.6	19.1	
White/ Caucasian	75.9	76.8	75.0	
Other/ Not Reported	8.8	11.6	5.9	
Ethnicity (% Hispanic/Latino)	35.8	24.6	47.1	$\chi^2(1)=7.49^*$
Free/Reduced Lunch (% Eligible)	47.4	55.9	39.1	$\chi^2(1)=3.85$
English Language Learner (% Yes)	17.5	5.8	29.4	$\chi^2(1)=13.22^{**}$
Comorbidities (%)				$\chi^2(3)=8.04$
ADHD	7.3	13.0	1.5	
SLI	8.8	7.2	10.3	
Other	0.7	1.4	0.0	

Note: \* $p < .01$ , \*\* $p < .001$

## Statistical Analysis

Group composition was compared across Intervention Type using a series of t-tests and chi-squared analyses. Groups were equivalent across all demographic characteristics (age, sex, race, free/reduced lunch status, and comorbidities) except ethnicity and EL status. Namely, the *Bridges* group had a greater proportion of Hispanic/Latino and EL students than the *Take Flight* group.

Pre-, mid-, and post-testing data were used to evaluate growth in oral and written language skills. Results of tests of statistical assumptions were satisfactory. Instances of missing data were imputed using sample means. Due to correlations between variables, omnibus multivariate analyses were run on all dependent variables by language domain and followed by univariate analyses. The data were modeled using a series of doubly multivariate analysis of covariance on Oral and Written Language measures across Interventions at pre- and mid-testing, controlling for ethnicity and EL status.

## Comparative Growth in Reading and Related Language Skills

Summary statistics of all outcome measures across intervention types are presented in Table 3. Select measures of oral and written language performance were included in follow-up analyses investigating differences in growth patterns across intervention types. Results of these analyses are depicted in Figures 2-4. These figures depict average change in standard score performance for each group over the course of the first academic year. Overall, the *Take Flight* group outperformed the *Bridges* group prior to the intervention. However, the two groups demonstrated comparatively similar growth in oral and written language skills over time.

Table 3. Univariate effect of Time and Group Performance on Study Evaluation Measures for the Comparative Sample.

	<i>Take Flight</i>			<i>Bridges</i>			<i>F</i>	$\eta^2$
	Pre	Mid	Post	Pre	Mid	Post		
Phonological Awareness <sup>a</sup>	92.02 (1.83)	98.44 (1.75)	98.47 (1.71)	88.32 (1.83)	92.75 (1.75)	92.64 (1.71)	8.91***	0.07
Word Identification <sup>b</sup>	77.15 (2.23)	83.01 (2.43)	87.59 (2.65)	68.53 (2.23)	76.66 (2.43)	83.99 (2.65)	36.2***	0.23
Spelling <sup>b</sup>	76.45 (1.07)	80.27 (1.33)	82.48 (1.88)	73.16 (1.07)	76.25 (1.33)	80.95 (1.88)	35.64***	0.23
Passage Comprehension <sup>c</sup>	90.74 (1.69)	92.74 (1.57)	94.31 (1.73)	87.5 (1.69)	87.82 (1.57)	90.12 (1.73)	0.46	0.01
Fluency <sup>d</sup>	83.96 (1.29)	85.05 (1.36)	84.61 (1.43)	80.49 (1.29)	81.99 (1.36)	83.05 (1.43)	0.15	0.00
Receptive Vocabulary <sup>e</sup>	96.18 (1.47)	99.04 (1.6)	98.31 (1.67)	95.65 (1.47)	95.33 (1.6)	95.81 (1.67)	0.91	0.01

Note: All scores presented are standard scores unless otherwise noted. Standard scores are adjusted for student age at testing and fall on a distribution with an average of 100 (50<sup>th</sup> percentile) and standard deviation of 15. Standard error in parentheses. a: CTOPP-2, b: WIST, c: WRMT-3, d:GORT-5, e: PPVT-5. \*\*\* $p < .001$

