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Exploring the contribution of set for variability in explaining reading development in typical and dyslexic readers

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EXPLORING THE CONTRIBUTION OF SET FOR VARIABILITY IN EXPLAINING READING DEVELOPMENT IN TYPICAL AND DYSLEXIC READERS

By

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Abstract

Set for variability (SfV) has been shown to be a strong predictor of reading outcomes in developing readers. In this study, we explore SfV as a predictor of word reading and nonword reading ability in typically developing children and children with dyslexia. A sample of 249 elementary school students was administered a battery of reading related measures (i.e. SfV, vocabulary, phonological awareness, rapid automatized naming, attention) and a set of word level reading measures (sight word reading efficiency, phonemic decoding efficiency, word attack, word identification) to measure word and nonword reading. We hypothesized that the task SfV would serve as a unique predictor of word and nonword reading above and beyond phonological awareness and other reading level measures. Additionally, we predicted that between group differences on SfV would exist between the subgroups of typical and dyslexic readers within our sample. We observed that SfV was a unique predictor, but that no realistically significant difference exists on this measure between groups. In sum our results support the connectionist model of reading, but further research is necessary to investigate the full implications of SfV.

Exploring the contribution of set for variability in explaining reading development in typical and dyslexic readers

An essential development in learning to read is the acquisition of automatic word reading skills (defined in this study as the ability to pronounce written words and nonwords in isolation) that are impenetrable to factors such as knowledge and expectation (Perfetti, 1992). Automaticity of word reading allows fluent and reliable retrieval of word representations from the orthographic lexicon, activating phonological, syntactic, morphological, and semantic information to be used by the reader to form faithful representations of text (e.g., Kintsch & Rawson, 2005). The progression from deliberate and effortful letter by letter decoding to the understanding of complex orthographic and phonemic patterns that make up words at a nearly automatic level is the hallmark of a skilled reader. In creating such complex, connected pathways to simultaneously decode and decipher words, the reader builds upon a knowledge of letter to sound correspondences that are sensitive to the irregularities of the English language. This ever-growing corpus of information continues to aid the reader when presented with novel stimuli and more generally in exposure to print.

Individual differences exist in regards to word reading ability that are evident from the beginning of early childhood and throughout adulthood. For a process so central to modern life, it is imperative to discern the specific subcomponents of reading, the processes they follow, and how they can impact an individual’s word reading ability. Strong ties have been established regarding the relationship between phonological awareness and reading skill. It has been shown through various studies that individual differences in phonological awareness, the awareness of and the ability to manipulate individual phonemes in words, and the ability to map graphemes onto phonemes when viewing words and nonwords, are strongly associated with variance in word reading ability in developing readers (see Ehri et al., 2001).

Phonological awareness, however, is not the only piece of the convoluted puzzle in determining what exactly accounts for high levels of automatic word reading. More contemporary multiple factor models (see Pennington, 2006) have been proposed to help explain how one progresses from a novice to an expert reader. Other important cognitive factors that help explain individual differences in word reading development, above and beyond that associated with phonemic awareness skills, include rapid automatized naming ability, letter-sound knowledge, and spelling pronunciation knowledge. The newest and least understood of these additional cognitive factors is spelling pronunciation knowledge, defined as the resultant phonological representation when a child re-codes a word using decoding (also referred to as the "decoded form"). For example, if a beginning reader sees the printed word was and associates the letters w, a and s with the sound sequence "w", "æ" (as in cat), "s" formed of the standard sounds of each letter this would leave the beginner with the "spelling pronunciation" "wæs", which is not a word. However, it has been shown that the ability to recognize spelling pronunciations, as measured by the set for variability (SfV) tasks, is a significant predictor of word reading development even after accounting for phonemic awareness and letter-sound knowledge (Elbro, de Jong, Houter, & Nielsen, 2012).

