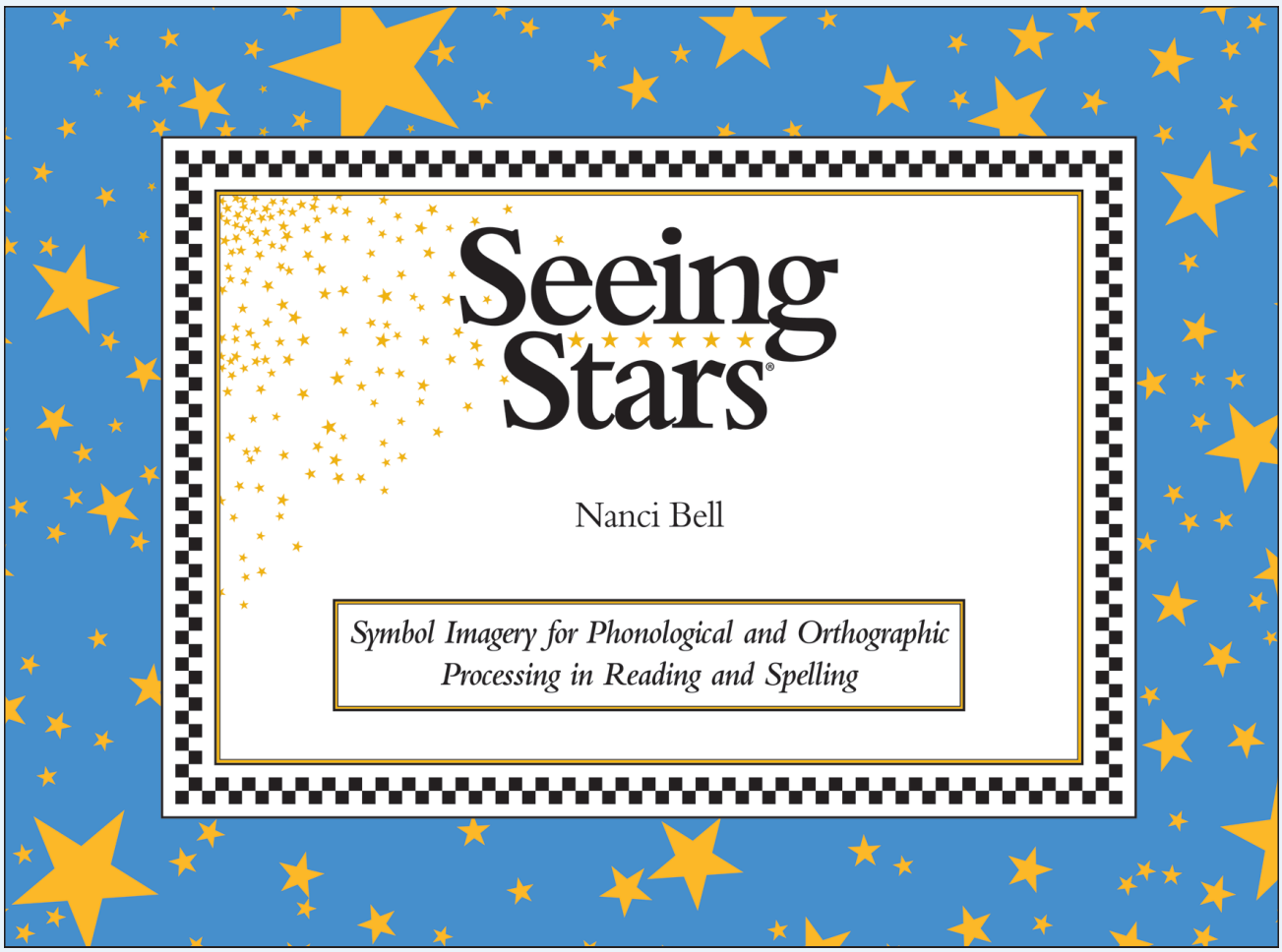
Current Efficacy Research for the Seeing Stars® Program



