

## **DYSLEXIA: A TREATABLE LEARNING DISORDER**

Dyslexia, the most common specific learning disability, causes difficulties with reading and spelling in approximately 10 to 15 percent of school age children (Shaywitz, Escobar, Shaywitz, Fletcher, and Makuch, 1992). The definition of dyslexia has been modified with advances in research since the first consensus definition was formulated by the World Federation of Neurology at Texas Scottish Rite Hospital for Children in 1968. The current definition specifies that children can be identified with dyslexia when they have problems accurately and efficiently sounding out (decoding) single words associated with difficulties processing the sound (phonological) structure of language (Lyon, Shaywitz and Shaywitz, 2003). Slow, inaccurate word reading leads to poor reading comprehension and is unexpected because most other cognitive and academic abilities are intact. The spelling problems of dyslexia contribute to difficulty acquiring proficiency in writing.

Definitions of dyslexia refer to the constitutional origin or intrinsic nature of the condition that represents an underlying neurobiological (brain) difference. Early postmortem (biopsy) studies and more recent neuroimaging research suggest that brain regions that are involved in word recognition have different structure, function and connections in individuals with dyslexia (Shaywitz, Pugh, Jenner, Fulbright, Fletcher, Gore, and Shaywitz, 2000). Family and twin studies show strong genetic influence, suggesting the brain differences in dyslexia are inherited (Olson, Forsberg, Gayan, and DeFries, 1999).

Although the core phonological deficit of dyslexia may persist, most impaired readers can learn to improve their reading skills. Teaching that promotes the acquisition of sound (phonological) awareness, letter-sound decoding skills and other word-level and reading comprehension skills can reduce the number of children who would otherwise qualify for a diagnosis of dyslexia (Vellutino, Fletcher, Snowling, and Scanlon, 2004). Moreover, improvement in reading skill with remedial instruction has been shown to be associated with changes in neuroimaging patterns consistent with normalization of brain function when reading (Simos, Fletcher, Bergman, Breier, Foorman, Castillo, Fitzgerald, and Papanicolaou, 2002). One theory is that new networks are established between regions of the brain that support word recognition.

### **TEXAS SCOTTISH RITE HOSPITAL FOR CHILDREN DYSLEXIA INTERVENTIONS: BUILDING ON A LEGACY**

Alphabetic Phonics (AP) originated at Texas Scottish Rite Hospital for Children (TSRHC) in the mid-1960s as an expansion and organization of the Orton-Gillingham (O-G) multisensory approach for teaching children with dyslexia (Cox, 1985). The central feature of O-G and other phonologically based programs is the systematic approach that is taken to establish a link between the alphabet and the language sounds (phonemes) it represents. In response to the requirement for intensive instruction for students with dyslexia (TEC 38.003), the Dyslexia Training Program (DTP), an adaptation of AP, was created (Beckham and Biddle, 1989). Using a video format, the DTP provides intensive phonics instruction to children who may not have access to trained dyslexia teachers.

During the past 40 years, research has emerged that supports the O-G form of instruction for individuals with dyslexia. Orton-Gillingham-based instruction has proven efficacy in reducing the central impairments in dyslexia, decoding and word recognition (Torgesen, Alexander, Wagner, Rashotte, Voeller, and Conway, 2001). The effectiveness specifically of the DTP has been evaluated in a comparison-control study (Oakland, Black, Stanford, Nussbaum, and Balise, 1998). That study, which met the scientific standards necessary to be included in the National Reading Panel Report (NICHD 2000), found gains that were notably significant in word reading.

There is less evidence that phonologically based remedial instruction can improve reading fluency or reading comprehension (NICHD 2000). Also, many students level off in their reading development after remediation or fail to apply word reading skills when working independently (Torgesen, et al., 2001). These findings and program evaluation data collected at TSRHC were the stimuli for curriculum development that culminated in *Take Flight: A Comprehensive Intervention for Students with Dyslexia (Take Flight)* (Avrit et al., 2006).

