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Exploring Differential Effects Across Two Decoding Treatments on Item-Level Transfer in Children with Significant Word Reading Difficulties: A New Approach for Testing Intervention Elements

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Abstract

In English, gains in decoding skill do not map directly onto increases in word reading. However, beyond the Self-Teaching Hypothesis (Share, 1995), little is known about the transfer of decoding skills to word reading. In this study, we offer a new approach to testing specific decoding elements on transfer to word reading. To illustrate, we modeled word-reading gains among children with reading disability (RD) enrolled in Phonological and Strategy Training (PHAST) or Phonics for Reading (PFR). Conditions differed in sublexical training with PHAST stressing multi-level connections and PFR emphasizing simple grapheme-phoneme correspondences. Thirty-seven children with RD, 3rd – 6th grade, were randomly assigned 60 lessons of PHAST or PFR. Crossed random-effects models allowed us to identify specific intervention elements that differentially impacted word-reading performance at posttest, with children in PHAST better able to read words with variant vowel pronunciations. Results suggest that sublexical emphasis influences transfer gains to word reading.

In English, early difficulty in the acquisition of context-free word identification skills is one of the most reliable indicators of reading disabilities (RD; Lovett et al., 1994; Torgesen, 2000). Deficits in phonological processing, more specifically phonemic awareness, have been causally linked to poor word-identification skills through a mechanism that disrupts the development of decoding skills (Bus & IJzendoorn, 1999; Rack, Snowling, & Olson, 1992; Stanovich & Siegel, 1994; Torgesen, 2000; Vellutino, Fletcher, Snowling, & Scanlon, 2004). For this reason, many remediation studies have focused on providing explicit training in phonologically-based decoding skills (Lyon, 1998; Swanson, 1999). The rationale is that if deficits in decoding skill can be eliminated through focused instruction, then the acquisition of word-reading skills through successful application of decoding rules can commence.

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Thus, for children with phonologically-based reading disabilities (i.e., deficits in phonological decoding), the initiation of the self-teaching process (Share, 1995; Share & Stanovich, 1995) is hypothesized to be the mechanism by which increases in decoding-skill knowledge are transferred to word-recognition skill.

For developing readers, attempting to decode an unfamiliar letter string can result in either full or partial decoding (see Elbro, de Jong, Houter, & Nielsen, 2012; Keenan & Betjemann, 2008; Tumner & Chapman, 2012; Venezky, 1999). Full decoding occurs when the reader has sufficient decoding skills to sound out the word *and* the word contains regular (or decodable) relationships between orthography and phonology. Partial decoding, on the other hand, occurs when the reader does not have sufficient decoding skills to sound out the word *or* the word is irregular and cannot be pronounced correctly by applying common decoding rules (Wang, Nickels, Nation, & Castles, 2013). During full or partial decoding, the role of the reader is to match the assembled phonology from decoding with the lexical representation of the word (see Venezky, 1999). Thus, the decodability of a word depends on both the decoding knowledge of the reader and the regularity of the orthographic-to-phonological relationships of the word. As such, the self-teaching mechanism is relevant to the learning of all words with differences in the speed of a child acquiring a reliable orthographic representation being influenced by a combination of the reader's decoding ability; the word's regularity, orthographic complexity, and frequency; and the overall number of word exposures the child experiences (see Perfetti, 1992, Seidenberg, Waters, Barnes, & Tanenhaus, 1984).

Intervention studies designed to improve word-level recognition processes in children with reading disabilities (e.g., Blachman, 2004; Foorman et al., 1997; Morris et al., 2012; Torgesen, Alexander, et al., 2001; Vellutino et al., 1996) have demonstrated that systematic instruction in phonemic awareness and decoding skills results in significant and lasting improvements in nonword decoding; however, generalization of decoding skill gains to word reading skills has posed a more serious problem for children with RD (see Compton, Miller, Elleman, Steacy, 2014; Olson, Wise, Ring, & Johnson, 1997). Torgesen, Wagner, and Rashotte (1997a) concluded "…we have not yet demonstrated that we understand the conditions that need to be in place for children with phonologically-based reading disabilities to acquire the level or type of phonetic reading skills that can be utilized within a self-teaching framework to produce advantages in the development of a rich orthographic reading vocabulary" (p. 230).

