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What's Meaning Got to Do With It: The Role of Vocabulary in Word Reading and Reading Comprehension

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There is at present no clear consensus as to the nature of the relations between oral vocabulary and specific literacy skills. The present study distinguished between vocabulary breadth and depth of vocabulary knowledge to better explain the role of oral vocabulary in various reading skills. A sample of 60 typically developing Grade 4 students was assessed on measures of receptive and expressive vocabulary breadth, depth of vocabulary knowledge, decoding, visual word recognition, and reading comprehension. Concurrent analyses revealed that each distinct reading skill was related to the vocabulary measures in a unique manner. Receptive vocabulary breadth was the only oral vocabulary variable that predicted decoding performance after controlling for age and nonverbal intelligence. In contrast, expressive vocabulary breadth predicted visual word recognition, whereas depth of vocabulary knowledge predicted reading comprehension. The results are discussed in terms of interrelations between phonological and semantic factors in the acquisition of distinct reading skills.

Keywords: word recognition, reading comprehension, language, vocabulary, semantics

The links between oral and written language have been widely discussed in recent developmental literacy research. Despite repeated observations of complex interrelations between oral and written language variables (Berninger, Abbott, Thomson, & Raskind, 2001; Catts, Fey, Zhang, & Tomblin, 1999; Dickinson, McCabe, Anastasopoulos, Feinberg, & Poe, 2003; Lonigan, Burgess, & Anthony, 2000; NICHD Early Child Care Research Network, 2005; Roth, Speece, & Cooper, 2002; Sénéchal, Ouellette, & Rodney, 2006; Storch & Whitehurst, 2002; see also Scarborough, 2005), there remains no clear consensus concerning the nature of the relations between oral language and reading. Although some posit a direct role of oral language on reading skill acquisition (Dickinson et al., 2003; Scarborough, 2005), others have described the relation as being mediated by phonological processing (Whitehurst & Lonigan, 1998). The link between phonological processing and reading is typically evidenced in associations between phonological awareness and word decoding (Snowling, 2002). Reading, however, involves more than decoding reliant on mapping grapheme–phoneme correspondences: Skilled readers must also recognize words rapidly and accurately, and the end goal of reading is intact comprehension. Thus, in order to better understand the development of skilled reading and of the important associations between oral and written language, one must consider a full range of reading skills in conjunction with potentially important components of oral language. In this respect, the present study investigates the role of oral vocabulary in the distinct reading skills of decoding, visual word recognition, and reading comprehension.

There is a theoretical interest in the role of oral vocabulary in reading (Muter, Hulme, Snowling, & Stevenson, 2004): Where correlations are available in empirical studies, a moderate association has been observed between oral vocabulary and both decoding and reading comprehension (see Scarborough, 2001; Sénéchal et al., 2006, for reviews). Once more, however, the nature of these associations has not been fully explained, and thus the role of oral vocabulary in reading development is not well understood (Hagtvet, 2003). This is compounded by the fact that its influence is often removed from analyses of reading by controlling for vocabulary and verbal IQ, thus obscuring any independent contribution of this potentially important language area (Dickinson et al., 2003; Nation, 2005; Snowling, 2002). A better understanding of the relations between oral vocabulary and reading skills has direct relevance to theories of literacy acquisition as well as applied significance in explaining individual differences and in guiding instructional approaches to literacy teaching and stimulation. Thus, rather than controlling for vocabulary, the present study attempts to elucidate the role of this component of oral language by considering the theoretical distinction between oral vocabulary breadth and depth of vocabulary knowledge.

ORAL VOCABULARY: BREADTH VERSUS DEPTH

The distinction between oral vocabulary breadth and depth of vocabulary knowledge is derived from models of the mental lexicon. In accordance with Levelt, Roelofs, and Meyer (1999), vocabulary storage involves lexical representations of the stored phonology or sound patterns of words within the lexicon, along with semantic representations of word meaning. Defined as such, the lexicon is envisioned as an organized store of (phonological) word forms, distinct from—yet connected to—semantic representations or meaning (Coleman, 1998; Levelt et al., 1999). There is accordingly an important distinction to be made between the number of lexical (phonological) entries (i.e., vocabulary breadth)

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and the extent of semantic representation (i.e., depth of vocabulary knowledge). This theoretically grounded distinction, however, has not been incorporated in developmental literacy research.