*Take Flight* builds on the success of the DTP for teaching phonics skills while providing more guided reading practice toward accuracy and automaticity. Etymology and phonemic awareness are expanded and integrated within decoding and spelling instruction to more fully develop word analysis strategies. The reading fluency component of *Take Flight* is designed to exceed the benefits realized with standard repeated reading practice by sequentially introducing phonic patterns of increasing complexity. A combination of instructional techniques develops vocabulary and verbal reasoning in the context of reading. Graphic organizers and illustrated cards are employed to teach more effective use of comprehension strategies during teacher-directed and student-directed learning. Improved reading comprehension is the ultimate goal.

## **A RESEARCH-BASED PROGRAM**

The report of the National Reading Panel identified the research-proven components of effective reading instruction to be phonemic awareness, phonics, fluency, vocabulary and reading comprehension (NICHD 2000). *Take Flight* was designed using the scientific evidence that supports the importance of each of these five components. Skillful word reading largely depends on the ability to learn letter sounds, which requires sufficient phonemic (speech sound) awareness (Wagner and Torgesen, 1987). Intensive training in phonemic awareness and letter sounds (phonics) is critical for the child with dyslexia to acquire word identification, spelling and general reading ability (Vellutino and Scanlon, 1987). **Phonemic awareness** training in *Take Flight* follows established procedures for explicitly teaching how articulatory gestures relate to sounds and spelling-sound patterns and how to manipulate sounds in analytic spelling and reading exercises (Olson, Wise and Ring, 1999). The **phonics** component of *Take Flight* was derived from the DTP. The effectiveness of the DTP was evident in the evaluation study cited by the National Reading Panel (Oakland, et al., 1998). The important role of **reading fluency** (rate and proper expression) in the comprehension and motivation of readers has been well documented

(Samuels, 2002). *Take Flight* fluency instruction uses research-proven directed practice in repeated reading (Meyer and Felton, 1999). However, modifications in the *Take Flight* approach have potential to help students improve their fluency when reading newly encountered words. Standard repeated reading results in fluency gains only in texts that contain practiced words (Faulkner and Levy, 1994). Vocabulary knowledge is strongly related to reading skill development. **Vocabulary** instruction in *Take Flight* features multiple word learning strategies (definitional, structural, contextual) and explicit teaching techniques with application in text shown to promote **reading comprehension** (Bryant, Goodwin, Bryant, and Higgins, 2003). Formal instruction in the application of comprehension strategies also has been shown to be highly effective in improving reading comprehension. *Take Flight* employs a multiple-approach strategy for reading comprehension instruction that combines methods that have the support of scientific evidence (i.e., cooperative learning, graphic organizers, story structure, question generation and answering, summarization, comprehension monitoring) (NICHD 2000). The systematic introduction of strategies, teacher modeling, guided practice and student-lead group instruction follows the Reciprocal Teaching Model (Palincsar and Brown, 1984).

### ***Take Flight* Treatment Effects: Descriptive Results**

The publication of *Take Flight* has been preceded by the evaluation of treatment effects with students attending the TSRHC Dyslexia Laboratory and dyslexia programs in public schools. Major findings are described and summarized below.

#### **Dyslexia Laboratory**

The Dyslexia Laboratory at TSRHC provides treatment services for local students with dyslexia who do not have access to adequate treatment options in their own schools. Students come to the hospital for class four days per week for two academic years. The *Take Flight* instruction at the laboratory is delivered by Certified Academic Language Therapists in small groups of two to four students for 90 minutes each day. Enrollment is approximately 40 children each year.

Descriptive data of reading skill development were collected from students receiving *Take Flight* instruction at the laboratory. Students were tested three times during the intervention: a baseline assessment, after one year of instruction and when treatment concluded at the end of the second year. Follow-up data were collected from a subset of the sample for four years post-treatment to document long-term effects after treatment.