We hypothesize that this disassociation between decoding skill learning and word reading gains is partially due to the grain size (see Compton et al., 2014; Ziegler & Goswami, 2005) of instruction often employed in decoding programs. It has been estimated that a typically developing reader's orthographic lexicon contains approximately 10,000 word-specific representations (excluding inflectional forms) by eighth grade (Ehri, 2005; Harris & Jacobson, 1982). This requires a sublexical system that can quickly establish and reliably retrieve word-specific spellings that activate pronunciation across a wide variety of orthographic patterns representing simple mono- and more complicated polysyllabic words (see Gough, Juel, & Griffith, 1992; Perfetti, 1992). However, many decoding programs disproportionately focus on sublexical connections at the grapheme-phoneme level, reducing the potential of instruction to promote connections across more complex orthographic-phonological sublexical units (see Berninger & Abbott, 2002; Lovett et al., 2000; Morris et al., 2012). While we recognize the critical importance of simple grapheme-phoneme connections to the acquisition of the alphabetic principle in developing readers, we theorize that over-reliance on simple grapheme-phoneme corresponce instruction may limit the formation of larger orthographic-phonological connections needed to establish new lexical entries with more complex spelling-to-sound relations (Ehri, 2014; Perfetti & Stafura, 2014).

Currently there is a need for studies that examine how the sublexical focus (i.e., grain size) of instruction in decoding programs affects transfer to word reading ability in children with RD. However, two issues have limited our ability to explicitly compare the effects of varying instructional components, in this case grain size, on word reading transfer across decoding programs. First, the outcome measures used to assess intervention responsiveness and transfer to word reading have tended not to sample words in a systematic fashion to allow the measure to be sensitive to individual differences in learning, they lack the capacity to change systematically and predictably with the interventions, and they do not permit estimates of transfer to a larger corpus of words. Second, until recently it has been impossible to model intervention effects at the item level to allow simultaneous estimates of both child-level and word-level effects. In this study, we offer a new approach combining a systematically constructed responsiveness measure with crossed-random effects item-level models that allows testing of the effects of specific intervention elements across two decoding programs. We explicitly test the hypothesis that systematic decoding instruction emphasizing multi-level sublexical connections will lead to differential transfer to word reading ability in children with RD compared to a program relying on simple grapheme-phoneme correspondences. By coding the words on the responsiveness measure for instructional features related to the grain size targeted in the interventions, we were able to determine item-level performance differences associated with particular intervention elements. This allowed us to evaluate whether certain types of sublexical connections emphasized in the multi-level decoding program differentially affect item-level transfer based on word characteristics. Finally, we estimate the utility of particular sublexical connections to transfer to a larger corpus of decodable words that children are expected to master.

To accomplish this we compared the responsiveness of children with RD, 3rd – 6th grade, who were randomly assigned to 60 lessons of either Phonological and Strategy Training (PHAST; Lovett, Lacerenza, & Borden, 2000) or Phonics for Reading (PFR; Archer, Flood, Lapp, & Lungren, 2002). PHAST and PFR vary in the level of sublexical training emphasized, with PFR emphasizing simple grapheme-phoneme correspondences and PHAST stressing multiple levels of orthographic-phonological connections. The outcome measure, referred to as the responsiveness measure in this study, systematically sampled 50 words from the approximately 3,500 words (drawn from the 5,000 most frequently printed words (Zeno, Ivens, Millard, & Duvvuri, 1995)) that would become decodable across both programs after 60 lessons. Crossed random-effects models were employed to parse item-variance between person and word to examine the predictive value of child characteristics, word features, and treatment group by word feature interactions. Significant interactions were followed up by estimating the utility of important sublexical connections to support transfer to decodable words in the general corpus of the 5,000 most frequent words (Zeno et al., 1995).