Connectionist models of reading development (e.g., Harm, McCandiss, & Seidenberg, 2003) have been employed to help explore why spelling pronunciations are important in typical word reading development and also how certain failures of this model can result in the symptoms common to individuals with dyslexia. In the Harm et al. study, connectionist models were created with varying degrees of phonological knowledge through the use of computer training.

This mimicked the individual differences in phonological knowledge one might encounter among individuals learning to read. The models that were created with phonological impairments exhibited difficulty in reading of nonwords. Importantly, the established connectionist model was able to account for these specific results. The impaired model placed greater stress on the model's hidden units, the units responsible for activation of mapping knowledge, as the phonological system was not strong enough to correct for incomplete or inconsistent results from attempting to read. This is the computational equivalent of the model trying to connect the spelling pronunciation with the actual phonological representation of the word. In order to compensate for the additional weight, the hidden units were forced to rely more heavily on whole unit memorization as opposed to parsed sublexical components. In this manner, a phonologically impaired model presented with a nonword does not have the full resources to accurately decode. It can, however, "get by" with reading some typical words through relying on the whole unit memorization method. It is when the model is presented with unfamiliar whole units that its inability to properly decode and store context/rime pattern sensitive representations is truly expressed. These results seem to suggest that the inability to match the spelling pronunciation with the actual phonological representation of the word is potentially important in explaining the nonword reading deficits characterizing dyslexia.

The connectionist model, in both describing typical and atypical word reading abilities, shines light on those classified as dyslexic. Much in line with the phonologically impaired connectionist model described by Harm et al. (2003), individuals with dyslexia also show significant impairment in nonword reading due to a lack of proper decoding skills. This information then begs the question as to why, if individuals who struggle to read show phonological awareness impairments and such impairments have a cumulative effect on word reading ability, is systematic phonics training not fully capable of serving as a remedy to create orthographic learning?

Savage et al. (2018) investigated this discrepancy by testing the effects of current or best practices (CBP) of reading instruction as compared to direct mapping and set for variability teaching (DMSfV) on word reading and spelling. CBP employs the techniques common to intensive phonics training while DMSfV mainly focuses on variable vowel pronunciations and explicit instruction of set for variability through attention to mapping incorrect to correct grapheme-phoneme correspondences. An important feature of the DMSfV is training and giving children practice in matching the spelling pronunciation with the actual phonological representation of the word (e.g., that the “spelling pronunciation” “wæs” represents the word was pronounced “wəz”). The results of this study indicate that DMSfV intervention works significantly better in increasing word reading and spelling as compared to CBP. DMSfV is postulated to have a greater impact on reading due to the fact that it taps into the method in which spelling pronunciations are used to inform standard pronunciations of words (Elbrow & De Jong, 2017). In Elbrow and De Jong’s (2017) model of reading, a skilled reader employs spelling pronunciation, standard pronunciation, and semantic representation simultaneously to read a written word; in contrast, a novice reader uses the written word first to create letter-sound correspondences in order to achieve a spelling pronunciation that mutually works with the standard pronunciation. Savage et al. (2018) suggests that “set for variability” (the ability to match spelling pronunciation with the standard pronunciation) acts as the link between spelling and standard pronunciations in beginning readers. Additionally, set for variability allows a child to have phonemic awareness of a word, but also suggests a deeper understanding of the statistical sensitivities that regulate word components such as variable vowel pronunciation, consonantal context, and orthographic and phonemic patterns (Steacy et al., 2018). This sensitivity factor could be responsible for enabling modulation of the sublexical components of spelling and standard pronunciation discrepancies necessary to create correct pronunciation and spelling of both words and nonwords in a language with an opaque orthography.