*Take Flight* improved upon previous versions of Alphabetic Phonics instruction provided at TSRHC by including specific treatment components for reading efficiency/fluency and comprehension. Additional reading data from students who received an older version of Alphabetic Phonics at the Dyslexia Laboratory are also presented to illustrate differential treatment outcomes of the added components.

Participants: The data on treatment effects were collected from six consecutive graduation groups of students at the Dyslexia Laboratory; the last group graduated in May 2011. The sample includes 113 children (51 females) in Grades 2 through 7 (Median: Grade 4). All students had a diagnosis of developmental dyslexia from the Luke Waites Center for Dyslexia and Learning Disorders at TSRHC.

Results:

Main Effects Summary statistics of phonological awareness<sup>1</sup>, word decoding<sup>2</sup>, reading<sup>3</sup>, comprehension<sup>3</sup>, reading efficiency<sup>4</sup>, oral reading<sup>5</sup> and math skills<sup>3</sup> are shown in Figure 1. The data show the sample’s mean skill levels at the beginning of treatment and observed gains in norm-referenced standard scores after the two-year *Take Flight* treatment. The data in Figure 1 indicate several important observations about the sample at the laboratory and the intervention outcome.

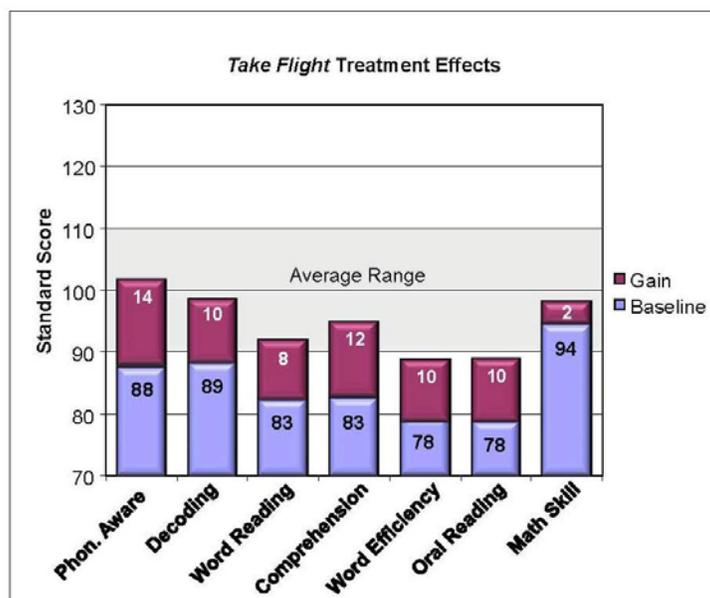


Figure 1: Average Baseline Levels and Gains at Post-Test

First, at baseline the sample was below the average range (i.e., 90-109 SS) in phonological processing and reading skills, particularly word and text reading efficiency, but showed average arithmetic abilities. Observed gains after treatment were statistically and clinically significant for phonological awareness and all reading skills, bringing the sample within, or close to, the average range Wilks’  $\Lambda = .22$ ,  $F_{(6, 95)} = 56.63$ ,  $p < .0001$ . The modest gains in arithmetic skill suggest that observed treatment effects were specific to the domain of reading and related skills and could not be readily attributed to effects of smaller classes and/or increased teacher attention.

An alternate account of both the observed gains in reading and comparatively modest growth in math skills is that both could be explained by effects of regression-to-the-mean (e.g., Weeks, 2007). In the absence of data from a randomized-control clinical trial, it is

difficult to separate confounding artifacts of regression with real treatment effects. However, data collected from clinical evaluations that documented the diagnosis of developmental dyslexia in this sample permits one way to assess regression effect sizes.

Briefly, the analysis is an adaptation of an interrupted time-series design. Patients were initially assessed in the TSRHC Dyslexia Evaluation Center an average of nine months prior to beginning treatment. The months between initial evaluation and the treatment baseline evaluation thus provide a contrast of differences in growth observed between a pre-treatment ‘control’ period and the subsequent two years of intervention.