Method

Participants

Participants were 37 children identified with RD in grades 3 through 6. Students were selected to the meet the following criteria: (a) identified by their special education teachers as having serious difficulties acquiring word-level reading skills, (b) special education individual education plan goals in the area of decoding skill development, (c) composite score on the Test of Word Reading Efficiency below the 25th percentile, (d) full-scale IQ above 70, (e) no obvious neurological or severe emotional problems, and (f) no uncorrected sensory deficits. A set of predictors was administered at pretest along with norm-referenced measures of decoding and word reading and the measure of intervention responsiveness (i.e., transfer) at pre- and post-test. Demographic data on the sample are presented in Table 1. Raw and standard scores assessing vocabulary, phonemic awareness, rapid automatized naming, and reading skill disaggregated by treatment condition (PHAST vs. PFR) at pretest are provided in Table 2. No differences were detected between the two intervention groups on sex: $\chi^2(1, N = 37) = 3.76$, $p = .152$; race: $\chi^2(2, N = 37) = 3.34$, $p = .065$; or age $F(1,36) = .030$, $p = .864$. In addition, no difference existed between intervention groups on pretest raw scores of vocabulary: $F(1,36) = 1.252$, $p = .271$; phonemic awareness: $F(1,36) = .725$, $p = .400$; rapid automatized naming; $F(1,36) = 1.786$, $p = .070$; word attack: $F(1,36) = .136$, $p = .714$; word identification: $F(1,36) = .372$, $p = .546$; sight word efficiency: $F(1,36) = 1.174$, $p = .286$; phonemic decoding: $F(1,36) = .776$, $p = .384$; or the responsiveness measure: $F(1,36) = .477$, $p = .496$.

Interventions

Children received 60 lessons, twice a week for 1.5 hours/lesson, of either the Phonological and Strategy Training (PHAST; Lovett, Lacerenza, & Borden, 2000) or Phonics for Reading (PFR; Archer, Flood, Lapp, & Lungren, 2002) taught in small groups by trained graduate student research assistants at a university in the Southeast United States. Both programs focus on teaching both single and polysyllabic words through systematic application of decoding procedures. However, PHAST and PFR differ in the relative emphasis placed on sublexical connections, with PHAST addressing a more varied set of sublexical connections including simple grapheme-phoneme correspondences, rime units, affixes, and varied pronunciations of vowel and vowel combinations and PFR stressing simple grapheme-phoneme correspondences.

PHAST—PHAST is a multifaceted decoding program developed by Lovett and colleagues (see Lovett, Lacerenza, Borden, et al., 2000) that provides training in (a) phonological awareness and simple grapheme-phoneme correspondences and (b) five word-identification strategies that offer different approaches to the decoding of unfamiliar single and polysyllabic words and exposure to different levels of sublexical processing. In this study we focus on the strategies associated with keywords, variable vowel pronunciation, and peeling off of affixes (see Lovett et al., 2000).

PFR—PFR (Archer, Flood, Lapp, & Lungren, 2002) is a synthetic phonics program targeting basic phonological awareness and general phonics rules that trains at the level of grapheme-phoneme correspondences. Lessons focus on teaching children phonemic decoding skills through the application of grapheme-phoneme correspondences to phonetically regular single and polysyllabic words. Students are introduced to single consonants, short vowels, double consonants, vowel and consonant digraphs, diphthongs, consonant blends, long vowels, vowel combinations, r-controlled vowels, and prefixes and suffixes.

Procedures

A multilevel design was employed in which homogeneous groups of children (based on initial decoding skill) were formed and these clusters were randomly assigned to the PHAST or PFR interventions (i.e., cluster random assignment). Thus, children were nested within groups, with the intervention administered at the group level. A fidelity-of-implementation checklist was created from the tutoring scripts for both PHAST and PFR, with each checklist listing all the components that make up the program. Graduate research assistants were trained to deliver both interventions with fidelity. Research assistants were provided with 3 full days of training after which each research assistant was required to practice each tutoring program for 15 hours. Finally, research assistants completed a mock tutoring session for each program with the trainer, who addressed all discrepancies as the session was conducted. In the rare event that fidelity of implementation was less than 90% during the mock session, the research assistant was given feedback, asked to practice more, and then required to complete another mock tutoring session with fidelity above 90%. During intervention, the project coordinator visited groups every 12 lessons to assess fidelity of treatment. Fidelity estimates were greater than 95% across groups over the course of the study.