Program Summary

Seeing Stars is a comprehensive program that teaches phoneme-grapheme correspondence based on the alphabetic structure of the English language. The theoretical basis for this program is grounded on the tenets of Dual Coding Theory (DCT), addressing the dual role of sound and symbol imagery. DCT serves as the best evidence-based theory in cognitive science to teach decoding and encoding. The Seeing Stars® program explicitly and systematically teaches phoneme-grapheme correspondence to develop orthographic mapping as applied to word attack, word recognition (decoding), spelling (encoding), and fluency. Uniquely, the program develops both phonological and orthographic processing (symbolic imagery for both sounds and letters). The program is not a sight word approach; rather, it stimulates the multi-sensory cognitive processes of linking phonemes to sight word recognition and fluency. Students move through a series of steps from single consonants/vowels to multisyllable and contextual reading to develop competency in reading and spelling.

By integrating phonological processing, orthographic processing, and contextual reading fluency, the program helps students move beyond analytical decoding to global reading, which then leads to comprehension. Instruction is explicit, systematic, and cumulative, and it includes sample lessons through the scope and sequence for teachers to follow while differentiating instruction. The instructional pedagogy employs a Socratic questioning discipline to develop student independence in the learning process. The sensory cognitive instructional methodology can be integrated and applied to any curriculum, multisensory developmental phonics program, or language arts program.

Materials include a teacher's manual, instructional kit, and workbooks, all available through Gander Publishing. Optional professional development, including introductory workshops and follow-up coaching, is provided exclusively by Lindamood-Bell Learning Processes.

Research Showing Program Effects

Researchers	Year	N	Students	Results	Reading Measures	ESSA Tier*
Eden et al.	2004	38	19 dyslexic and 19 non-dyslexic participants	Increased activity in left-hemisphere regions. Performance improvements in tutored compared to non-tutored dyslexics	Accuracy, Comprehension	Promising
Krafnick et al.	2011	11	Children with dyslexia, recruited as part of larger dyslexia study	Significant increases in scores for word attack, reading comprehension, phonemic awareness, and symbol imagery	Word Recognition, Symbol Imagery, Word Attack	Promising
Olulade et al.	2013	30	Typically-reading individuals with intelligence at or above normal range	Better reading ability, greater activity in the right area V5/MT during visual motion perception	Accuracy, Word Recognition, Word Attack, Phonemic Awareness, Symbol Imagery	Promising
Christodoulou et al.	2015	47	26 of the children held a language-based learning disability diagnosis	There were statistically significant benefits for students receiving the Seeing Stars intervention.	Symbol Imagery, Word Attack, Fluency, Vocabulary	Promising
Joo et al.	2017	48	Native English speakers averaging 9.48 years of age with heterogeneous reading abilities	Linear increases in reading skills with nearly identical amounts of change over the intervention	Orthographic Processing, Word Recognition	Promising
Romeo et al.	2017	65	Children age 6-9 with reading disabilities and diverse socioeconomic statuses	Children from lower-SES families and children with more severe RD were more likely to benefit from the intervention than children with higher-SES or less severe RD.	Phonemic Awareness, Word Attack, Vocabulary	Promising
Huber, Donnelly, Rokem & Yeatman	2018	43	24 children age 7-12 with dyslexia received intervention.	Reading skills improved substantially, to within one standard deviation of population norm.	Word Recognition, Accuracy, Fluency	Promising
Donnelly, Huber & Yeatman	2019	31	Participants reported a clinical diagnosis of dyslexia.	Linear growth in reading skills, decoding, reading fluency, and comprehension. Reading skills increased linearly with each hour of intervention.	Reading Fluency, Comprehension	Promising
Yeatman & Huber	2019	34	Children age 7.2 to 12.8 with parent-reported reading difficulties and/or clinical diagnosis of dyslexia	The amount of change observed in an individual subject is not dependent on that subject's age.	Symbol Imagery, Reading Rate, Comprehension	Promising
Krafnick et al.	2022	31	Children with dyslexia	Gains on reading skills: phonemic awareness, visual imagery, single-real word reading,word attack, and reading comprehension	Word Recognition, Symbol Imagery, Word Attack, Phonemic Awareness, Comprehension	Promising