Set for variability may be a particular component of interest in regards to reading ability, as it may directly aid the process of going from labored decoding to automatic word recognition. In a study conducted by Steacy et al. (2018) investigating variable vowel pronunciations, results indicated that set for variability was the “strongest predictor of nonword reading base-rate surpassing both phonemic awareness and word reading efficiency” (p. 11). In addition, set for variability predicted both use of high frequency vowel pronunciations and low frequency vowel pronunciations. Due to its surprisingly strong load on word reading skills as compared to other well-known factors such as phonological awareness, set for variability has amounted to a compelling component of word reading that deserves further investigation. Importantly, set for variability may provide key insight into explaining and understanding the symptomatology of individuals who struggle to read, such as those with dyslexia.

Dyslexia is currently explained through the phonological deficit hypothesis, which identifies phonological processing as a key cognitive component that underlies the many difficulties individuals with dyslexia face when reading, writing and spelling (Elliott and Grigorenko, 2014). These individuals tend to have great difficulty making the transition from phonological decoding to automatic word recognition, a key component in orthographic learning. When presented with words, individuals with dyslexia are inclined to focus on whole units as opposed to decoding the word and storing its sublexical representations. Decoding enables typical readers to extrapolate learned patterns to reading similar and novel words, while dyslexics have difficulty creating such beneficial pathways. Individuals with dyslexia also exhibit significant impairments in the reading of nonwords. Studies using nonword tasks eliminate the opportunity to rely on memorization as a tactic to reading. It forces the individuals to attempt to decode the written nonword and results of such studies show that dyslexics tend to lack proper decoding techniques (Snowling, 1980). Although phonological awareness has been strongly linked to the symptoms of dyslexia, research still needs to be conducted regarding other measures of word reading ability. Due to the fact that set for variability has been shown to both be related to high level representations in the connectionist and Elbro and De Jong models, as well as shown high prediction in variable vowel usage, it is a worthy candidate in attempting to further explain the reading difficulties of those with dyslexia (Harm et al., 2003; Elbro & De Jong, 2017). If set for variability does reflect a representational component, it is expected that it too reflects more than just simple word reading ability. We believe that set for variability is a factor related to reading that acts in a similar way as Harm et al.'s (2003) clean-up unit. If dyslexics do lack strong phonological skills and phoneme-based interventions do not show as strong results as one would expect, then it is possible that set for variability is an additional component of reading that operates on a higher level and is necessary for accurate word and nonword reading in an opaque language such as English.

Proposed Research Questions

The purpose of the present study is to examine the strength of association between SfV and word and nonword reading skill (controlling for other important cognitive factors including vocabulary, phonemic awareness, rapid automatized naming, attention) in typically developing and dyslexic students. In accordance with the information collected regarding reading, SfV, and other important reading related processes of those identified as poor readers, a set of research questions has been developed to investigate this material further.

1. While controlling for other well-known predictors of word reading (e.g. phonemic awareness, age, rapid automatized naming, vocabulary knowledge, and attention), does SfV independently predict differences in word and nonword reading?
2. In analyzing typical readers versus those with reading difficulties (i.e. dyslexics) on word reading ability, does the typical reader group rely more heavily on SfV for word and nonword reading?

It is worth investigating the first proposed research question in order to help establish a general comparison of the importance of common reading related tasks on reading within a sample of children. It is hypothesized that the results from this initial analysis will show that SfV independently predicts individual differences in word and nonword reading ability. The second research question looks further into the first, by specifically comparing the relationships between SfV and word and nonword reading in poor and good readers. We propose a weaker relationship between SfV and word and nonword reading in poor readers as compared to good readers, indicating that set for variability may be tapping into more than just word reading skill and may be more related to the representational component presented in the connectionist model (Harm et. al, 2003).

Method

Participants

A sample of 249 grade school children (grades 2-5) was obtained from public elementary schools in Tallahassee, Florida and from three private schools along the east coast. Within our sample, 50% identified as male and 50% identified as female. The mean age of participants was 9.42 years. Additionally, demographic data on the sample indicated the following breakdown of racial categories: 32% Caucasian, 55% African American, 12% Hispanic, and 1% identifying as Multiracial. Students with intellectual disabilities were excluded from this study. Our sample included typically developing readers and those with reading difficulties (dyslexics), as defined by standardized clinical cutoff scores (performing below the 16th percentile based on national norms) on both measures of sight word efficiency and phonemic decoding efficiency.