Responsiveness Measure

Our measure of responsiveness was designed to be sensitive to individual differences in learning, have the capacity to change systematically and predictably with instruction, and allow for transfer estimates to the larger corpus of the 5000 most frequent words (see Compton et al., 2005). Since the measure was tied directly to the intervention methods, it had the potential to be more sensitive to changes in decoding skill as a result of instruction. To create the measure, a systematic procedure was developed for sampling words based on an optimal growth function predicting whether, and if so at what lesson, each of the 5000 most frequent words becomes decodable as a function of the PHAST and PFR intervention lessons (see Compton et al., 2005 for a detailed discussion of this procedure). This allowed individual growth on the assessment measure to generalize to a larger corpus of decodable words. Appendix A provides the optimal growth curves for the corpus and for the responsiveness measure. These growth curves reflect the corpus of words that can be accurately decoded as a function of intervention lesson assuming 100% mastery learning of the PHAST or PFR intervention. Of the 5000 words, approximately 80% were decodable in PHAST and 75% were decodable in PFR. We then sampled 50 words purposely from the remaining decodable corpus of approximately 3500 words in such a way that the list mirrored the optimal growth curve in terms of word frequency and length (see Appendix B for the list of words on the responsiveness measure). Thus, the 50 words on the responsiveness measure are considered decodable at posttest for all participants in the study assuming mastery learning of the PHAST or PFR intervention components. It is important to note that the words that make up the responsiveness measure were not taught as part of either intervention program and therefore represent transfer items that are capable of being read based on the decoding instruction. In terms of reliability, the correlation between pre and posttest performance on the responsiveness measure was .89.

Child Measures

Sight word (SWE) and phonemic decoding (PDE) efficiency—The TOWRE (Torgesen, Wagner, & Rashotte, 1997b), used in subject selection, is a norm-referenced measure of word- and nonword-reading accuracy and fluency. The SWE and PDE subtests assess the number of words and pronounceable nonwords that can be accurately identified in 45 s.

Word identification (WID) and attack (WA)—WID and WA were assessed using the Woodcock Reading Mastery Tests - Revised/Normative Update (Woodcock, 1988). For WID children read words and for WA decodable nonwords aloud without time limit.

Phonological awareness (PA)—PA was measured with the Elision subtest of the Comprehensive Test of Phonological Processing (CTOPP; Wagner, Torgesen, & Rashotte, 1999). Children were presented a word, asked to repeat the word, and then asked to say the word without a specified syllable or phoneme.

Rapid automatized naming (RAN)—RAN was assessed using the Rapid Letter Naming subtest of the CTOPP (Wagner, Torgesen, & Rashotte, 1999). The total score was the number of seconds it took the child to name the letters on both test.

Vocabulary (VOC)—The Peabody Picture Vocabulary Test—Third Edition (Dunn & Dunn, 1997) is a norm-referenced test of receptive vocabulary skill.

Word measures

Word length—The number of letters in each word, with words varying from 3 to 12 letters.

Keyword—Words were coded to reflect whether the keyword strategy in PHAST would facilitate the decoding of the word. For example, in order to read the word *floating*, children in the PHAST condition were taught the keyword *boat* and were taught to say “if I know boat, then I know float.” This was a dichotomous variable (1 or 0).

Variable vowel pronunciation—Words were coded as to whether they included a variable vowel pronunciation. A variable vowel refers to a vowel, or vowel combination, that can take on different sounds. This covariate was included to address the “Vowel Alert” strategy in PHAST. Using this strategy, students are encouraged to try multiple pronunciations of a vowel to arrive at the correct word. Pronunciations are taught according to the frequency with which they occur in English print. For example, students in the PHAST condition would be taught to attempt different sounds for *ea* (i.e., first try /i/ as in meat, then try /ɛ/ as in head, and then try /eɪ/ as in steak,). This was a dichotomous variable (1 for yes or 0 for no).

Affixes—Words were coded as to whether they contained affixes, to which students in the PHAST condition would be able to apply the "Peeling-Off" strategy. This was a dichotomous variable (1 for yes or 0 for no).

Concreteness—Concreteness of the target words was coded using ratings from Brysbaert, Warriner, and Kuperman (2014). Brysbaert et al. provide concreteness ratings for 40,000 generally known English words. People were asked to rate the concreteness of words on a scale of 1 (abstract) to 5 (concrete). Concreteness was included as a word feature to provide a proxy for lexical word properties (i.e., semantics) in the models. Keenan and Betjemann (2008) have speculated that such lexical properties might be related to semantic activation, which may help to "fill voids" in phonological-orthographic processing in individuals with poor mappings, such as children with RD.