*The ESSA Tiers of Evidence provide districts and schools with a framework for determining which programs, practices, strategies, and interventions work in which contexts and for which students. Attributes of studies designated Tier 3 ("Promising Evidence") include a "well-designed and implemented correlational study, [that] statistically controls for selection bias;" "Statistically significant positive effect on a relevant outcome;" and "No strong negative findings from experimental or quasi-experimental studies."

Abstracts

Eden et al. (2004)

In this study, a group of adults with diagnosed dyslexia received eight weeks of Lindamood-Bell instruction. Before and after instruction, subjects were administered basic reading skills assessments and functional magnetic resonance imaging (fMRI). A similar group of adult dyslexics went through the same procedures but did not receive Lindamood-Bell instruction. Lindamood-Bell subjects received an average of 112 hours of Lindamood-Bell instruction to develop reading skills. This experiment investigated the constructs of Dual Coding Theory using the Seeing Stars program (some subjects received instruction in the Lindamood Phoneme Sequencing program as well). Instruction was delivered by specially trained Lindamood-Bell staff. Assessments, neuroimages, and findings were all conducted by Georgetown University's Center for the Study of Learning, and fMRIs were administered by independent researchers.

Sadoski & Willson (2006)

In this study, the authors examined achievement in Grades 3-5 during the years 1998-2003. Pueblo School District 60 schools and schools statewide were compared through a series of repeated measures analyses of covariance controlling for school size, percentage of minority students enrolled, socioeconomic status, and the amount of time a school was included in the intervention. Statistically significant and increasing gains favoring the Lindamood-Bell reading intervention were found both overall and in analyses of Title 1 schools.

Krafnick et al. (2011)

This study followed eleven children with dyslexia who underwent reading intervention, examining changes in gray matter volume along with any intervention-induced gains in reading performance. The intervention was successful, as it resulted in behavioral gains in reading ability as well as for skills that are associated with good reading acquisition. On average, pretest to retest gray matter volume changes were statistically significant in all brain regions. Similarly, test scores revealed a statistically significant increase from pretest to retest. Post- to follow-up (neuroimaging and behavioral) were not significant; demonstrating that the improvements were specific to the intervention. The results of this study support the Dual Coding Theory model of cognition and illustrate that instruction in the Seeing Stars program leads to increased brain structure and improved reading. Future studies were scheduled to determine a finer-grained analysis on after neurological effects of the intervention.

Olulade et al. (2013)

Using fMRI, we demonstrate in typical readers a relationship between reading ability and activity in area V5/MT during visual motion processing and, as expected, also found lower V5/MT activity for dyslexic children compared to age-matched controls. However, when dyslexics were matched to younger controls on reading ability, no differences emerged, suggesting that weakness in V5/MT may not be causal to dyslexia. To further test for causality, dyslexics underwent a phonological-based reading intervention. Surprisingly, V5/MT activity increased along with intervention-driven reading gains, demonstrating that activity here is mobilized through reading. Our results provide strong evidence that visual magnocellular dysfunction is not causal to dyslexia, but may instead be consequential to impoverished reading.

Christodoulou et al. (2015)

This 2015 study investigated the impact of the Seeing Stars intervention program implemented for early education children with reading disabilities. The two groups in the study, intervention and nonintervention, both began with similar pretest scores. However, significant gains were observed in the children who received Seeing Stars intervention on the majority of reading measures (Slosson Intelligence Test, Woodcock Reading Mastery Tests: Word Identification, Woodcock Reading Mastery Tests: Word Attack, Test of Word Reading Efficiency: Phonemic Decoding Efficiency, and Dynamic Indicators of Basic Early Literacy Skills: Oral Reading Fluency), while the control group exhibited stagnation or post- score declines. The intervention effects were substantial, as the differences in the growth means favored the intervention group over the nonintervention group across measures.

