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Does Set for Variability Mediate the Influence of Vocabulary Knowledge on the Development of Word Recognition Skills?

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This study investigated the hypothesis that vocabulary influences word recognition skills indirectly through *set for variability*, the ability to determine the correct pronunciation of approximations to spoken English words. One hundred forty children participating in a 3-year longitudinal study were administered reading and reading-related measures at four time points. Hierarchical regression and path analyses indicated that vocabulary and phonemic awareness made independent contributions to variance in set for variability; that vocabulary directly influenced future reading comprehension and indirectly influenced future decoding and word recognition through set for variability; and that set for variability influenced future reading comprehension indirectly through both decoding and word recognition, controlling for autoregressive effects.

Research by Sénéchal, Ouellette, and Rodney (2006) suggests that early vocabulary knowledge has a direct predictive relation to future reading comprehension. To determine whether the relation of early vocabulary to future reading comprehension is direct or mediated through other variables, Sénéchal et al. reanalyzed data from two longitudinal studies of early literacy development. In support of a direct relation, they found that vocabulary in kindergarten accounted for unique variance in reading comprehension in Grades 3 and 4, even after controlling for the effects of other important reading-related variables, including phonological

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awareness in kindergarten, parent education and literacy, early literacy in kindergarten (alphabet knowledge, decoding, and invented spelling), reading in Grade 1, listening comprehension in kindergarten, and reading fluency at the end of Grade 4. Although text comprehension is a complex process that comprises several component processes (e.g., quickly and accurately locating individual words in lexical memory, determining the intended meaning of individual words, assigning appropriate syntactic structures to sentences, deriving meaning from individually structured sentences, and building meaningful discourse on the basis of sentential meaning; Lorch & van den Broek, 1997), vocabulary knowledge is a component of language that is essential for comprehending text. Children who do not understand, or only partially understand, the meanings of the words of text will be impaired in their ability to understand text.

More recently, researchers have begun to focus attention on the possible role of vocabulary knowledge in the development of word recognition skills (Bowey & Rutherford, 2007; Nation & Cocksey, 2009; Ouellette, 2006; Ricketts, Nation, & Bishop, 2007). The aim of the current study was to investigate three hypotheses regarding the role of vocabulary knowledge in the development of word recognition skills. First, in addition to having a direct predictive relation to future reading comprehension as reported by Sénéchal et al. (2006), vocabulary contributes to the development of both decoding and word recognition skills. Second, vocabulary contributes to the development of word recognition skills indirectly through a variable called *set for variability* (Venezky, 1999), the ability to determine the correct pronunciation of approximations to spoken English words. Third, three factors may influence the development of set for variability in beginning readers; vocabulary knowledge, phonemic awareness, and syntactic awareness.

Regarding the first hypothesis, much, if not most, of what children learning to read in English come to know about the orthography is acquired through implicit learning (Bryant, 2002; Gough, 1996; Gough & Hillinger, 1980; Snow & Juel, 2005; Tunmer & Nicholson, 2011; Venezky, 1999). As the reading attempts of beginning readers with phonemic awareness and a firm understanding of the alphabetic principle become more successful, the orthographic representations of more words become established in lexical memory from which additional spelling-sound relationships can be induced without explicit instruction. In contrast to letter-sound correspondences acquired by direct instruction, which are largely context free (i.e., involve one-to-one correspondences between single letters/digraphs and single phonemes), letter-sound correspondences acquired by implicit learning are mostly context sensitive (i.e., depend on position-specific constraints or the presence of "marker" letters). The acquisition of letter-sound patterns also draws upon morphophonemic rules that speakers of English know implicitly, such as that regular noun plural inflection is realized as /s/ when it follows a voiceless stop consonant, as in *cats*, and as /z/ when it follows a voiced

phoneme, as in *dogs*. From his research on the development of beginning readers' knowledge of morphological spelling rules, Bryant (2002) concluded that much of this knowledge is acquired through implicit learning, stating, "Learning to read and spell is certainly not a passive business where children are just learning what they are taught. On the contrary, they are actively puzzling things out for themselves" (p. 214).

As children continue to develop in reading, they will begin making greater independent use of letter-sound information to identify unfamiliar words in text (Share, 1995). Once this point is reached, the most effective way that children can achieve further progress in learning to read is through print exposure, as reading itself provides practice opportunities for building fluency and for facilitating implicit learning of additional letter-sound patterns, skills that foster further growth in reading by enabling children to cope with more difficult materials (Snow & Juel, 2005; Tunmer & Nicholson, 2011). However, children with poorly developed vocabulary knowledge will have trouble identifying and assigning appropriate meanings to unknown printed words (especially partially decoded words, irregularly spelled words, or words containing polyphonic or orthographically complex spelling patterns), if the corresponding spoken words are not in their listening vocabulary or are only weakly represented phonologically in their mental lexicon (Perfetti, 2007). This, in turn, will limit the development of their decoding skills, as additional spelling-sound relationships can be induced from the stored orthographic representations of words that have been correctly identified. Vocabulary knowledge should therefore contribute to the development of both decoding skills and real-word recognition.