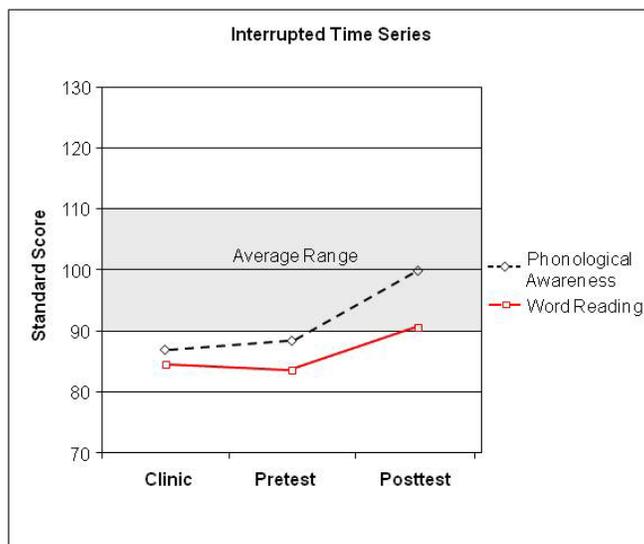


Figure 2: Regression Effects from Clinic to Posttest Assessment

Figure 2 shows average phonological awareness and word identification standard scores from a subset of the sample with sufficient data points for the analyses ( $n = 105$ ). A regression-to-the-mean explanation for observed gains would predict a more-or-less linear trend from initial clinic evaluation to the posttest evaluation. The observed trends indicate a significant inflection in the average growth curves at the point of intervention. Repeated-measures profile analyses confirmed that there were no significant gains in phonological awareness,  $F_{(1, 96)} = 3.2, p = .08, \eta^2 = .03$  over the pre-intervention ‘control’ period from diagnosis to baseline evaluation. The data also show that relative word identification decreased over the same period,  $F_{(1, 104)} = 5.7, p = .02, \eta^2 = .05$ . In contrast, significant development was observed from baseline to posttest evaluations in both phonological awareness,  $F_{(1, 96)} = 106.7, p = .0001, \eta^2 = .59$ , and word reading,  $F_{(1, 104)} = 87.1, p = .0001, \eta^2 = .46$ .

*Comparative Effects Take Flight* differs from previous curricula at TSRHC with the inclusion of specific instruction to develop reading fluency and comprehension. Descriptive data from a sample of students who received treatment at the laboratory with the DTP that did not include those specific components are added for comparative purposes.

The comparative data were taken from a sample of 25 students (11 female) from Grades 2 through 7 (Median: Grade 4). The students were two consecutive graduation groups of the lab; the last group graduated in May 2002. All students in this historical control sample also had a diagnosis of developmental dyslexia from the Luke Waites Center for Dyslexia and Learning Disorders at TSRHC Diagnostic Clinic. The intervention was delivered by Certified Academic Language Therapists. The DTP intervention was of equal duration and intensity as *Take Flight* intervention.