Joo, Donnelly & Yeatman (2017)

Researchers from the University of Washington used an intensive reading intervention program (Seeing Stars) to test the causal relationship between learning to read and motion processing in children. The data show that, while the reading intervention enhanced reading abilities, learning to read did not affect motion sensitivity. Motion sensitivity remained stable over the course of the intervention. Furthermore, the motion sensitivity deficit did not negatively impact the learning process. Children with poor motion sensitivity showed the same improvement in reading skills as children with typical motion sensitivity. These findings call into question the view that motion processing deficits are due to poor reading experience. The researchers propose that the correlation between the two measures arises from other common mechanisms, or that motion processing deficits are among a collection of correlated risk factors for reading difficulties.

Romeo et al. (2017)

A research team from Massachusetts Institute of Technology's McGovern Institute for Brain Research, the MG Institute of Health Professions, and the Harvard Graduate School of Education investigated the relationship between SES (socioeconomic status) and RD (reading disability) on neuroanatomy and/or intervention outcomes. The joint influence of SES and RD on neuroanatomy and/or response to intervention was previously unknown. All children completed standardized reading assessments and magnetic resonance scans measuring cortical thickness. The research shows that this statistically significant summer reading intervention (Seeing Stars) produced cortical growth, and that the growth was especially beneficial for children with RD who come from lower-SES home environments.

Huber, Donnelly, Rokem & Yeatman (2018)

This study was conducted to examine experience-dependent growth in both reading skills and white matter conductivity in struggling grade school readers. Using both behavioral measures and fMRI measurements of the brain's neural connections, this study revealed large changes in the white matter tracts as associated with growth in reading skills after eight weeks of Seeing Stars intensive intervention. Researchers concluded that controlling for a child's educational environment through the use of the targeted intervention program (Seeing Stars) induces rapid, widespread changes in white matter tissue properties as compared to the control group in a traditional education setting.

Donnelly, Huber & Yeatman (2019)

The goal of this study was to analyze reading growth curves during an intensive summer Seeing Stars program. Researchers collected behavioral measures over eight weeks, assessing decoding, oral reading fluency, and comprehension. There was significant linear growth on every measure of reading skill and none of the measures showed non-linear growth trajectories. These results highlight the opportunity to improve reading skills over an intensive, short-term summer intervention program, yielding a linear dose-response relationship between duration and gains. This finding offers guidance for setting reading level goals and the design treatment plans to achieve them.

Yeatman & Huber (2019)

Researchers used an intensive reading intervention program, in combination with longitudinal diffusion MRI measurements in school-aged children with dyslexia, to investigate the sensitive period for white matter plasticity and literacy learning. They found that the intervention induced large-scale changes in white matter diffusion properties, as well as improvements in reading scores, but that the magnitude and time-course of plasticity does not depend on the subject's age. Thus, we conclude that, for the intensive, one-on-one reading intervention program employed in this study, if a sensitive period exists, it does not end before middle school.

Krafnick et al. (2022)

Using a randomized crossover design, 31 children with dyslexia were assigned to a phonological- and orthographic-based tutoring period as well as a within-subjects control period to examine: (1) intervention induced changes in behavior (reading performance) and in brain activity (during reading); and (2) behavioral and brain activity pre-intervention data that predicted intervention induced gains in reading performance. The researchers found gains in reading ability following the intervention, but not following the control period. However, there were no changes in brain activity following the intervention (regardless of sex), suggesting that individual brain changes are too variable to be captured at the group level. Reading gains were not predicted by pre-intervention behavioral data, but were predicted by pre-intervention brain activity in bilateral supramarginal/angular gyri.

Seeing Stars: Results on Reading Measures

Symbol Imagery:

- "For the symbol imagery measure… students receiving the intervention improved significantly, whereas students in the control group declined significantly."