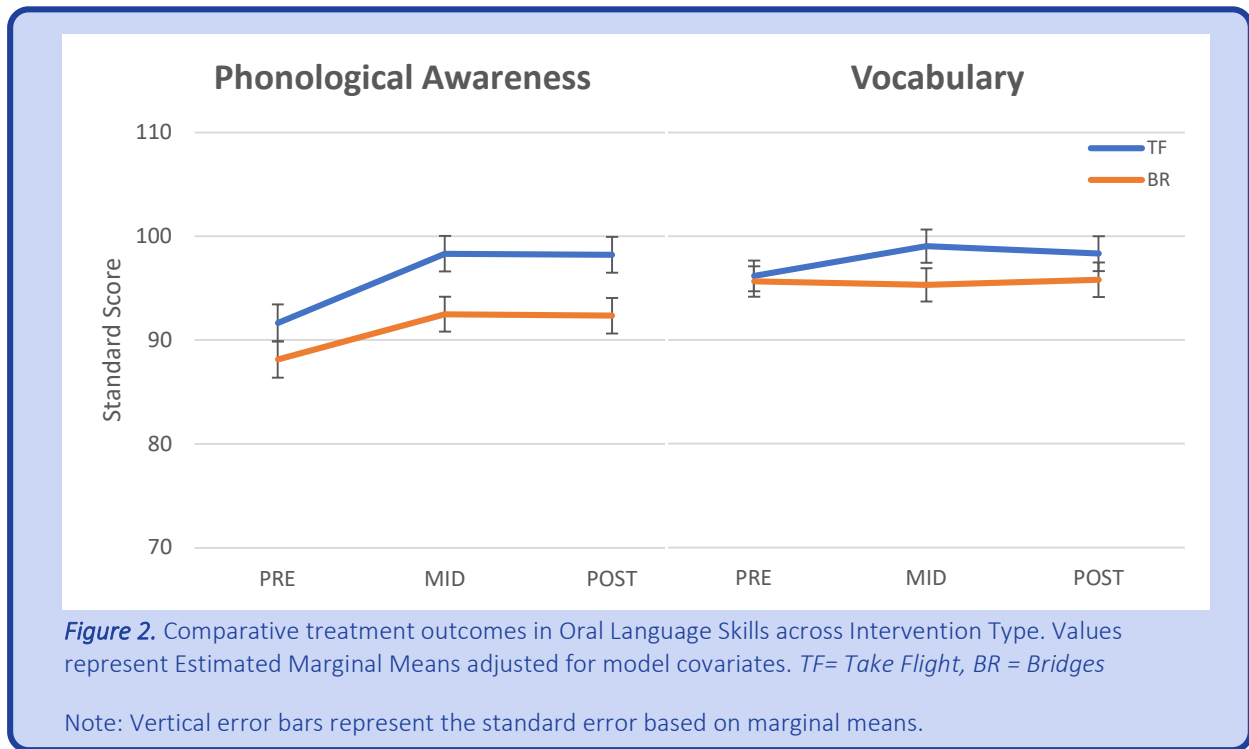
Table 4. Model results from doubly multivariate analyses of variance for pre-test, mid-test, and post-test scores.

		Type of Effect	Assessment Name	<i>df1, df2</i>	<i>F</i>	$\eta^2$
<i>Oral Language Skills</i>		<i>MV</i>		4,128	4.71**	.13
	Vocabulary	UV	PPVT	2,262	0.43	.00
	Phonological Awareness	UV	CTOPP	2,262	10.36***	.07
<i>Word-Level Skills</i>		<i>MV</i>		4,123	19.18***	.38
	Word Reading	UV	WIST	2,252	43.53***	.26
	Spelling	UV	WIST	2,252	41.26***	.25
<i>Passage-Level Skills</i>				4,128	0.60	.02
	Reading Fluency	UV	GORT	2,262	0.36	.00
	Passage Comprehension	UV	WRMT	2,262	1.02	.01

Note: Results of Multivariate analyses in italics. MV = multivariate, UV = Univariate. PPVT = Peabody Picture Vocabulary Test, WRMT = Woodcock Reading Mastery Test, CTOPP = Comprehensive Test of Phonological Processing, WIST = Word Identification and Spelling Test.