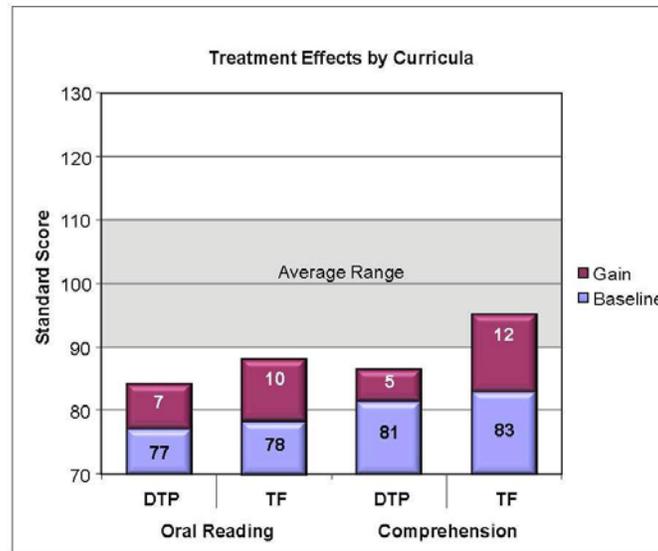


Figure 3: Oral Reading and Reading Comprehension Outcomes by Curricula

Figure 3 presents data from standardized measures of oral reading<sup>5</sup> and reading comprehension<sup>3</sup>. The data show significant improvements in both text reading fluency<sup>6</sup> and reading comprehension for students receiving both curricula,  $F_{(1, 115)} = 14.4$ ,  $p = .0001$ ,  $\eta^2 = .11$ ;  $F_{(1, 124)} = 34.9$ ,  $p = .0001$ ,  $\eta^2 = .22$ , respectively. Additionally, the *Take Flight* sample shows significantly larger growth in reading comprehension relative to students who received DTP instruction,  $F_{(1, 124)} = 6.0$ ,  $p = .02$ ,  $\eta^2 = .05$ . The *Take Flight* sample also showed an advantage in growth of oral reading skill but that difference was not statistically reliable.

Longitudinal Effects Post-treatment evaluation is important for documenting immediate effects of treatment. However, longitudinal data months or years post-treatment are needed to provide evidence that treatment outcomes are durable. Follow-up data were collected annually for four years post-treatment from 69 former students (34 female) of a total sample of 81 graduates in the last five lab groups eligible for follow-up assessment. Figure 4 presents word recognition and reading comprehension outcomes in standard scores over the intervention and at each of the four follow-up evaluations.

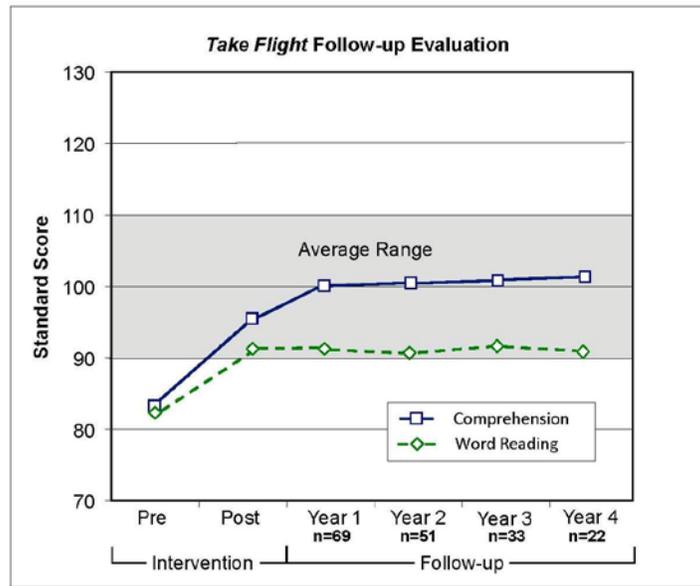


Figure 4: Reading Comprehension and Word Reading for Four Years Year Post-Treatment

The follow-up data suggest several important conclusions about the long-term effects of *Take Flight*. The significant rate of growth in reading comprehension skill continues post-treatment and the group average is approaching the population average of 100 SS at one year follow-up,  $F_{(1, 66)} = 10.1, p = .002, \eta^2 = .13$ . Word recognition skill shows a different developmental pattern. The rate of growth observed during the intervention period slows after treatment concludes and is no longer statistically significant,  $F_{(1, 66)} < 1, p = .8, \eta^2 = .00$ . The reported data are in standard scores; therefore, the observed result suggests that although growth rates were slower, the students' word recognition skills still developed at the same rate as their same age peers for the one year after treatment.

The data from 51 students who returned for a second follow-up evaluation show that observed growth in reading comprehension in the first year after treatment slows and is no longer statistically significant after two years,  $F_{(1, 50)} < 1, p = .83, \eta^2 = .00$ . Although statistically non-significant, the data suggests that the reading comprehension skills of students in the follow-up sample continue to improve at similar rates as their same-aged peers.