Data analysis

Item-response based crossed random effects models were used to address the research questions. These models allowed us to partition the item-level variance across children and words. Random intercepts were included for child, word, and small group membership (i.e., controlling for nesting). Fixed effects were included for all child- and word-level features along with random slopes that were required to best fit the data. A detailed description of these analyses is beyond the scope of this report, but have been widely used in the literature (e.g., Duff & Hulme, 2012; Gilbert, Compton, & Kearns, 2011; Goodwin, Gilbert, & Cho, 2013; Kearns et al., in press; Kim, Petscher, Foorman, & Zhou, 2010).

We conducted a simulation to determine how much power we had to detect a significant effect by estimating the minimal detectable effect size defining power at .80 (alpha= .05). Because crossed-random effects models do not yield traditional effect size estimates, our simulation estimated the minimal R^2 change detectable when a covariate was added to the model to predict either child or word variance and then this minimal variance change was converted into an F^2 statistic which is interpretable using guidelines provided by Cohen (1988). Using this method, our sample of words and children allows us to detect a minimal variance change on words equivalent to Δ 4.84% and on children equivalent to Δ1.40%. These reductions in variance correspond to F^2 statistics of .05 for words and .014 for children, both representing small effects. Therefore, our models, with a sample size of 37 children and 50 items (totaling 1,850 observations), are powered to detect small to medium effects based on Cohen's criteria for multiple R^2 (Cohen, 1988).

Results

Pretest and posttest group means, standard deviations, and *F*-tests (i.e., effects of time and time x condition) are presented in Table 2. We found a main effect of time for all of the word-level reading measures indicating that decoding and word reading skills increased significantly with time (presumably due to instruction). However, the time x condition interaction was not significant for any of the reading measures, signifying that gains in decoding and word reading skill were equivalent across the two conditions.

The crossed random effects model indicated that there were several significant child and word covariate main effects (see Table 3). The unconditional model had a logit intercept of -.178 indicating an average student reading an average word had a .46 probability of reading the word correctly. As expected pretest item-level performance was a significant predictor (γ_{001}= 1.314, z=5.353), there was a significant main effect for child word identification (γ_{006}= .091, z=7.293), and a significant main effect at the word level for number of letters (γ_{007} = -.580, z=4.884) and variant vowel (γ_{009} = −1.582, z=4.172). The negative coefficients on these two word level predictors indicated that as the number of letters increased and when a word contained a variable vowel, the probability of a correct response decreased. While there was a significant change across time in mean performance on the responsiveness measure from pretest to posttest, no significant difference was detected for condition on posttest performance (γ_{002}= −.652, z=1.863).

In addition to the main effect of variable vowel, we found a significant interaction between condition and variable vowel. This interaction is presented in Figure 1 and demonstrated that overall the students in the PHAST group did not differ in the probability of correctly reading words with variable vs. nonvariable vowel patterns, whereas a significant difference emerged in the PFR group favoring words with nonvariable vowels. A corpus level analysis of the 5000 most frequent words revealed that over 50% of the decodable words contained a variable vowel pattern (including words containing schwa).

Discussion

In this study we offer a new approach to testing specific decoding elements on transfer to word reading. Specifically, we demonstrated how combining a systematically constructed responsiveness measure with crossed-random effects item-level models allows testing of the effects of specific intervention elements across two decoding programs. To illustrate, this study specifically tested whether children with RD would differentially transfer decoding gains to a purposefully sampled set of words as a function of whether the phonics program emphasized multiple sublexical connection levels versus single sublexical level. We also tested whether certain types of sublexical connections emphasized in the multi-level decoding program would affect item level transfer based on word characteristics. Both conditions exhibited significant and equivalent gains in decoding skill as a function of time. In addition, results indicated that there was no overall difference between the two phonics programs in terms of the effect on our treatment aligned responsiveness measure. Thus, across all items, the two phonics programs lead to a similar probability of transfer to decodable words. Additionally, we found that item-level variance was explained by item pretest performance, person-level word identification skill, and word length and presence of a variable vowel.