\*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p \leq .001$

## Comparative Growth in Oral Language Skills

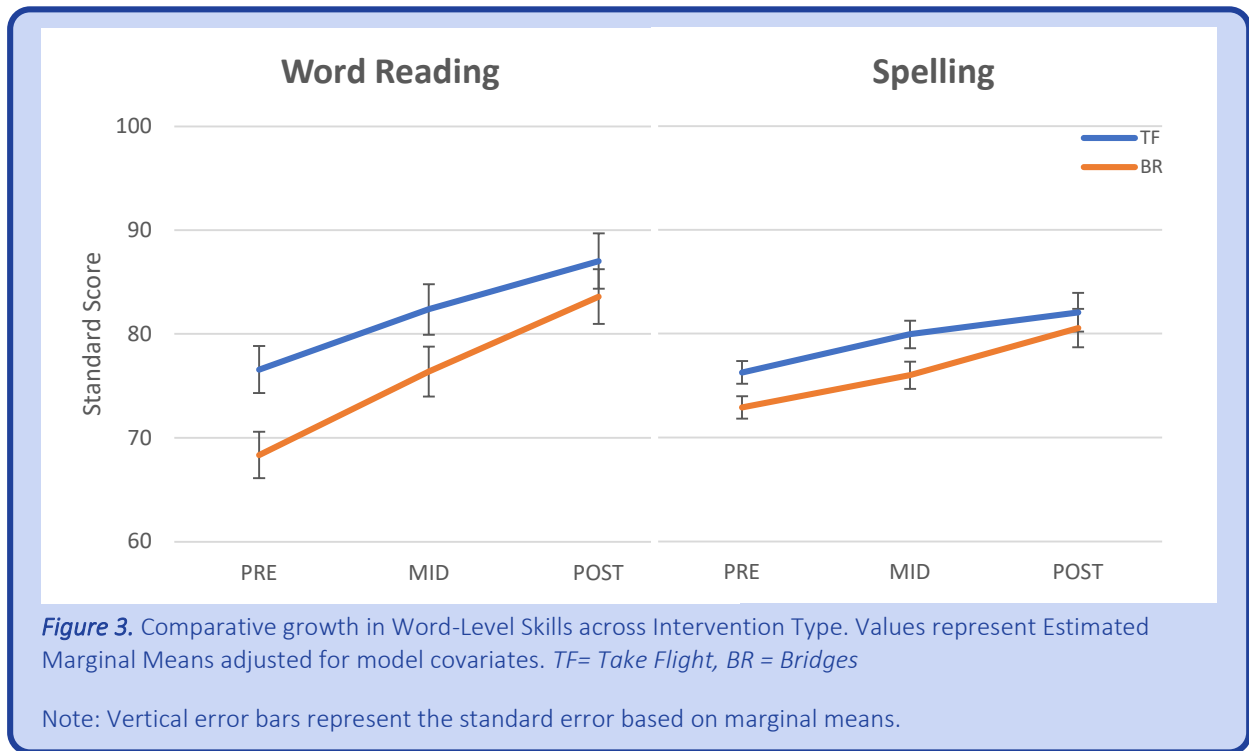


Oral Language skills support reading acquisition and are potential complicating factors for students with dyslexia. These skills, particularly phonological awareness, typically respond well to intervention with early and sustained improvements in response to direct systematic instruction. As early indicators of reading ability, oral language skills are often a key component of core literacy instruction in early grades and are monitored through universal screening measures. In the current sample, students in both groups scored within or just below the Average Range on a measure of phonological awareness at pre-test, suggesting these skills to be relative strengths for our sample.

Nonetheless, oral language skills improved over time for the sample as a whole. Performance on a measure of phonological awareness revealed significant growth for both the *Take Flight* and *Bridges* groups over time. Both groups exhibited greatest growth during the first year of the intervention, whereas standard score performance was maintained the second year. That is, during the second year of intervention, phonological awareness continued to develop at a rate comparable to age-equivalent peers in the norming sample. Students receiving *Take Flight* and *Bridges* instruction demonstrate early and rapid response to instruction for Phonological Awareness.