Vocabulary, however, should exert a stronger influence on exception word reading than on regular and nonword reading. All unknown words that beginning readers encounter in print are functionally nonwords that they have no choice but to attempt to decode (Bowey & Rutherford, 2007). The decoding skills of beginning readers will enable them to identify many unknown words with regular spelling. They will even be able to "read" (i.e., correctly pronounce) many regularly spelled words that they do not know the meaning of, as well as pronounce orthographically regular nonwords that have no meaning. When beginning readers apply their developing knowledge of letter-sound relationships to unknown exception words, the resulting partial decoding will often be close enough to the correct phonological form that they will be able to arrive at a correct identification, but only if the word is in their listening vocabulary. Consistent with these claims, Nation and Snowling (1998) found that 9-year-old poor comprehenders were significantly less accurate at reading exception words than skilled comprehenders of the same age, despite the two groups being matched on nonword reading (see also Ricketts et al., 2007). They argued that the poor comprehenders' difficulty with reading exception words was a manifestation of their underlying vocabulary weakness.

Regarding the second hypothesis investigated in the current study, Venezky's (1999) comprehensive analysis of the structure of English orthography and discussion of the implications of his analysis for teaching children to read provided the basis for considering a possible mechanism by which vocabulary influences the development of word recognition skills. Venezky argued that, because of the nature of English orthography, one of the main functions of phonics instruction is to provide beginning readers with a process for generating approximate phonological representations of unknown words that gets them close enough to the correct phonological form that, with context, the correct identification can be made. Beginning readers should therefore be encouraged to become active problem solvers with regard to graphic information in text, adopting what Venezky called a "set for variability," an essential skill that he claimed children must acquire to learn to read in English. In acquiring this skill, children learn to use their developing knowledge of spelling-to-sound relationships to produce approximate phonological representations, or partial decodings, for unknown words, especially those containing irregular, polyphonic, or orthographically complex spelling patterns. The phonological representations then provide the basis for generating alternative pronunciations of target words until one is produced that matches a word in the child's lexical memory and makes sense in the context in which it appears. As Venezky put it, "If what is first produced does not sound like something already known from listening, a child has to change one or more of the sound associations (most probably a vowel) and try again" (p. 232).

In the current study, set for variability was operationalized as the ability to determine the correct pronunciation of mispronounced spoken English words derived from regularized pronunciations of irregularly spelled words (e.g., *stomach* pronounced as "stow-match"), the incorrect pronunciation of words containing polyphonic spelling patterns (e.g., *glove* pronounced like "clove"), and approximations to correct pronunciations based on the application of context-free spelling rules (e.g., *kind* pronounced like "pinned"). Regarding the latter, research indicates that beginning readers initially acquire relatively simple one-to-one letter-sound correspondences that are, for the most part, insensitive to position-specific constraints or the presence of other letters (e.g., Zinna, Liberman, & Shankweiler, 1986). This measure of set for variability is similar to measures of precision of phonological representations, such as those developed by Anthony et al. (2010). However, unlike measures of other oral language skills, all the stimulus items presented in our set for variability task are specifically linked to features of English orthography (viz., irregular spellings, polyphonic spelling patterns, context-sensitive letter-sound correspondences). Compared to the nonword reading task, which assesses beginning readers' knowledge of letter-sound patterns, the set for variability task is concerned with the next step in the process, namely, children's ability to go from partial decodings generated from emerging decoding skills to word identification.

According to the third hypothesis investigated in the current study, three factors may contribute to individual differences in set for variability among beginning readers. Vocabulary knowledge was included because children should have difficulty identifying approximations to spoken words if the target words are not in their listening vocabulary or if the phonological representations of the words are weakly established in lexical memory. Phonemic awareness was hypothesized to be required in performing the operation described by Venezky (1999) in which children vary one or more of the sounds in approximations to spoken words in an effort to find a match to a word in their listening vocabulary that is contextually appropriate. Torgesen, Al Otaiba, and Grek (2005, p. 129) made a very similar claim regarding the importance of phonemic awareness in generating alternative possibilities for partially decoded words in connected text. This claim draws attention to a third factor that may contribute to variance in set for variability. The ability to use sentence context to select the correct word among a set of candidate pronunciations generated from approximations to spoken words requires sensitivity to the semantic and syntactic constraints of sentence contexts, or syntactic awareness.