We also found that there was a significant interaction between condition and variable vowel favoring the multilevel decoding program. This interaction indicates that despite no overall difference between the effectiveness of the programs, students in the PHAST condition were significantly more flexible with vowel pronunciations. We attribute this advantage to the "Vowel Alert" strategy in PHAST, which encourages students to systematically attempt different vowel pronunciations when decoding words. The findings suggest that the single sublexical level program resulted in better decoding of words without variable vowels but was significantly less effective at teaching flexibility with vowels. Furthermore, our corpus estimate reveals that approximately 50% of the roughly 3,800 decodable words in the corpus contained a variable vowel. Given the difficulties struggling readers have with vowel representations (e.g., Ehri & Saltmarsh, 1995; Shankweiler & Liberman, 1972), flexibility with vowels may be an important skill for accessing words within the greater corpus. Keeping in mind that group differences were not detected on the responsiveness measure, the significant interaction leads us to infer that the PHAST program may have greater ability to transfer decoding gains to the larger corpus of decodable words that contain variable vowel pronunciations whereas PFR to those words with nonvariable vowels. Consistent with Venezky's (1999) concept of "set for variability", our results suggest that teaching children to be flexible in how they approach decoding new words may be warranted.

In general, we interpret the results of this study as supporting this new approach to testing specific decoding elements on transfer to word reading and encourage others to adopt the general procedure of combining a systematically constructed responsiveness measure with crossed-random effects item-level models to allow testing of specific intervention elements across instructional programs. However, results must be tempered by the limited number of students in the study, the generalizability of PHAST and PFR to represent single- vs. multi-level sublexical decoding programs, and the ability of the transfer measure to represent the larger corpus from which decodable words were sampled. Item-level replications across phonics programs varying on important dimension are warranted based on these findings.

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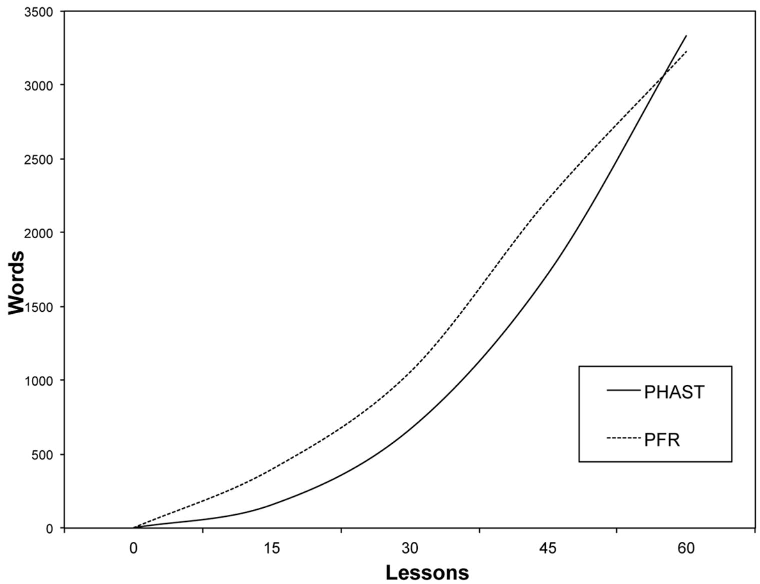
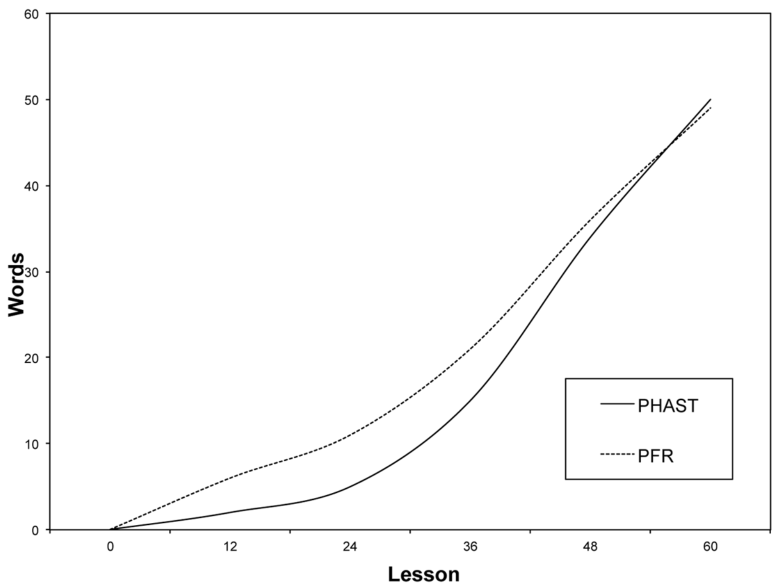
Appendix A