Phonemic Awareness:

- "From an educational standpoint, the intervention was successful, as it resulted in behavioral **gains for measures of reading ability** as well as for skills that are associated with good reading acquisition. These gains may be due to the multi-sensory approach used in the intervention **(phonological training and visual imagery),** but future studies will need to determine which components of programs… are critical in driving these increases in reading performance."
- "In an exploratory, post hoc analysis using the raw scores, significant linear growth was seen for all measures, and significant quadratic growth was seen in the timed measure of phonemic decoding."
- **"Decoding skills** showed **substantial growth** [Cohen's d = 0.85 (WJ Basic Reading Skills)], with **fluency and comprehension growing more gradually** [d = 0.41 (WJ Reading Fluency)]."

Fluency:

- "Reading improvement relative to pretest scores was achieved by 50% of the participants in the intervention group (M = −0.81, SD = 6.39) as indicated by composite change scores (posttest minus pretest) greater than zero based on standardized reading outcome measures (WRMT WI, WRMT WA, TOWRE SWE, TOWRE PDE)."
- "On oral reading fluency (DIBELS ORF), the intervention group improved while the nonintervention group showed no statistically significant change. On symbol imagery (SIT), the intervention group improved while the nonintervention group declined."
- "First, we found a strong, systematic improvement in reading skills across the four measurement sessions (Fig. 2a; session effects: b=4.13, SE=0.53, p<10−10, linear mixed-effects model with subjects as a random effect)."
- "In line with these results, scores on the TOWRE Index, a timed measure of reading, improved substantially (F(1,77)=53.69, p < 10−9), as did scores on the Woodcock–Johnson Reading Fluency subtest (F(1,76)=36.042, p < 10−7)."
- "Enrollment in 160 h of intensive, one-on-one intervention over the course of the summer led to systematic linear growth in reading skills, including real and pseudo-word decoding, reading fluency, and comprehension. Here we find significant growth in both decoding skill and reading fluency and provide data demonstrating how much improvement we can expect based on each hour of one-on-one intervention."

Accuracy:

- "Standard scores on the Woodcock–Johnson Basic Reading Composite, an untimed measure of reading accuracy, improved significantly over the course of the intervention (F(1,77)=59.75, p < 10−10, linear mixed effect model with a fixed effect of intervention time, in hours, and a random effect of subject)… Growth in reading accuracy was specific to the intervention group (intervention vs. control)."

[1] Christodoulou et al., 2015
[2] Krafnick et al., 2011
[3] Donnelly et al., 2019
[4] ibid
[5] Christodoulou et al., 2017
[6] ibid
[7] Joo et al., 2017
[8] Huber et al., 2018
[9] Donnelly et al., 2019
[10] Huber et al., 2018.

Efficacy: Impacts of the Intervention

Eden et al. (2004)

"Skills that were directly targeted by the instructional method (phonological processing through auditory and visual modalities) improved significantly following the intervention."

"Following a course of phonologically based instruction, adults with persistent dyslexia enjoyed measurable gains in phonological processing skills. This improved understanding of the phonological features of language was transferred to some aspects of reading ability, leading to improved accuracy on non-word decoding and oral paragraph reading."

"These findings provide evidence that adults with persistent characteristics of dyslexia are capable not only of responding positively to intensive intervention, but demonstrate changes in functional neuroanatomy attributable to training."

Sadoski & Willson (2006)

"Statistically significant and increasing gains favoring the Lindamood-Bell reading intervention were found both overall and in analyses of Title 1 schools."

"All differences favored the PSD60 schools, and, in general, the differences increased over time. In comparison with proficient and advanced scores, differences were increasingly inverted for unsatisfactory and partially proficient scores. That is, relative to the state average, percentages of unsatisfactory and partially proficient scores decreased, percentages of proficient and advanced scores increased, and the inversion tended to amplify from 1998 to 2003."

"At Grade 3, after controlling for school size, minority percentage, and SES, as well as degree of treatment implementation, PSD60 schools outperformed the average of the remaining comparable schools in the state in an increasingly positive way during the years 1998–2003 as the intervention was implemented across an expanded population of the district's schools. The statistically significant three-way interactions indicated that differences favoring the PSD60 schools increased over time."