A measure of breadth of vocabulary knowledge was used in the current study because vocabulary breadth should be more strongly related to the development of word recognition skills than depth of vocabulary knowledge, where vocabulary breadth is the number of lexical (phonological) entries in the mental lexicon and vocabulary depth is the extent of semantic representation associated with lexical items (Ouellette, 2006). If beginning readers generate a partial decoding for an unknown printed word for which the corresponding spoken form is stored in lexical memory (the likelihood of which is greater if the number of lexical entries is high), and the partial decoding is a close enough approximation to the phonological form of the target word to allow identification, the result will be an accurate decoding of the word. The orthographic representation of the target word can then be stored in lexical memory, thus contributing to the database from which additional letter-sound patterns can be induced. This increase in implicit knowledge of English orthography in turn makes it possible for children to identify additional words in text from which more orthographically complex spelling patterns can be acquired through implicit learning. According to this view, then, it is breadth of vocabulary knowledge, the overall number of phonological representations stored in lexical memory, that is most important in facilitating implicit learning of letter-sound patterns and identifying unknown words in text, not depth of vocabulary knowledge. In support of this claim, Ouellette (2006) found that vocabulary breadth was more strongly associated with nonword and exception word reading than was vocabulary depth. Relatedly, Nation and Cocksey (2009) found that familiarity with the phonological form of the word (as measured by an auditory lexical decision task) made an independent contribution to exception word reading, whereas vocabulary depth (as measured by definition knowledge) did not.

One way in which the current study differed from other investigations of vocabulary and word recognition skills was in the age of the participants, who averaged 5 years 9 months at the beginning of the study (when vocabulary knowledge was assessed) and 7 years 6 months at the end. In most previous studies, the samples included children 7 years of age or older. If set for variability is an important mediating factor in the pattern of correlations between vocabulary and word recognition skills, it should begin exerting an influence on the development of word recognition skills as soon as children have acquired a sufficient level of letter-sound knowledge to produce partial decodings of words, which would most likely occur during the second half of their first year of formal reading instruction.

METHOD

Participants

The children who participated in this study were part of an original cohort of 152 new school entrants who took part in a 3-year longitudinal study in New Zealand of factors associated with beginning literacy achievement. The mean age of the original sample of children at school entry was 5 years 1 month (range = 4 years 11 months to 5 years 3 months). The children were enrolled in 16 urban schools located in a range of socioeconomic areas.

Several reading and reading-related measures were administered throughout the study, each at developmentally appropriate times. To test the hypotheses of the current study, data were analyzed from selected measures administered toward the end of Year 1 (when the mean age of the 140 remaining target children was 5 years 9 months), at the middle of Year 2 ($n = 134$, M age = 6 years 5 months), end of Year 2 ($n = 131$, M age = 6 years 10 months), and middle of Year 3 ($n = 122$, M age = 7 years 6 months). The end of Year 1 measures were phonemic awareness, syntactic awareness, vocabulary knowledge, set for variability, decoding skill, and context-free word recognition; the measure at the middle and end of Year 2 was exception word reading; and the middle of Year 3 measures were decoding skill, exception word reading, context-free word recognition, and reading comprehension.

Tests

Phonemic awareness. At the end of Year 1 children's ability to segment spoken words into phonemic elements was assessed using a modified version of a phoneme counting task developed by Tunmer, Herriman, and Nesdale (1988). Scoring was based on the number of items correctly segmented, giving a total possible score of 24. The internal reliability coefficient for this scale was .83.

Syntactic awareness. Children's sensitivity to the semantic and syntactic constraints of sentences was assessed at the end of Year 1 using an oral cloze task adapted from a task developed by Tunmer, Nesdale, and Wright (1987). Children were asked to supply the missing word in each of 25 orally presented sentences. The missing words included both content and function words and the location of the missing words varied across items. For many deleted words there were alternative words that could be supplied which would yield semantically and syntactically well-formed sentences. Children's responses were therefore scored as correct if the word they provided was acceptable in the sentence context. The internal reliability for this measure was .79.

Vocabulary knowledge. Breadth of receptive vocabulary knowledge was assessed at the end of Year 1 using raw scores from the Peabody Picture Vocabulary Test–Form M (Dunn & Dunn, 1981). For each item the children were presented with four pictures and asked to choose the picture that corresponded to a test word spoken aloud by the experimenter. Standardized scoring procedures were used. The internal reliability estimate for this scale was .81.

Set for variability. Children's ability to determine the correct pronunciation of mispronounced spoken words was assessed at the end of Year 1 using an adapted version of a task developed by Tunmer and Chapman (1998). The words were derived from regularized pronunciations of irregularly spelled words, the incorrect pronunciation of words containing polyphonic spelling patterns, and approximations to correct pronunciations based on the application of context-free spelling rules. The task comprised 40 mispronounced words that were first presented in isolation and then, on another occasion, in underdetermining sentence contexts. The 40 target words and associated sentence contexts are presented in Appendix A of Tunmer and Chapman (1998).