Students in the current sample exhibited relatively strong vocabulary prior to beginning intervention. Standard score performance on a measure of Receptive Vocabulary did not change over time for either group. Although vocabulary is specifically introduced through morphology and comprehension strands of both interventions, average pre-intervention vocabulary performance for both groups suggests that the students in the current sample had age-appropriate vocabulary skills. Students who begin intervention with deficient vocabulary may benefit more from these activities, and consequently demonstrate greater growth in this domain.

## Comparative Growth in Word-Level Skills



Dyslexia is a reading disorder characterized by deficits which typically manifest as inaccuracy and/or dysfluency at the level of the individual word. Thus, improving word-level skills is the focus of interventions designed to improve literacy skills for students with dyslexia. Decoding (reading) and encoding (spelling) activities are a key component of instruction in both the *Take Flight* and *Bridges* curricula. Each phonics concept introduced as part of the program is practiced through decoding and encoding exercises. Furthermore, improving word-level skills can have the added benefit of providing additional support for higher-order reading skills such as passage-level fluency and comprehension.

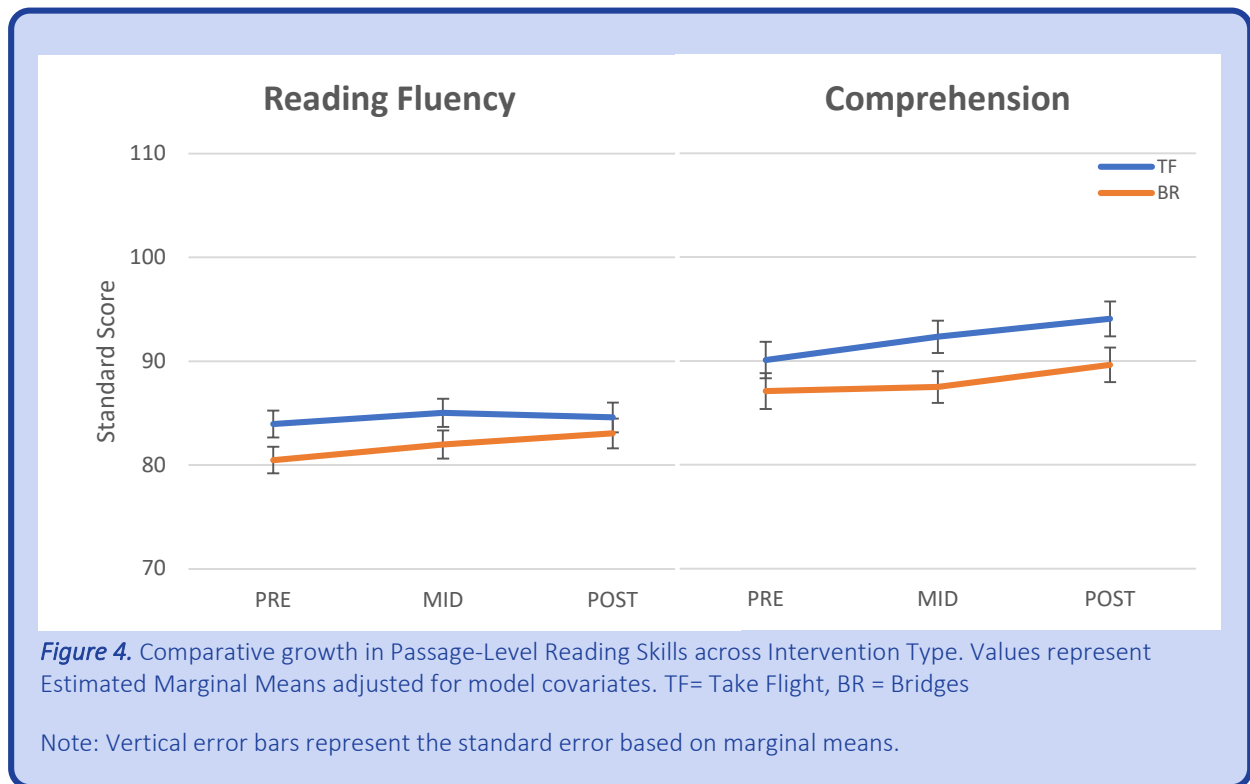
In the current sample, performance on standardized tests of word-level skills increased over the course of intervention for both groups. The reading and spelling measure utilized in this study was selected due to its depth of analysis, requiring students to read and spell lists of mostly regular words. As shown in Figure 3, both groups were deficient in word-level reading and spelling prior to the intervention.