Observations of early childhood language validate the distinction between vocabulary breadth and depth of vocabulary knowledge. Children may store a word form in their lexicon, contributing to their vocabulary breadth, without fully understanding that word's meaning (see Lahey, 1988). Over time, word meanings are refined, adding to the child's depth of vocabulary knowledge. Vocabulary growth thus encompasses adding and refining phonological representations to the lexicon as well as storing and elaborating the associated semantic knowledge. In observations of surface language, this distinction is parallel to that between how many words are known (i.e., vocabulary breadth) and how well the meanings are known (i.e., depth of vocabulary knowledge). Breadth and depth are thus described here as distinct facets of the construct of oral vocabulary. Recognizing this distinction in developmental literacy research can potentially lead to a better understanding of the role of oral vocabulary in reading skill acquisition and ultimately guide approaches to literacy teaching. Likewise, by delineating distinct reading skills, complex interrelations with oral vocabulary can be more fully evaluated.

VALIDITY OF DISCRETE READING SKILLS

Recently, Share and Leiken (2004) stressed that the multicomponential nature of reading must be acknowledged in assessment and research; these researchers argued that different reading tasks should not be seen as interchangeable measures of a single reading construct. In accordance with this view, it is argued here that in order to fully evaluate the role of vocabulary in reading acquisition, one must first define and assess psychologically valid reading skills.

Reading theory typically differentiates two broad component skills that constitute reading performance: word recognition and comprehension (Gough & Tumner, 1986; Kamhi & Catts, 1991; Stothard & Hulme, 1995). Although models differ according to which of these areas is emphasized, and in the independence of each component, they tend to concur in stressing the distinction between word reading and textual comprehension. For instance, recent structural equation modeling of literacy acquisition has suggested that word reading accuracy and comprehension are distinct skills that are influenced by different factors (Storch & Whitehurst, 2002; see also Oakhill, Cain, & Bryant, 2003). Word-level reading and comprehension are also dissociated in dyslexia and in children with specific difficulties with comprehension (Cain, Oakhill, & Bryant, 2000; Nation & Snowling, 1998). Likewise, in studying adults with a childhood diagnosis of dyslexia, Ransby and Swanson (2003) found reading comprehension differences between their participants and chronological-age-matched adults even when word recognition was partialed from the analysis. Thus, reading comprehension appears to involve processes beyond word recognition, and these processes are typically thought to be related to overall language comprehension (Gough & Tumner, 1986; Kamhi & Catts, 1991; Nation, 2005; Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001; Snowling, 2005).

Word recognition itself can be decomposed according to the various ways in which words can be read. Leading developmental theorists including Ehri (1997) and Share (1995), for instance, distinguished between serial decoding and retrieving words from memory. Treiman (1984) and Freebody and Byrne (1988) have presented subgroups of readers with significant gaps between their decoding (sounding out and blending) and visual word recognition (sight-word reading) skills, thus supporting distinct processes for these two types of word reading. The differentiation between decoding and visual word recognition is also reflected in dual-route models of skilled word reading that propose a sublexical route that involves a serial grapheme–phoneme conversion and a lexical route that recognizes words as wholes, possibly through parallel processing (Coltheart, 2005; Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001). Alternative computational models of word reading also allow for an explanation of word recognition through serial decoding and word-specific connections between orthography and phonology. The often-termed *triangle* models based on Seidenberg and McClelland's (1989) connectionist model of word reading, for instance, account for word reading through both phonological decoding and recognition of word-specific orthography.[1] Research with adult readers and neurologically impaired patients supports the validity of these distinct word recognition processes in adults (see Coltheart, 2005), and there is neuroanatomical evidence that different brain regions are activated for word and nonsense word reading (Joubert et al., 2004).