The task was presented in the form of a game involving a handheld puppet that said words the "wrong way." The child's task was to figure out what the puppet was trying to say. The children were administered the task in two sessions that were separated by 1 to 2 weeks. During the first session the mispronounced words were presented in isolation (e.g., *wasp* pronounced/wăsp/). During the second session the same mispronounced words were presented in underdetermining contexts (e.g., "He ran away from the/wăsp/"). Initial scoring was based on the number of words correctly identified under the second presentation condition. The internal reliability for set for variability (context) was .86.

Decoding skill. An adapted version of a nonword reading task developed by Richardson and DiBenedetto (1985) was used to measure knowledge of letter-sound patterns at the end of Year 1 and middle of Year 3. Thirty monosyllabic

TABLE 1
Intercorrelations, Means, and Standard Deviations for Measures Taken at the End of Year 1

Measures	*1*	*2*	*3*	*4*	*5*	*6*	*7*
1. Age (years)	–						
2. Phonemic awareness	.11	–					
3. Syntactic awareness	.14	.54	–				
4. Vocabulary knowledge	.07	.49	.61	–			
5. Set for variability (context)	.11	.65	.61	.62	–		
6. Decoding skill	.06	.77	.57	.51	.67	–	
7. Context-free word recognition	.03	.67	.55	.46	.64	.87	–
M	5.75	11.52	14.58	67.29	21.00	39.06	16.86
SD	.07	7.41	3.64	13.01	6.52	26.95	12.23
Maximum score	–	24	25	175	40	101	110

Note. $N = 140$. All intercorrelations except those with age are significant ($p < .001$).

nonwords from Section 3 of their Decoding Skills Test were presented in the form of a game in which the children were asked to try to read the "funny sounding names of children who live in faraway lands." The items were scored according to the total number of sounds pronounced correctly in each item, provided the sounds in the item were blended together into a single syllable. The total number of possible points was 101. Scoring was based on the number of sounds pronounced correctly rather than the number of items pronounced correctly to discriminate between children who had little or no knowledge of letter-sound patterns and those who had sufficient knowledge to produce partial decodings, a skill that was considered important in the context of the current study. In support of this decision, at the end of Year 1 the children tended to perform at floor levels when their scores were based on the total number of items pronounced correctly, averaging only 2.7 out of 30 (compared to an average of 39 points out of 101; see Table 1). The internal reliability estimate for this scale using the total points scoring procedure was .99.

Exception word reading. At the middle of Year 2 exception word reading was assessed for the first time in the study, and again at the end of Year 2 and middle of Year 3, using the first 40 words of a list of 50 irregularly spelled words developed by Adams and Huggins (1985), with one exception.[1] Scoring was based on the number of exception words read correctly. The internal reliability for this test was .97.

[1]Because New Zealand has converted to a metric system of measurement, the word *pint*, which may be unfamiliar to many New Zealand children, was replaced with *ache*, which appeared later in Adams and Huggins's (1985) list.

Context-free word recognition. The Burt Word Reading Test, New Zealand Revision (Gilmore, Croft, & Reid, 1981) was used to assess context-free word recognition at the end of Year 1 and middle of Year 3. The Burt is a standardized test in which children are presented with a list of 110 words of increasing difficulty and asked to look at each word carefully and read it aloud. Testing continued until 10 successive words were read incorrectly or not attempted. Scoring was based on the number of words read correctly. The Burt test has a reliability coefficient of .97.

Reading comprehension. The Comprehension Subtest (Form 1) of the Neale Analysis of Reading Ability, Revised (Neale, 1988) was used to assess reading comprehension ability at the middle of Year 3. The children were asked to read aloud a series of narrative and expository passages that were graded in difficulty. All passages were eight sentences in length with the exception of the Level 1 passage, which contained four sentences. The cumulative number of words ranged from 26 words for the Level 1 passage to 505 words for the Level 6 passage. After completing each passage the children were presented with a series of questions relating to the passage. Standardized scoring and procedures were used, and the reliability estimate was .89.

RESULTS

Intercorrelations (End of Year 1)

Displayed in Table 1 are the intercorrelations, means, and standard deviations for all tests administered to the children at the end of Year 1. As noted previously, Venezky (1999) conjectured that the ability to identify approximations to spoken words operates in conjunction with using contextual constraints. In the initial analyses carried out, set for variability was therefore based on the number of mispronounced words correctly identified during the second session of the set for variability task when the mispronounced words were presented in underdetermining sentence contexts.