Materials

Participants were given various tasks to measure a broad scope of factors relating to reading ability. Data analysis will focus particularly on SfV and reading ability, as measured by timed and untimed word identification and nonword reading skill. The remaining tasks will be controlled for during analysis.

Set for variability (SfV). Set for variability was measured using Steacy et al.'s (2018) task to examine participants' ability to derive a correct pronunciation from a mispronounced word. The task was presented to participants as a word game and they were given instruction to discern what the main character of the game was attempting to say. Each participant was given two practice examples showing how to derive the correct pronunciation from a missed pronounced word (e.g. "/mŏther/" to "/məT͟Hər/" and "/brēkfăst/" to "/brekfəst/") before beginning the task.

Phonemic awareness (PA). The Elison task from the Comprehensive Test of Phonological Processing was used to test phonemic awareness by having participants remove certain phonemes from words (Wagner et al., 2013). Correct deletion of phonemes and subsequent correct pronunciation served as an indicator of high phonemic awareness.

Rapid automatized naming (RAN). Rapid automatized naming was measured using the letter naming task from the Comprehensive Test of Phonological Processing (Wagner et al., 2013). Scores were derived from the amount of time, measured in seconds, that it took participants to correctly name a sequence of letters.

Attention (ATTN). Participants' general level of attention was measured through teacher evaluations on the SWAN index of items 1 through 9 (Swanson et. al).

Vocabulary knowledge (VOC). Vocabulary knowledge was measured using the vocabulary portion from the Wechsler Abbreviated Scale of Intelligence (Wechsler, 2011), in which participants had to name visual objects and provide definitions for presented words.

Sight word reading efficiency (SWE). Participants were administered the Test of Word Reading Efficiency's SWE portion, which is a timed measure of word reading (Torgesen et. al, 2012).

Phonemic decoding efficiency (PDE). Participants were administered the Test of Word Reading Efficiency's PDE portion, which is a timed measure of nonword reading (Torgesen et. al, 2012).

Word identification skill untimed (WID). Students' ability to identify words was measured using the Word Identification component of the Woodcock Reading Mastery Tests-Revised/Normative Update (Woodcock, 1988). This task was not timed and required that each student read aloud words one by one. An item was only marked correct if the accurate pronunciation was given.

Word attack nonword reading skill untimed (WA). The Woodcock Word Attack component of the Woodcock Reading Mastery Tests- Revised/Normative Update was used to measure nonword reading ability (Woodcock, 1988). This task was not timed and required that each student read aloud nonwords one at a time. An item was only marked as correct if the correct pronunciation was given.

Procedures

Informed consent forms were given to all guardians of the sampled students and the student's assent to be a participant of the study was also received. The tasks were administered by trained Research Assistant, who had received 80% procedural fidelity prior to testing participants in a single, 45-minute session. Results from each task were scored by two Research Assistants and entered twice in order to minimize human error. Additionally, interrater reliability was assessed by evaluating twenty percent of each Research Assistant's sessions.