Reading theory and research highlight the multicomponential nature of reading, and hence a thorough assessment of reading ability should include consideration of decoding, visual word recognition, and reading comprehension. The present study thus assesses all of these identifiable reading skills.

CONNECTIONS BETWEEN ORAL VOCABULARY AND SPECIFIC READING SKILLS

With these constructs defined, associations between vocabulary and the distinct reading skills identified above can be considered. In doing so, parallels to models of word reading will be drawn where sensible, and the importance of considering both breadth and depth of vocabulary will be highlighted.

Decoding

Support for a role of vocabulary in decoding comes from developmental studies that repeatedly report moderate correlations between oral vocabulary and decoding performance (see Scarborough, 2001; Sénéchal et al., 2006). It has been proposed that the association between vocabulary and decoding is due to the role of vocabulary growth in the development of phoneme awareness (Goswami, 2001; Metsala, 1999; Walley, Metsala, & Garlock, 2003). According to this view, as more word forms are added to the lexicon, children must become more and more sensitive to sublexical detail, thus benefiting growth in phoneme awareness. This interpretation suggests that it is the number of words added to the lexicon that is the important factor: That is, breadth, not depth, is the facet of oral vocabulary that is associated with decoding.

[1] In fact, triangle models can also be described as dual-route models of word reading, as they themselves do allow for two routes to word recognition (Coltheart, 2005), although these pathways are not necessarily mutually exclusive.

With respect to computational models, it is of interest to note that although a dual-route model of word reading has no direct connections between vocabulary knowledge and the decoding route, the triangle model proposed by Seidenberg and colleagues does allow for an interaction between vocabulary knowledge and decoding by a top-down availability of semantics (Harm & Seidenberg, 1999, 2004). Within the framework of vocabulary presented here, semantics is seen as depth of vocabulary knowledge. Therefore, one may hypothesize that according to a triangle model of word reading, depth of vocabulary knowledge can be directly related to decoding proficiency.

There are thus two alternative explanations for the association between vocabulary and decoding: one that highlights vocabulary breadth and the other that includes depth of vocabulary knowledge. To date, no study has considered these facets of oral vocabulary separately so as to clarify the nature of the relation between vocabulary and decoding.

Visual Word Recognition

Visual word recognition can be assessed with irregular words. Because these words do not correspond to conventional phonics rules, they cannot be read through regularized serial decoding processes. It is interesting to note that developmental relations between oral vocabulary and visual word recognition have gone relatively unexplored, despite the importance of rapid word recognition in the acquisition of skilled reading (Ehri, 2005). Meanwhile, studies of reading performance for neurologically impaired adults have consistently demonstrated a direct relation between semantic knowledge and the ability to read specific irregular words (Funnell, 1996; Graham, Hodges, & Patterson, 1994; Patterson & Hodges, 1992). Accordingly, despite different specifications, virtually all models of skilled word reading propose that semantic information interacts with orthographic representation in visual word recognition (Coltheart, 2005; Harm & Seidenberg, 2004). Further, triangle models have been used to demonstrate an increased role of semantics in learning, with semantic information used in a top-down fashion to facilitate learning, especially for exception words (Plaut, McClelland, Seidenberg, & Patterson, 1996). Following these models, then, one would hypothesize depth of vocabulary knowledge to be pertinent to efficient visual word recognition.

Despite proposed connections between vocabulary knowledge and visual word recognition in models of skilled word reading, many developmental theories of sight-word acquisition focus on the role of phonology rather than semantics. In fact, the mechanisms behind both decoding and sight-word reading are thought by many to be phonologically based. In particular, Rack, Hulme, Snowling, and Wightman (1994) proposed a learning process whereby a direct link between sequences of letters and their pronunciations are stored in memory by an automatic mapping of sound–letter correspondences (for a particular word, not necessarily on the basis of phonics rule learning). Similarly, Share (1995), Ehri (1997, 2005), and Perfetti (1985) all described phonological-based storage strategies for representing words in memory in which children first learn to associate individual graphemes and phonemes, then larger chunks of letter–sound correspondence, and eventually complete orthographic representations with their respective phonology.