With the exception of age, all measures were significantly intercorrelated ($p < .001$), and the magnitudes of the correlation coefficients ranged from moderate to high. In support of Venezky's (1999) claim regarding the importance of phonemic awareness in generating alternative possibilities for approximations to spoken words based on partial decodings is the relatively strong correlation between phonemic awareness and set for variability ($r = .65$).

As expected, the correlation between vocabulary and set for variability was moderately high ($r = .62$). Children will not be able to determine the correct pronunciation of mispronounced words if the target words are not in their listening

vocabulary or are only weakly represented in their mental lexicon. The correlations between vocabulary and decoding skill ($r = .51$) and between vocabulary and context-free word recognition ($r = .46$) were both moderate, and both correlations were significantly smaller ($p < .01$ for both comparisons) than the corresponding correlations between set for variability and decoding skill ($r = .67$) and between set for variability and context-free word recognition ($r = .64$). This pattern of results is consistent with the hypothesis that set for variability has a more direct influence on the development of word recognition skills than does vocabulary.

Preliminary Analysis of Set for Variability (Context)

Although set for variability (context) correlated strongly with word recognition skills at the end of Year 1, the question remains as to which of the two conceptually distinct components of the measure is primarily responsible for these relationships; the ability to identify mispronounced words presented in isolation or the ability to use sentence context to arrive at a correct identification of a mispronounced word. To address this question, two additional measures of set for variability were examined, one for each component. Set for variability (isolation; $M = 10.72$, $SD = 4.01$) was based on the number of mispronounced words correctly identified during the first session of the set for variability task when the words were presented in isolation. Set for variability (ratio; $M = 36.12$, $SD = 17.33$) assessed the ability to use context to identify mispronounced words that could not be identified in isolation and was based on the ratio of contextual gain (i.e., the number of mispronounced words identified in context minus the number of mispronounced words identified in isolation) to potential improvement (as indicated by the number of mispronounced words presented in isolation that were not correctly identified).

Presented in Table 2 are the results of a hierarchical regression analysis of the relation of set for variability (isolation), set for variability (ratio), and all other end of Year 1 measures to exception word reading ($M = 9.33$, $SD = 8.24$) at the middle of Year 2, the measure of word recognition skill to which vocabulary and set for variability were expected to be most strongly related. Because the children performed at floor levels on the exception word reading test at the end of Year 1, it was not possible to include end of Year 1 exception word reading in the regression model to control for autoregressive effects. However, the context-free word recognition test, which includes both regular and exception words, was given at the end of Year 1 and was therefore included in the regression model as a substitute for end of year 1 exception word reading. This decision seems justified because there was a strong predictive correlation between end of Year 1 word recognition and middle of Year 2 exception word reading ($r = .86$), and a strong concurrent correlation between the two measures at the middle of Year 3 ($r = .92$).

TABLE 2
Hierarchical Regression Analysis With Set for Variability (Isolation), Set for Variability (Ratio), and All Other End of Year 1 Measures Predicting Middle of Year 2 Exception Word Reading

Step	*Variable Added*	R^2	ΔR^2	β
1	Age	.000	.000	.003
2	Phonemic awareness	.305	.305***	−.125
3	Syntactic awareness	.347	.042**	−.022
4	Decoding skill	.579	.232***	.061
5	Context-free word recognition	.747	.168***	.793***
6	Vocabulary knowledge	.749	.002	−.002
7	Set for variability (ratio)	.752	.003	.069
8	Set for variability (isolation)	.762	.010*	.132*

Note. Standardized beta values correspond to the variable in the complete model after all other variables have been entered.
*$p < .05$. **$p < .01$. ***$p < .001$.

Two findings of interest emerged from the regression analysis. First, set for variability (isolation) made a unique contribution to variance in exception word reading (as indicated by the significant beta weight of .132), but set for variability (ratio) did not make a significant independent contribution. This finding suggests that the ability to identify mispronounced words is primarily responsible for the relation of set for variability to exception word reading, not the ability to use context to select the correct word among a set of candidate pronunciations.[2] Second, in support of the hypothesis that set for variability has a more direct influence on exception word reading than does vocabulary, set for variability (isolation) accounted for a small but significant amount of unique variance in exception word reading, whereas vocabulary did not. The only other variable to make a significant independent contribution to variance in exception word reading was word recognition. The much stronger influence exerted by word recognition compared with set for variability (as indicated by the larger beta value of .793) was anticipated, as current word recognition ability would be expected to be highly predictive of future growth in word recognition skill.