The groups did not differ in rate of growth for Word Identification or Spelling. However, the *Bridges* group was significantly weaker than the *Take Flight* group on reading and spelling skills at pre-intervention but performed equivalently at the end of intervention, suggesting that the *Bridges* intervention supported growth in these skills even for the most impaired learners.

Growth in spelling skills over time was modest relative to reading growth. This is in line with previous findings suggesting the spelling skills are less malleable compared to reading skills. Nevertheless, the increase in spelling performance over time was statistically and clinically significant for both groups, bringing them closer to the average range by the end of treatment.



## Comparative Growth in Passage-Level Skills



Passage-level reading skills, such as oral reading fluency and comprehension, are often secondary deficits for students with dyslexia who experience weaknesses at the word-level. These abilities are synonymous with skilled reading and are typically acquired later in the developmental sequence as word-level skills are developed to proficiency and with additional reading experience. Best practices for supporting these complex skills rely on increasing exposure to print, including repeated reading, connected text reading, and strategy instruction. These components, among others, are incorporated into both the *Take Flight* and *Bridges* curricula to support the development of high-order reading ability.

Student performance on standardized tests of passage-level reading skills generally increased over the course of intervention, though this growth did not reach a level of statistical significance for either group. Performance on a test of passage-level reading fluency was below average for both groups throughout the intervention. On this measure, students are scored for both the accuracy and rate with which passages are read orally. Therefore, improvements in passage-level fluency scores require accelerated growth in both the accuracy and speed with which students read increasingly challenging texts. Further investigation into reading fluency subscales revealed that students in both groups significantly improved in reading rate but maintained similar levels of age-based performance for reading accuracy.

Both programs systematically include instructional activities targeting reading comprehension. Average standard score performance on a measure of passage comprehension increased over time, but this change did not reach statistical significance. Students in both groups exhibited strengths in passage comprehension relative to word-level reading skills prior to intervention and reached the average range by the end of the intervention.

## Conclusions

Students in this sample receiving public-school dyslexia intervention improved in oral and written language skills over the course of instruction. As expected, growth was generally greatest for phonological awareness, followed by word-level skills such as word reading and spelling. Growth in standard score performance was evident for passage-level skills, but this growth did not reach a level of statistical significance. This pattern of skill acquisition is typical for students with dyslexia who are developing characteristically weak reading abilities and suggests students in the sample are acquiring reading skills in a developmentally appropriate way. Additional growth in higher-order reading skills such as reading fluency and comprehension may be evident with additional practice and exposure to print.

Rate of change over time did not differ across groups for any measured skill. That is, student growth was generally similar regardless of the type of instruction the student received. This suggests that the traditional and tech-assisted instructional programs are equally effective in eliciting growth in literacy skills over the course of intervention. It is important to note that these findings are aggregated at the student level and do not reflect the individual performance of any given teacher or student. However, these findings do suggest that the direct and systematic approach to instruction in these areas for SRC programs elicits similar growth across traditional and tech-assisted program approaches.

These data provide additional support for the hypothesis that the innovative *Bridges* approach to dyslexia intervention is not inferior to traditional approaches of *Take Flight*. Students receiving *Bridges* instruction demonstrated similar improvements in measured skills in comparison to those receiving traditional instruction both in the amount and the rate of growth observed over two years of dyslexia intervention.

There are several important limitations to the interpretation of these findings. First, although covariates were entered into each of the models to account for pre-existing differences across groups, these differences cannot be nullified and therefore warrant caution in the comparison of performance across groups. However, these findings do support the initial efficacy and equivalence of instructional approaches in eliciting early reading growth. Finally, and perhaps most critically, these data were collected on a group of students receiving instruction during a range of school years which saw several surges in the COVID-19 pandemic, which caused upheaval in both educational and personal contexts for many students and their families. These limitations preclude the generalization of the current findings to broader populations and educational contexts. However, the improvements documented in this sample support the benefit of explicit, systematic, intensive dyslexia intervention even under the most challenging of circumstances.

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