Krafnick et al. (2011)

"One-way repeated measures ANOVAs showed significant within-subjects effects over the three time points for all behavioral measures with the exception of working memory (Digit Span). Specifically, there were significant increases in the scores for single real word reading (W-J WID) $F(2,20)=10.77$, $p=0.001$; pseudoword reading (W-J Word Attack) $F(2,20)=6.321$, $p=0.007$; reading comprehension (W-J PC), $F(2,20)=5.420$, $p=0.013$; phonemic awareness (LAC-3) $F(2,20)=5.150$, $p=0.016$; rapid naming (RAN), $F(2,20)=7.655$, $p=0.003$; and Symbol Imagery (SI), $F(2,20)=30.723$, $p<0.001$. Working memory as measured by the Digit Span tests did not show significant changes, $F(2,20)=0.444$, $p=0.648$."

"Post hoc t-tests were run on all behavioral measures (except Digit Span) to compare scores between T1 and T2, T1 and T3, as well as between T2 and T3. For the comparisons of scores between T1 and T2, single real word reading (W-J WID), phonemic awareness (LAC-3), and Symbol Imagery (SI) were each significant at $p<0.001$. Rapid Naming of letters and numbers (RAN) was significant at $p<0.01$. Pseudoword reading (W-J Word Attack) and reading comprehension (W-J PC) were both significant at $p<0.05$. Each of these measures was still significant when comparing T3 with T1 except for phonemic awareness (LAC-3). However, there were no significant changes in performance when comparing the scores between T2 and T3."

"From an educational standpoint, the intervention was successful, as it resulted in behavioral gains for measures of reading ability as well as for skills that are associated with good reading acquisition."

"The students showed significant gains in reading (as well as reading-related measures) following the intervention and GMV increases specific to the intervention period (T2 compared to T1) were observed in four areas."

Olulade et al. (2013)

"These gains were specific to the reading intervention itself, rather than being attributed to development, or a Hawthorne effect due to the tutoring."

"We then provided the dyslexic children with a phonological-based reading intervention, which resulted in better reading ability, and, somewhat surprisingly, also in greater activity in right area V5/MT during visual motion perception."

Christodoulou et al. (2015)

"Posttest scores were significantly higher for the intervention group than the nonintervention group on SIT, WRMT WI, WRMT WA, TOWRE PDE, and DIBELS ORF (Figure 1). There was no significant group difference on posttest TOWRE SWE scores."

"For untimed real-word reading (WRMT WI), untimed pseudoword reading (WRMT WA), and timed pseudoword reading (TOWRE PDE), the intervention group showed no statistically significant changes in scores while the nonintervention group declined significantly. On oral reading fluency (DIBELS ORF), the intervention group improved while the nonintervention group showed no statistically significant change. On symbol imagery (SIT), the intervention group improved while the nonintervention group declined."

"Reading improvement relative to pretest scores was achieved by 50% of the participants in the intervention group (M = −0.81, SD = 6.39) as indicated by composite change scores (posttest minus pretest) greater than zero based on standardized reading outcome measures (WRMT WI, WRMT WA, TOWRE SWE, TOWRE PDE)."

"Untimed word reading (WRMT WI) yielded an effect size of 0.96 (intervention: M = 0.61, SD = 7.90; nonintervention: M = −6.70; SD = 7.30). Untimed pseudoword reading (WRMT WA) yielded an effect size of 0.87 (intervention: M = 0.65, SD = 11.61; nonintervention: M = −8.00; SD = 7.95). Timed word reading (TOWRE SWE) yielded an effect size of 0.19 (intervention: M = −4.17, SD = 7.14; nonintervention: M = −5.50; SD = 7.03). Timed pseudoword reading (TOWRE PDE) yielded an effect size of 1.08 (intervention: M = 1.09, SD = 10.47; nonintervention: M = −8.52; SD = 6.96). Oral reading fluency (DIBELS ORF) yielded an effect size of 0.76 (intervention: M = 11.48, SD = 18.52; nonintervention: M = 0.35; SD = 9.02). The SIT yielded an effect size of 1.32 (intervention: M = 9.55, SD = 9.73; nonintervention: M = −3.09; SD = 9.40)."