Data Analysis

Structural equation modeling (i.e., path analysis) was used to analyze the data as it allowed us to accomplish the following goals related to our two research questions. To begin, we were interested in looking at SfV as an independent predictor of word and nonword reading above and beyond the contribution of phonological awareness in a single model. We hypothesized that SfV would be a significantly stronger predictor of word and nonword reading as compared to phonological awareness. In conducting a path analysis model, we were able to hold all predictors constant (e.g. SfV, vocabulary, phonological awareness, rapid automatized naming, and attention) while then looking independently at SfV's contribution to explaining variance in word and nonword reading. Additionally, path analysis allowed us to more wholly investigate our model through the incorporation of latent factors. Latent factors representing word (constructed using WID & SWE) and nonword reading (constructed using WA & PDE) were not measured directly, but rather were constructs created through the combination of separate tasks given during testing. We referenced longstanding theory to initially build our latent factors, word reading (WR) and nonword reading (NWR), and then used factor analysis to ensure proper loading of these set constructs. The literature has long supported the notion of word and nonword reading as tapping into the separate and distinct reading related skill sets of word identification and decoding. There is strong backing for the tasks word attack (WA) and phonetic decoding efficiency (PDE) collectively mapping onto the reading skill of decoding. Decoding is the primary skill necessary to effectively read nonwords and is therefore the factor outlined in our study as nonword reading. In contrast, the tasks sight word reading efficiency (SWE) and word identification (WID) are constructs heavily associated with and were used to measure word reading. We refer to this initial model (Fig. 1) as our main effects model, as it allows independent comparisons regarding the covariance of each parameter while simultaneously relating the models path structure to the broader concepts of word and nonword reading.

In addition to investigating unique predictors, we were interested in covariance structure differences across the two groups (i.e., typically developing and dyslexic children) in our main effects model. Path analysis gave us the opportunity to investigate this within sample subgroup heterogeneity. Within our sample, it was unrealistic to assume that all reading related tasks that were given mapped onto the model in the same way for all reading abilities. In particular, it was likely that certain tasks and outlined skills in our model would have stronger or weaker pathways in comparing typical readers versus those with dyslexia. We hypothesized that typically developing readers rely more heavily on SfV to complete word and nonword reading. Discovering such differences may have implications in shaping assessment measures of reading ability and educational interventions for poor readers. Multigroup path analysis allowed prior equality assumptions in our initial main effects model to be relaxed for each significant parameter in the main effects model until a best model fit was established for our sample of typical readers and for those with dyslexia. These two models were then compared on the basis of covariance through computing the differences between the change in chi-square values among matched parameter pathways in each model. For example, the statistically significant covariance between the latent factors in our main effects model was replicated in each of the typical reader and dyslexic groups. However, the covariance values differed significantly between these two groups. This was computed by first relaxing the relationship between the latent factors and then comparing the differences in the chi square values between each model.

Results

To test our main hypothesis investigating if SfV is a unique predictor of word and nonword reading above and beyond phonological awareness, we first present zero-order correlations. Correlations between predictors (see Table 1) ranged from a low of .10 (RAN and attention) to a high of .64 (SfV and phonemic awareness) and between predictors and reading measures correlations ranged from a low of .29 (word attack and vocabulary) to a high of .78 (SfV and word attack). Table 2 provides zero-order correlations disaggregated by typically developing and dyslexic samples. A single group structural equation modeling path analysis was then used to model the relationship between the predictors (i.e., SfV, vocabulary, phonemic awareness, RAN, and attention) and the latent variables representing word reading and nonword reading of each correlation onto an initial main effects model. Error variances between sight word efficiency and phonemic decoding efficiency measures were allowed to covary in the model due to common task requirements (i.e., speeded response). In general, the fit of the model was adequate: X^2 (10) = 71.87, $p < .05$; CFI = .949; RMSEA = .158. As seen in Fig. 1 and Table 3, statistically significant direct pathways exist from SfV, RAN, and attention to latent word reading and from SfV, vocabulary, phonemic awareness, RAN, and attention to latent nonword reading. Various indices were gathered to account for the path analysis run. SfV, as directly compared to phonemic awareness, had a significant contribution to both word and nonword reading while phonemic awareness did not (Table 3). Within our main effects model, both latent factors covaried significantly with each other.