The data presented in Figure 4 indicate that the developmental patterns observed in the second year after treatment continue for the remainder of the follow-up evaluations for both reading comprehension and word reading ability. Taken as a whole, the data suggest a pattern of maintenance of treatment effects up to four years post-treatment.

### Field Evaluation

The data collected in the lab at TSRHC provide some evidence of treatment outcomes. However, the lab is a controlled environment with limited enrollment. The majority of

students who will receive instruction in *Take Flight* will be students who are served by their school’s dyslexia program. For this reason, it is necessary to document the effects of *Take Flight* in a field study.

Descriptive data of *Take Flight* treatment effects were collected from several Texas school districts that used the curriculum for their state-mandated<sup>7</sup> dyslexia program. All students enrolled in the field study were identified and instruction delivered for two academic years by the respective school districts’ dyslexia program personnel. Figure 5 shows baseline levels and treatment gains on academic measures after two years of instruction for 59 public school students (29 female) in Grades 3 through 5. Data from the Dyslexia Lab sample are added for comparison.

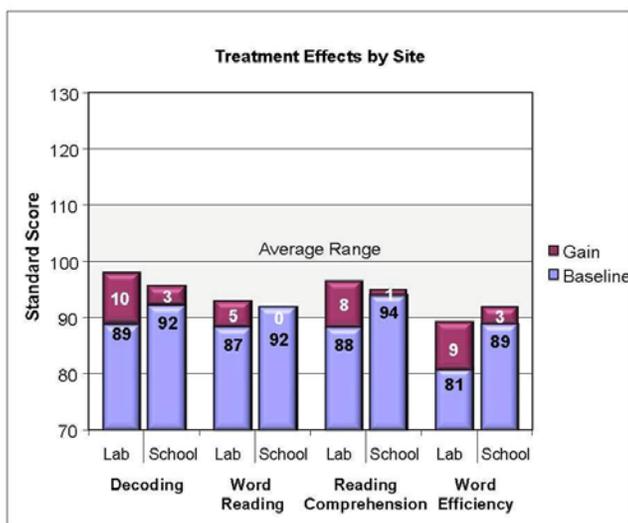


Figure 5: Treatment Effects in Dyslexia Lab and Public School Samples

The results in Figure 5 show several important differences between the lab and school samples. First, the school sample average was significantly higher at baseline on measures of decoding<sup>2</sup>, word recognition<sup>2</sup>, comprehension<sup>2</sup> and word reading efficiency<sup>4</sup>, Wilks’  $\Lambda = .9$ ,  $F_{(4, 152)} = 4.14$ ,  $p = .01$ ,  $\eta^2 = .04$ . In addition, treatment effects after the intervention were statistically smaller than those observed in the lab, Wilks’  $\Lambda = .74$ ,  $F_{(4, 151)} = 13.2$ ,  $p = .0001$ ,  $\eta^2 = .25$ . Although the gains observed in the school sample were rather modest, these results are reported in standard scores; thus, the reading skills of the school sample were progressing at the same rate or, in some cases, faster than their same age peers.

However, the data presented in Figure 5 show scores averaged across the entire sample. There was significant variation in both baseline levels and treatment effects in the school sample. Growth curves for each individual showed a relatively consistent pattern where students with lower scores at baseline tended to show larger gains during treatment.