A very similar pattern of results was obtained from a separate regression analysis examining the relation of end of Year 1 measures to exception word reading at the end of Year 2, but not for a regression analysis in which exception word learning at the middle of Year 3 was the criterion variable (only Year 1 word recognition made a unique contribution). Although these regression models are

[2] As expected, set for variability (isolation) correlated strongly with set for variability (context; $r = .73$), and moderately with the other Year 1 measures; phonological awareness (.48), syntactic awareness (.45), vocabulary knowledge (.51), decoding skill (.53), and word recognition (.54).

very stringent, end of Year 1 set for variability (isolation) made a significant independent contribution to variance in exception word reading at the middle and end of Year 2 even after controlling for the powerful effects of word recognition at the end of Year 1. Set for variability (isolation) was therefore selected for use in the following analyses that tested the three key hypotheses of this study.

Relation of End of Year 1 Measures to Middle of Year 3 Reading Measures

Presented in Table 3 are the predictive correlations between End of Year 1 measures and Middle of Year 3 reading measures. Of particular interest was the finding that vocabulary correlated more strongly with exception word reading ($r = .48$) than with decoding skill ($r = .39$), a difference that was significant ($p < .05$). Although this difference in the magnitude of correlation coefficients was predicted, it was not as great as that reported by others (Ouellette, 2006; Ricketts et al., 2007), most likely because the children tested in the current study were younger. The influence of vocabulary on exception word reading is likely to be greater in the later school grades when children begin to confront more semantically complex materials.

Hierarchical regression and path analyses were carried out to examine more closely the structure of relationships between the Year 1 and Year 3 measures. A preliminary analysis of the distributional characteristics of all variables included in the regression models indicated that there were no outliers, floor or ceiling

TABLE 3
Predictive Correlations Between Year 1 Measures and Year 3 Reading Measures

	Reading Measures (Year 3)			
Predictor Variables (Year 1)	*Decoding Skill*	*Exception Word Reading*	*Context-free Word Recognition*	*Reading Comprehension*
Phonemic awareness	.71	.68	.68	.64
Syntactic awareness	.52	.57	.53	.62
Decoding skill	.76	.81	.81	.71
Context-free word recognition	.74	.86	.86	.70
Vocabulary knowledge	.39	.48	.43	.64
Set for variability (isolation)	.51	.54	.59	.57
M	74.86	13.07	38.79	11.07
SD	17.30	10.60	14.46	5.50
Maximum score	101	40	110	44

Note. $N = 122$. All predictive correlations are significant ($p < .001$).

TABLE 4
Hierarchical Regression Analyses Predicting Year 3 Reading Measures

Step	*Variable Added*	R^2	ΔR^2	β
Reading comprehension (Year 3)				
1	Age	.001	.001	.035
2	Phonemic awareness (Year 1)	.401	.400***	−.045
3	Syntactic awareness (Year 1)	.515	.114***	.102
4	Context-free word recognition (Year 3)	.704	.189***	.426***
5	Decoding skill (Year 3)	.716	.012*	.259**
6	Vocabulary knowledge (Year 1)	.774	.058***	.307***
7	Set for variability (Year 1)	.774	.000	.013
Decoding skill (Year 3)				
1	Age	.012	.012	−.056
2	Phonemic awareness (Year 1)	.507	.495***	.270**
3	Syntactic awareness (Year 1)	.536	.029**	.124
4	Decoding skill (Year 1)	.631	.095***	.465***
5	Vocabulary knowledge (Year 1)	.634	.003	−.110
6	Set for variability (Year 1)	.647	.013*	.143*
Context-free word recognition (Year 3)				
1	Age	.002	.002	−.001
2	Phonemic awareness (Year 1)	.461	.459***	.095
3	Syntactic awareness (Year 1)	.500	.039**	.058
4	Decoding skill (Year 1)	.672	.172***	.168
5	Context-free word recognition (Year 1)	.766	.094***	.559***
6	Vocabulary knowledge (Year 1)	.766	.000	−.077
7	Set for variability (Year 1)	.785	.019**	.178**

Note. Standardized beta values correspond to the variable in the complete model after all other variables have been entered.

*$p < .05$. **$p < .01$. ***$p < .001$.

effects, or major departures from normality. Presented in Table 4 are the results of regression analyses predicting Year 3 reading measures. To test the prediction that early vocabulary has a direct predictive relation to future reading comprehension, Year 3 reading comprehension was selected as the criterion variable in the first regression model in Table 4 with Year 3 measures of word recognition skills as predictors, along with reading-related measures taken in Year 1. Because the two Year 3 word recognition measures (context-free word recognition and exception word reading) were so highly correlated ($r = .92$), only one of the measures, context-free word recognition, was included in the regression model. An attempt was made to control for possible autoregressive effects resulting from Year 1 reading comprehension by using scores from the reading comprehension subtest of the Interactive Reading Assessment System developed by Calfee and Calfee (1981; see Tunmer et al., 1988, for a description of this

test). However, the children performed at floor levels on the test with over 80% of them failing to score above zero, even after time adjustments were made to the test.