Additionally, we were interested in differences in the proportion of variance explained by set for variability for word and nonword reading between typical and dyslexic readers within our sample. The sample was split into a typical reading (N = 180) and dyslexic subgroup (N = 69). Path estimates for the two groups along with a test for significant difference (i.e., ΔX^2) across each group are presented in Table 4. A small significant difference (typically developing > dyslexics) was found in regard to set for variability's effect on word and nonword reading between the groups. In addition, there was a small but significant difference between groups on the path from phonemic awareness and nonword reading (typically developing > dyslexics). The largest statistically difference was found between typical readers and dyslexics on the pathway between the model's latent factors (typically developing > dyslexics).

Discussion

The purpose of this study was to investigate the broad implications of the task SfV on word and nonword reading and then look further into these effects within a typically reading and dyslexic subgroup within our sample. On a comprehensive level, our first research question directly looked at SfV in comparison to the skillset of phonological awareness, also controlling for vocabulary, RAN, and attention. Based on our model, results suggest that set for variability is in fact a unique predictor of word and nonword reading above and beyond phonological awareness. This reinforces prior findings of Savage et. al (2018) in that set for variability appears to account for the most variance in word and nonword reading, as it taps into a spelling pronunciation skillset that further increases sensitivity to the statistical regularities of written words. These findings suggest that tasks such as set for variability may be better adept than phonological awareness tasks to test and reinforce the skills necessary for both decoding and word reading in early readers.

Our second research question looked further into the diversity of reading level within our sample and imposed the main effects model onto a typically developing and dyslexic reading group. Although there was a small significant difference between the covariances of SfV in the two groups, it is likely that this difference is not of clinical significance (i.e., real world applications). This finding was contrary to what we expected based on the literature. We postulated that because SfV taps into a skillset needed to create spelling pronunciations and form those into proper written (or standard) representations, that SfV reliance would be stronger for better readers as compared to poorer readers (Savage et.al, 2018). It is plausible that our results suggest no real-life significance of SfV as there is no direct differential effect of this task on word and nonword reading measures. Future work investigating set for variability's indirect effects on word and nonword reading may have more promising applications. Further, a noteworthy significant difference between the groups was found in the covariance between the latent factors. Those with dyslexia demonstrated a weaker relationship between decoding skills and word reading. This is most likely due to differences in reading ability, as dyslexic readers tend to learn to read words without incorporating decoding skills due to poor phonological processing skills (Harm et. al, 2003).

A potential limitation of this study includes the lack of consideration of other diversity factors within our sample and how those may affect word and nonword reading. For example, individual differences in socioeconomic status may impact the quality of reading resources available to students with reading difficulties. This in turn could affect the implications of this study, as set for variability could potentially be of greater need and have a higher impact on word and nonword reading in areas with lower socioeconomic status.

To further build on this study, future lines of research are necessary to investigate the implications of set for variability. This could be conducted through the formulation of a longitudinal study designed to better track reading development in conjugation with set for variability. In addition, a randomized clinical trial would also be of aid in establishing a causal model related to reading development. Set for variability may still be an important factor in word and nonword reading between our groups, but its effects may be more prominent with the aforementioned study designs.

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Table 1

Zero Order Correlations Between Cognitive Reading Measures (N = 249).

	1	2	3	4	5	6	7	8	9
1. Set for Variability (SfV)	-								
2. Vocabulary (VOC)	.41*	-							
3. Phonological Awareness (PA)	.64*	.41*	-						
4. Rapid Automatized Naming (RAN)	-.31*	-.11	-.22*	-					
5. Attention (SWAN1_9)	.26*	.21*	.34*	-.10	-				
6. Word Identification (WID)	.77*	.34*	.58*	-.46*	.34*	-			
7. Word Attack (WA)	.78*	.29*	.68*	-.29*	.40*	.79*	-		
8. Sight Word Reading Efficiency (SWE)	.54*	.23*	.41*	-.60*	.33*	.78*	.59*	-	
9. Phonemic Decoding Efficiency (PDE)	.72*	.28*	.61*	-.43*	.32*	.76*	.78*	.70*	-

Note. * $p < .01$.