Joo et al. (2017)

"First, we found a strong, systematic improvement in reading skills across the four measurement sessions (Fig. 2a; session effects: b=4.13, SE=0.53, p<10−10, linear mixed-effects model with subjects as a random effect). However, once motion discrimination thresholds stabilized during the first session prior to reading intervention, thresholds remained stable across all subsequent sessions as subjects underwent reading intervention."

Huber & Yeatman (2018)

"Using a linear mixed effects LME model to analyze changes in MD as a function of intervention hours (fixed effect of intervention time in hours and random effect of subject), we find significant intervention-driven change in PC1 (t(112) = -3.10, p = 0.0024) and PC4 (t(112) = 3.00, p = 0.0034). However, the amount of change observed in an individual subject is not dependent on that subject's age. Specifically: (1) fitting an LME model with age, time (intervention hours), and their interaction indicated that the interaction was not significant for any of the five PCs (all p-values > 0.16); (2) the correlation between age and individual growth rates (change in MD per hour of intervention estimated as a linear fit to each individual's data)."

"For the intervention program employed here, neither white matter plasticity nor reading growth rates diminish between first grade and middle school. These findings stand in stark contrast to our predictions: (1) in terms of white matter plasticity, younger and older children show rapid and widespread changes with an equivalent magnitude and time-course; (2) in terms of improvements in reading skills, younger and older children show equivalent gains in reading accuracy and reading rate."

"What is unique about the intervention employed here is the intensity (four hours a day, five days a week), and the one-on-one delivery of the curriculum, which allows a skilled instructor to tailor the pace of the program to the individual student's needs. These two factors might be critical for promoting both white matter plasticity and learning over a broad age range. In line with this idea, we see large behavioral effects across the full age range of our sample, which deviates from the expectation that intervention efficacy declines sharply with age. Determining the specific aspects of an intervention and, more broadly, the environmental factors that prompt large-scale changes in white matter tissue properties, is an important direction for future research."

Romeo et al. (2018)

"These findings indicate that effective summer reading intervention is coupled with cortical growth, and is especially beneficial for children with RD who come from lower-SES home environments."

"Despite reduced cortical thickness in canonical language regions at baseline, lower-SES children responded more favorably to an intensive summer reading intervention than their higher-SES peers, both in terms of reading scores and structural plasticity throughout the neural reading networks. Taken as a whole, this suggests that intensive summer reading intervention might be even more effective for these dually at-risk children."

Donnelly et al. (2019)

"Age-normed, standardized measures of reading skills were stable or declining during the baseline period before the beginning of the intervention, and then increased systematically over the course of the intervention."

"To compare the effects of the intensive intervention to changes that might be observed in a typical classroom setting (or due to repeated testing), we compared growth in the intervention participants to an age and reading skill matched control group that did not participate in the intervention."

"Even though there was substantial variability in initial reading scores and age, there was steady growth during the intervention. All measures of reading skills showed significant intervention-driven growth."

"Age was not predictive of the linear growth observed in any composite measure, indicating that improvements were equivalent across the broad range sampled here."

"We conclude that over 160h of intervention, improvements in reading skills follow a predominantly linear trajectory."

Yeatman et al. (2019)

"We find that the intervention induces large-scale changes in white matter diffusion properties, and improvements in reading scores, but that the magnitude and time-course of plasticity does not depend on the subject's age. Thus, we conclude that, for the intensive, one-on-one reading intervention program employed here, if a sensitive period exists, it does not end before middle school."