The results of the first regression analysis presented in Table 4 indicate that three variables independently influenced reading comprehension. As expected, both context-free word recognition and decoding skill made significant independent contributions to variance in reading comprehension. Unless children can accurately recognize the words of text, and successfully decode the unfamiliar ones, they will be limited in their ability to comprehend text. The finding that Year 1 vocabulary exerted such a strong independent influence on Year 3 reading comprehension is consistent with research indicating that vocabulary is one of the best predictors of reading comprehension (Sénéchal et al., 2006).

Of greater interest are the regression analyses predicting Year 3 decoding skill and context-free word recognition, both of which include Year 1 controls for autoregressive effects. The regression model for word recognition also includes Year 1 decoding skill as an additional control variable, as it is well established that letter-sound knowledge plays an essential role in the development of word recognition skills (Ehri, 2005). The results of the second regression analysis show that, in addition to the expected contribution of Year 1 decoding skill to variance in Year 3 decoding skill, phonemic awareness and set for variability in Year 1 each independently influenced Year 3 decoding skill. Phonemic awareness enables children to discover mappings between phonemes and graphemes (Shankweiler & Fowler, 2004), and set for variability enables children to identify words based on partial decoding attempts from which additional letter-sound patterns can be induced.

Results of the third regression analysis presented in Table 4 show that set for variability made a significant independent contribution to the development of word recognition ability, even after controlling for the effects of Year 1 phonemic and syntactic awareness, vocabulary knowledge, decoding skill, and word recognition (the autoregressor). The findings presented in Table 4 are summarized in the path diagram displayed in Figure 1.[3] In support of the first and second hypotheses of the study, the diagram indicates that Year 1 vocabulary directly influenced Year

[3]Standard recursive procedures and theoretical considerations relating to longitudinal data were used in generating the path model. The first step in the analysis was to determine which variables in the data set made significant independent contributions to variance in Year 3 reading comprehension. Only three did: decoding skill and word recognition in Year 3 and vocabulary knowledge in Year 1. The next step was to determine which of the Year 1 variables made independent contributions to decoding skill and word recognition in Year 3, controlling for autoregressive effects. The final step was to determine which of the remaining Year 1 variables made independent contributions to decoding skill, set for variability, and word recognition in Year 1. We did not use structural equation modeling procedures to generate fit statistics for the resulting path model because of sample size and lack of multiple measures for any of the variables in the model.

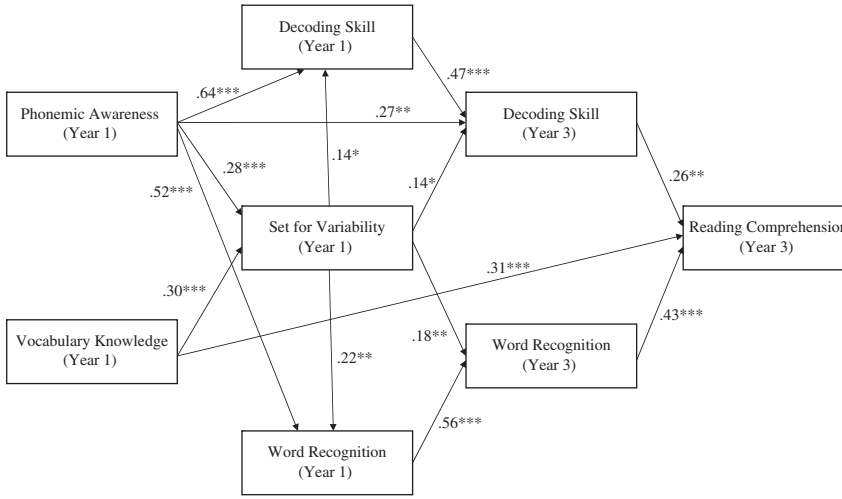

FIGURE 1 Path model displaying structure of relationships between Year 1 measures and Year 3 reading measures. (Standardized beta values are shown on each path. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.)

3 reading comprehension and indirectly influenced Year 3 decoding skill and word recognition through Year 1 set for variability, and that set for variability influenced reading comprehension indirectly through both decoding skill and word recognition, controlling for autoregressive effects. The diagram also shows the results of a regression analysis in which age, vocabulary, phonemic awareness, and syntactic awareness predicted set for variability. Vocabulary knowledge and phonemic awareness each made independent contributions to set for variability (as indicated by the significant beta weights of .30 and .28), which supports the hypotheses that children will not be able to identify approximations to spoken words if the target words are either not present or poorly represented in lexical memory and that phonemic awareness is required for children to be able to generate alternative possibilities for approximations to spoken words. Consistent with the predictive paths shown in Figure 1, separate regression analyses with age, vocabulary knowledge, phonemic awareness, and set for variability (concurrently) predicting Year 1 decoding skill in one model and Year 1 word recognition in the second model revealed that only phonemic awareness and set for variability made independent contributions to the criterion variables (for decoding skill, the standardized beta weights were .64, $p < .001$, and .14, $p < .05$, for phonemic awareness and set for variability, respectively; for word recognition, the beta weights were .52, $p < .001$, and .22, $p < .01$, respectively).