Table 2

Correlations of Cognitive Reading Measures in Typical Readers (N = 180) versus Dyslexics (N = 69).

Reading Related Measure	1	2	3	4	5	6	7	8	9
1. Set for Variability (SfV)	-	.48*	.53*	-.13	.36*	.72*	.68*	.49*	.72*
2. Vocabulary (VOC)	.44*	-	.44*	-.01	.20	.35*	.30*	.32*	.39*
3. Phonological Awareness (PA)	.62*	.41*	-	-.09	.32*	.48*	.64*	.35*	.55*
4. Rapid Automatized Naming (RAN)	-.20*	-.14	-.12	-	.10	-.39*	-.09	-.35*	-.23
5. Attention (ATTN)	.11	.23*	.25*	.04	-	.29*	.42*	.23	.30*
6. Word Identification (WID)	.75*	.41*	.54*	-.23*	.16*	-	.66*	.83*	.68*
7. Word Attack (WA)	.73*	.64*	.64*	-.14	.26*	.77*	-	.46*	.78*
8. Sight Word Reading Efficiency (SWE)	.42*	.29*	.27*	-.52*	.12*	.57*	.44*	-	.58*
9. Phonemic Decoding Efficiency (PDE)	.65*	.31*	.58*	-.26*	.14	.66*	.70*	.54*	-

Note. *p < .01. Red = Typical readers. Blue = Dyslexics.

Table 3

Path Coefficients to Word Reading and Decoding, Latent Covariances, and Error Covariance for the Main Effects Model (N = 249).

Paths	$\hat{\beta}$	Standardized $\hat{\beta}$	z	p
Word Reading				
SfV	.70	.60	12.78	.000*
VOC	.01	.01	.03	.978
PA	.17	.09	1.87	.061
RAN	-.56	-.27	6.03	.000*
ATTN	1.36	.14	3.31	.001*
Nonword Reading				
SfV	.60	.61	13.41	.000*
VOC	-.15	-.10	2.37	.018*
PA	.48	.31	6.50	.000*
RAN	-.16	-.09	2.34	.019*
ATTN	1.24	.15	3.78	.000*
Latent Covariance				
WR ↔ NWR	18.71	.67	10.38	.000*
Error Covariance				
SWE ↔ PDE	21.99	.41	6.39	.000*

Note. SfV=Set for Variability; VOC=Vocabulary; PA= Phonemic Awareness; RAN=Rapid Automatized Naming; ATTN=Attention; WR= Word Reading; NWR= Nonword Reading; SWE= Sight Word Reading Efficiency; PDE= Phonemic Decoding Efficiency.

*p < .05

Table 4

Path Coefficients to Word Reading and Decoding, Latent Covariances, Error Covariance, and Path differences for Typical Readers and Dyslexics.

	Typically Developing (n = 180)				Dyslexic (n = 69)				
Paths	$\hat{\beta}$	Standardized $\hat{\beta}$	z	p	$\hat{\beta}$	Standardized $\hat{\beta}$	z	p	ΔX^{2a}
Word Reading									
SfV	.43	.66	11.32	.000*	.82	.63	9.80	.000*	12.23*
VOC	.08	.07	1.29	.196	.08	.05	1.29	.196	
PA	.10	.10	1.56	.117	.10	.07	1.53	.126	
RAN	-.31	-.21	4.03	.000*	-.31	-.21	3.42	.001*	1.68
ATTN	.45	.08	1.57	.116	.45	.05	1.52	.128	1.36
Nonword Reading									
SfV	.52	.62	10.71	.000*	.48	.59	6.64	.000*	4.66*
VOC	-.11	-.08	1.42	.154	-.11	-.08	.82	.378	
PA	.48	.36	5.76	.000*	.33	.34	3.73	.000*	4.63*
RAN	-.06	-.03	.96	.336	-.06	-.06	.95	.340	
ATTN	.83	.11	2.70	.007*	.83	.14	2.67	.008*	2.09
Latent Covariance									
WR ↔ NWR	12.38	.83	7.51	.000*	6.82	.36	2.68	.007*	5.23*
Error Covariance									
SWE ↔ PDE	10.84	.23	3.63	.000*	10.84	.41	4.30	.000*	1.67