Krafnick et al. (2022)

"Repeated measures ANOVAs conducted on the standard scores of the three measures of reading and the five measures of reading related skills, as well as the three math skills, immediately prior to and following the reading intervention (Time Point as within subjects factor and Sex as between-subjects factor) found six of the eight reading/reading-related measures showed a significant main effect of Time Point and increased scores following the reading intervention (this indicated a basic repeat of the positive findings in the original 2011 study)—real word reading (W-J WID), pseudoword reading (W-J WA), reading comprehension (W-J PC), phonemic awareness (LAC), naming fluency of letters/numbers (RAN L&N), and visual imagery (SI)."

"Overall, the children made strong gains in reading performance (single real word reading, single pseudoword decoding and reading comprehension) as well as the two skills trained during the intervention (phonological and orthographic processing). These gains were specific to the reading intervention as the control math intervention resulted in gains on math but not reading measures."

Dual Coding Theory

Applied research: Teaching comprehension in a public education setting (Pueblo School District 60).

"During the implementation years (1997-2003), reading comprehension was taught in classrooms using the V/V program. The program was implemented at the individual school level through inservice teacher and support staff training and the use of special program materials that scaffolded to standard materials, including basal readers and content area textbooks. Program fidelity assurance was conducted on-site by trained staff. The program was implemented in increasing numbers of PSD60 schools during the implementation years, providing a robust, large-scale test.

"An independent evaluation study focused on CSAP performance in grades 3, 4, and 5 (Sadoski & Wilson, 2006). Data analysis was conducted through a series of repeated measures of analyses of covariance between PSD60 schools and the state-wide CSAP average. Covariates included school size, minority student percentage, socioeconomic status, and the total time in the intervention. Controlling for these factors, statistically significant ($p < .0001$) and increasing gains favoring the V/V intervention were found in all three grades."

Sadoski, M., & Paivio, A. (2001).

"As a candidate for a unified theory of reading, [Dual Coding Theory] strengths lie in the body of research it conserves and the parsimony of applying the same theoretical constructs and principles to decoding, comprehension, and response.

"These two codes have distinct forms of processing that are also derived from experience, such that the verbal code is more sequential in processing and the nonverbal code more simultaneous in processing. Associative connections within and between the two codes are the vehicle for all processing and memory structures. Hence, the mansion of DCT has rooms for decoding, comprehension, and response. DCT is therefore an associationist or connectionist theory that differs from all others in that class in that what gets connected is as important as the strength of the connections.

"DCT is a general theory of mind that has been directly applied to literacy. As noted earlier, this theory was originally developed to account for verbal and nonverbal effects on memory, but it has been extended to other domains through a systematic program of research over many years (Paivio, 1971, 1986, 1991, 2007). It has been extended to literacy as an account of reading comprehension (Sadoski & Paivio,1994; Sadoski, et al.,1991), written composition (Sadoski, 1992), spelling (Sadoski, Willson, Holcomb & Boulware-Gooden, 2005), and as a unified theory of literacy (Sadoski & Paivio, 2001, 2004)."

Sadoski, M., & Paivio, A. (2007).

"DCT is a general theory of all human cognition that has been extended into many domains (Paivio, 2007). It has been applied in detail to various aspects of literacy including reading, composing, and spelling (see Paivio 1971, 1986, 2007; Sadoski, 1992; Sadoski, Goetz, Stricker & Burdenski, 2003; Sadoski, Kealy, Goetz & Paivio, 1997; Sadoski & Paivio, 1994, 2001, 2004; Sadoski, Willson, Holcomb & Boulware-Gooden, 2005). DCT has challenged single-code theories such as schema theory and construction-integration theory (Kintsch, 1998, 2004) as an explanation of comprehension and memory in reading (Sadoski & Paivio, 1994, 2001, 2004; Sadoski, Paivio & Goetz, 1991)."

Sadoski, M., McTigue, E. & Paivio, A. (2012).

"DCT is among the strongest current candidates for developing a unified, scientifically-based theory of literacy.

"DCT principles apply to grapheme-phoneme correspondences, vocabulary, grammar, the construction of mental models of text episodes, and imaginative responses to text including the social construction of self and others in literacy encounters."

Sadoski, M. & Krasny, K. (2019).

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