DISCUSSION

The aim of this study was to investigate the role of vocabulary knowledge in the development of word recognition skills, especially the possibility that the influence of vocabulary on the growth of word recognition skills is mediated by set for variability, the ability to determine the correct pronunciation of approximations to spoken English words. Venezky (1999) argued that because of the complex nature of English orthography, beginning readers need to become active problem solvers with regard to graphic information in text, adopting what he called a set for variability in which children learn to use decoding patterns to produce phonological representations that provide the basis for generating alternative pronunciations of target words until one is produced that matches a word in their listening memory and is contextually appropriate.

Three hypotheses were investigated in this study. First, in addition to making a strong independent contribution to future achievement in reading comprehension, vocabulary should also exert an influence on the development of both decoding skill and word recognition. Second, vocabulary should influence the development of decoding and word recognition indirectly through set for variability, controlling for autoregressive effects and metalinguistic abilities. Third, vocabulary and phonemic awareness should each capture unique variance in set for variability. Set for variability was hypothesized to contribute to the development of both decoding and word recognition skills by enabling children to identify unknown words based on partial decodings from which additional letter-sound patterns could be induced (through implicit learning) from the orthographic representations of the words stored in lexical memory.

Data from a 3-year longitudinal study of beginning reading development were analyzed to test these predictions. A preliminary analysis was carried out to determine which component of the original set for variability measure was most responsible for the strong correlations of the measure with decoding skill and word recognition, the ability to identify mispronounced words or the ability to use sentence context to select the correct word among a set of candidate pronunciations. The results of the analysis suggested that it was the ability to determine the correct pronunciation of approximations to spoken words that was primarily responsible for the strong relationships between the original set for variability measure and word recognition skills.

In the second set of analyses the structure of relationships between Year 1 and Year 3 measures was examined to test the three hypotheses of the study. In support of the hypotheses, the results of hierarchical regression and path analyses showed that Year 1 vocabulary directly influenced Year 3 reading comprehension and indirectly influenced Year 3 decoding skill and word recognition through

Year 1 set for variability and that set for variability influenced reading comprehension indirectly through both decoding skill and word recognition, controlling for autoregressive effects. The results also indicated that phonemic awareness and vocabulary knowledge each made independent contributions to variance in set for variability.

In summary, the theoretical arguments and evidence presented in this study suggest that set for variability may play an important role in the development of word recognition skills. However, this general conclusion should be regarded as preliminary for three reasons. First, given the correlational nature of our study, further research is required before any firm conclusions can be drawn regarding causality. Training studies are needed to determine whether exposing children to activities designed to promote the development of set for variability can produce a significant increase in this skill which in turn has a positive effect on word recognition skills.

Second, because the amount of additional variance accounted for by set for variability in the regression models was relatively small, there is the possibility that the results are spurious. However, in acknowledging this possibility, we note that all the regression models were very stringent. For example, Year 1 set for variability made a significant independent contribution to Year 3 word recognition even after controlling for the effects of Year 1 phonemic awareness, syntactic awareness, vocabulary knowledge, decoding skill, and word recognition (the autoregressor). In addition, the findings for set for variability were very consistent. Significant results were obtained at several time points, for three different measures of word recognition skills (exception word reading, nonword reading, and real word recognition), and over a period of almost two years with autoregressive effects controlled.

Third, recent research indicates that commonly used reading comprehension tests vary in the component skills (decoding vs. oral language comprehension) that they assess (Keenan, Betjemann, & Olson, 2008) and appear to make differential demands on two aspects of oral language comprehension: vocabulary knowledge and sentence-processing abilities (Cutting & Scarborough, 2006). Perhaps the test of reading comprehension used in this study influenced the results. However, available research suggests that the distortions that occur appear to be largely due to using reading comprehension tests that involve one- or two-sentence passages. In such cases the unique variance in reading comprehension attributable to oral language factors (including vocabulary knowledge) is greatly reduced relative to reading comprehension tests that use longer passages (Cutting & Scarborough, 2006; Keenan et al., 2008). Such distortions would have been less likely in our study, as we used the Neale reading comprehension test in which all passages are eight sentences in length with the exception of the lowest level passage (see Method section).

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