Note. SfV=Set for Variability; VOC=Vocabulary; PA=Phonemic Awareness; RAN=Rapid Automatized Naming; ATTN=Attention; WR= Word Reading; NWR= Nonword Reading; SWE= Sight Word Reading Efficiency; PDE= Phonemic Decoding Efficiency; ΔX^2=Chi-square Change.

^{a}df=1; *p < .05.

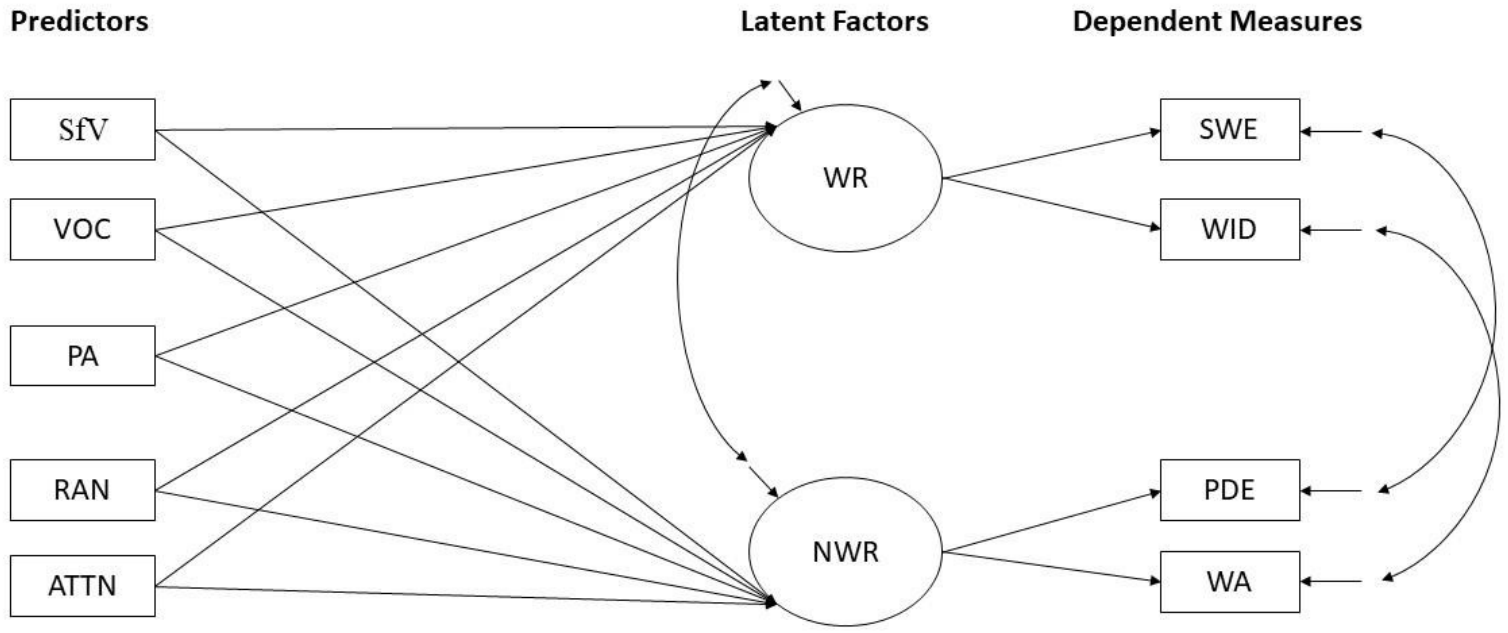

Figure 1. Main effects path analysis model showing pathways tested for significance during data analyses.