Optimal Growth Curve (upper) and Response Measure (lower) for PHAST and PRF

Appendix B

Table 1B

List of Words on the Responsiveness Measure

Word	PHAST Lesson	PFR Lesson	Letters (Est/Act)
sad	5	3	3

Word	PHAST Lesson	PFR Lesson	Letters (Est/Act)
math	8	12	4
gift	16	3	4
tail	21	23	4
limit	24	3	5
visit	25	3	5
cake	27	30	4
goat	27	28	4
drop	28	19	4
string	31	20	6
planet	32	20	6
husband	34	16	7
sixth	35	12	5
beside	36	34	6
artist	30	35	6
seated	37	25	6
crime	37	32	5
gather	38	37	6
unlike	39	41	6
repeat	40	43	6
sharply	42	47	7
enter	43	37	5
floating	45	27	8
chosen	46	33	6
operate	46	37	7
finish	46	56	6
camera	47	37	6
distant	47	41	7
amazing	47	55	7
shout	48	48	5
reflect	48	43	7
perfectly	48	47	9
negative	48	58	8
shining	49	32	7
organized	49	39	9
gravity	49	47	7
primitive	49	50	9
destroyed	50	45	9
screen	51	29	6
available	51	55	9
constantly	53	49	10
expensive	54	58	9
holiday	54	44	7

Word	PHAST Lesson	PFR Lesson	Letters (Est/Act)
construction	55	49	12
underneath	56	53	10
pleasant	56	60	8
equipment	57	52	9
instrument	59	55	11
applying	60	55	8
argument	57	59	8

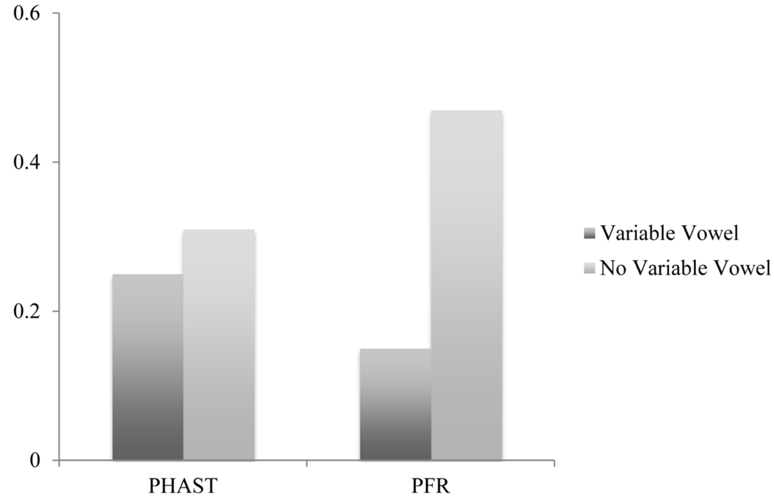


Figure 1.

Estimated probability (conditionalized on item and person predictors) of a correct response for intervention groups and variable vowel. *Note*. PHAST = Phonological and Strategy Training; PFR = Phonics for Reading.