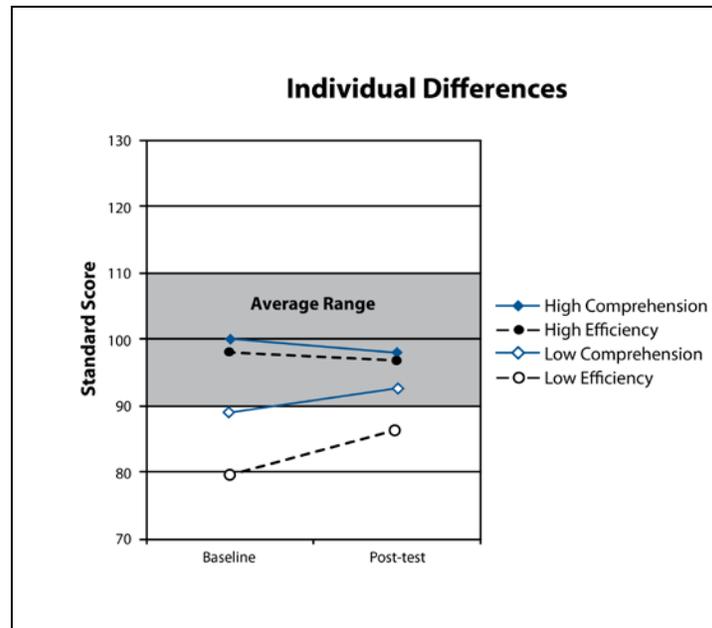


Figure 6: Treatment Effects as a Function of Baseline Skill

Figure 6 illustrates this effect of individual differences. The figure shows relatively little additional growth in both reading comprehension and word reading efficiency for students in the top half of the sample at baseline. Note that those results are reported in standard scores, and that those students' average scores are already near the population average. In contrast, students in the lower half of the sample present a different developmental profile with significantly stronger growth in each reading skill,  $F_{(1, 57)} = 11.9, p = .001, \eta^2 = .17$ ;  $F_{(1, 57)} = 23.7, p = .0001, \eta^2 = .29$ , respectively. Students with more severe reading impairments derived greater benefit from treatment.

## Conclusions

The data show that in a relatively well-controlled environment of the lab at TSRHC, children receiving *Take Flight* instruction show statistically and, more importantly, clinically significant growth in all areas of reading. At the conclusion of treatment, children were within the average range in decoding, word reading and comprehension. Final status of word and text reading efficiency was lower, but still very near the low average range. Moreover, the significant contrast of growth during treatment with the nine month period prior to treatment suggests that the observed treatment effects were specific to the treatment and not due to regression artifact or general developmental effects. Comparisons of reading growth from *Take Flight* with alternative versions of Alphabetic Phonics instruction provide suggestive evidence for the efficacy of added comprehension and reading rate instruction. Finally, longitudinal results indicate that during the first year after treatment, these children maintained the word recognition gains and continued to show additional significant growth in reading comprehension. The remaining follow-up

assessments showed that treatment gains continued to be maintained up to four years post-treatment.

The results from the field study suggest there is some generalization of *Take Flight* treatment effectiveness outside the lab environment, although that efficacy is more modest and variable. Specifically, the treatment seems to be most beneficial for students with relatively weaker skills at the onset of intervention. The reasons for the differential effects compared with the lab results may be attributed to several factors that are difficult to control within a school environment, including criteria for placement, co-existing problems, class size, variable contact time and instruction delivery.

The only way to definitively document treatment effectiveness is in a randomized clinical trial. The data presented in this summary were not collected from a study of that design and therefore conclusions about treatment efficacy of *Take Flight* are tentative. However, norm-referenced standardized measures such as those used for these evaluations do provide a baseline to compare observed treatment effects against expected reading development for average-achieving children.

In summary, these data show that *Take Flight* has a beneficial impact on the reading skills of children with significant reading difficulties. Future research will determine how well *Take Flight* compares with comparable alternative treatments and what components of the curriculum are responsible for observed outcomes.

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<sup>1</sup> Comprehensive Test of Phonological Processing (ProEd, Inc.).

<sup>2</sup> Woodcock Reading Mastery Test (American Guidance Services).

<sup>3</sup> Wechsler Individual Achievement Test (PsychCorp).

<sup>4</sup> Test of Word Reading Efficiency (ProEd, Inc.).

<sup>5</sup> Gray Oral Reading Test (ProEd, Inc.) Oral Reading Quotient.

<sup>6</sup> DTP sample with oral reading data is 10 of 25 possible participants.

<sup>7</sup> Texas Education Code 38.003.