Table 1

Demographic Statistics

	Full Sample *N* = 37			
Variable	***n***	**%**	**Mean**	**(SD)**
Age (years)			8.77	(1.36)
Gender				
Female	13	35.14		
Male	24	64.86		
Race				
African American	17	45.95		
Caucasian	19	51.35		
Hispanic	1	2.70		

Table 2

Pretest and Posttest Performance on Child-Level Measures for the PHAST and PFR Intervention Groups

	Pretest				Posttest					
	PFR		PHAST		PFR		PHAST			
Measure	**M**	**(SD)**	**M**	**(SD)**	**M**	**(SD)**	**M**	**(SD)**	F_{time}	$F_{time \times condition}$
VOCAB										
Raw Score	98.56	(19.85)	105.05	(15.30)						
Standard Score	87.33	(13.10)	91.84	(11.43)						
PA										
Raw Score	13.61	(2.57)	14.42	(3.17)						
Standard Score	80.83	(7.71)	83.26	(9.50)						
RAN										
Raw Score	13.44	(4.53)	16.05	(3.37)						
Standard Score	80.33	(13.58)	88.16	(1.012)						
WID										
Raw Score	29.38	(16.31)	34.68	(10.14)	39.72	(13.01)	43.84	(10.35)	98.59*	.35
Standard Score	84.89	(10.02)	83.11	(7.68)	87.44	(8.92)	85.47	(8.01)		
WA										
Raw Score	6.38	(4.50)	7.57	(5.33)	14.05	(6.70)	14.15	(5.44)	67.19*	.48
Standard Score	84.72	(9.29)	83.53	(10.34)	94.22	(9.91)	91.95	(7.01)		
SWE										
Raw Score	27.11	(17.21)	32.47	(12.66)	34.00	(17.86)	38.57	(10.68)	25.38*	.09
Standard Score	85.11	(11.25)	83.68	(9.95)	85.17	(11.64)	83.89	(9.85)		
PDE										
Raw Score	5.22	(4.56)	6.57	(4.81)	10.94	(7.66)	10.68	(6.32)	18.78*	.51
Standard Score	81.50	(10.33)	80.42	(8.93)	85.22	(8.76)	82.42	(7.57)		
Responsiveness										
Raw Score	9.72	(10.86)	11.87	(8.21)	20.88	(14.64)	25.36	(11.79)	132.07*	1.58

Note. PFR = Phonics for Reading; PHAST = Phonological and Strategy Training; VOCAB=vocabulary (PPVT); PA=phonological awareness; RAN=rapid automatized naming; WID = word identification; WA = word attack; SWE = sight word efficiency; PDE = phonemic decoding efficiency.

* $p < .001$ ($df = 1, 35$).

Table 3

Fixed Effects and Variance Estimates Predicting Responses on the Posttest Responsiveness Measure using Child and Word Covariates

	Unconditional model			Interaction model		
Fixed Effects Parameter	**Est.**	**(SE)**	**z**	**Est.**	**(SE)**	**z**
Intercept (γ_{000})	−.178	(.493)	.360	−1.447	(.825)	1.753
Item covariate						
γ_{001} Pretest	—	—	—	**1.314**	**(.246)**	**5.353**
Child covariates						
γ_{002} Condition	—	—	—	−.652	(.350)	1.863
γ_{003} Vocabulary	—	—	—	.013	(.007)	1.807
γ_{004} PA	—	—	—	.032	(.057)	.560
γ_{005} RAN	—	—	—	.050	(.038)	1.319
γ_{006} Word Identification	—	—	—	**.091**	**(.013)**	**7.293**
Word covariates						
γ_{007} Number of Letters	—	—	—	**−.580**	**(.119)**	**4.884**
γ_{008} Keyword	—	—	—	.301	(.370)	.813
γ_{009} Variant Vowel	—	—	—	**−1.582**	**(.379)**	**4.172**
γ_{010} Affixes	—	—	—	−.094	(.452)	.209
γ_{011} Concreteness	—	—	—	.246	(.180)	1.370
Interactions						
γ_{012} PA × Keyword	—	—	—	.010	(.051)	.195
γ_{013} Condition × Variant Vowel	—	—	—	**1.247**	**(.304)**	**4.104**
γ_{014} Condition × Affixes	—	—	—	.357	(.322)	1.109
γ_{015} Condition × Keyword	—	—	—	−.016	(.296)	.053
Random Effects	Variance			Variance		
Intercepts						
Word	3.781			.858		
Person	2.220			.084		
Group	1.639			<.001		

	Unconditional model			Interaction model		
Fixed Effects Parameter	**Est.**	**(SE)**	**z**	**Est.**	**(SE)**	**z**
Person slopes						
Letters	—			.066		
Deviance	1611			1440		

Note. PA = phonemic awareness; RAN = rapid automatized naming.