One investigation that did specifically examine vocabulary knowledge and visual word recognition within a sample of children was reported by Nation and Snowling (1998). These investigators identified a small sample ($N = 16$) of 8–9-year-old children with weak vocabulary skills (and identified as poor comprehenders for reading) and compared their reaction time and accuracy in reading irregular words with that for a chronologically aged control group that was also matched on decoding skill. The group of students with poor vocabulary skills was found to be slower and less accurate in reading aloud exception words. Noteworthy in this research, the vocabulary assessment undertaken went beyond typical measures of single-word recognition or labeling and included tasks specifically designed to tap underlying depth of vocabulary knowledge and organization: oral definitions including words with multiple meanings, comprehension of synonyms, figurative language, and semantic fluency tasks.

The results presented by Nation and Snowling (1998) suggest an association between depth of vocabulary knowledge, when assessed thoroughly, and visual word recognition in children with reading comprehension difficulty. Likewise, Vellutino, Scanlon, and Spearing (1995) suggested that children with semantic (vocabulary depth) weakness may experience difficulty in associating characters with verbal labels, a skill pertinent for visual word recognition. It is not certain, however, whether these findings generalize to typical development or are restricted to a disordered population. Nation and Snowling (2004) did evaluate typically developing 8-year-olds on a number of reading and vocabulary tasks and reported that expressive vocabulary and semantic skills (word associations, synonyms) each predicted a small yet significant amount of variance in word recognition when entered into separate regression models after controlling for age, nonverbal intelligence, and phonological skills. Unfortunately, these vocabulary-related measures were never subjected to a principal-components analysis to evaluate their underlying constructs nor were they ever entered into the same regression to allow for a consideration of their shared versus unique contributions to word reading. Once again, distinguishing between breadth and depth in vocabulary assessment can help clarify hypothesized contributions of oral vocabulary to visual word recognition, thus leading to important knowledge relevant to both theory and teaching practice.

Reading Comprehension

Reading does not only involve decoding and visual word recognition: The end goal is comprehension. The influence of oral vocabulary on reading comprehension has been repeatedly demonstrated within longitudinal studies. Muter et al. (2004) reported a moderate correlation between receptive vocabulary levels in kindergarten and reading comprehension 2 years later ($r = .52$). Snow, Tabors, Nicholson, and Kurland (1995) reported similar correlations between performance on vocabulary measures in kindergarten and a standardized reading assessment that included comprehension tests in Grade 1 ($r = .44$ and .53 for receptive vocabulary and oral definitions, respectively). Similar correlations between vocabulary measures in kindergarten and subsequent reading comprehension in Grade 1 ($r = .38$ and .53 for receptive vocabulary and oral definitions, respectively) and Grade 2 ($r = .41$ and .70 for receptive vocabulary and oral definitions, respectively) were also reported by Roth et al. (2002). Further, regression analyses for Grade 2 reading comprehension indicated that vocabulary knowledge measured in kindergarten was a more powerful predictor than phoneme awareness, although it should be noted that the final sample size of this longitudinal study was quite small ($N = 39$). Likewise, Share and Leiken (2004) reported a regression analysis in which a composite of receptive vocabulary and syntax measured in kindergarten accounted for 13.6% of the variance in reading comprehension measured in Grade 1, when entered into the model after age, gender, nonverbal IQ, and socioeconomic status level ($N = 454$). Even when phoneme segmentation was added to the control variables, the composite vocabulary and syntax score remained significant in accounting for 6.6% of variance.

These results suggest a longitudinal, predictive role of oral vocabulary for later emerging reading comprehension. Given that the vocabulary score was combined with syntax measures in the multiple regression analyses reported by Share and Leiken (2004), however, the specific role of vocabulary in this more stringent analysis cannot be ascertained. The specific association between oral vocabulary and reading comprehension was examined through stringent longitudinal regression analyses reported by Sénéchal et al. (2006). In these analyses, receptive vocabulary measured in kindergarten was found to predict 4% of unique variance in reading comprehension in Grade 3 after controlling for parent education and literacy level, child early literacy skills, and phonological awareness. Together with the correlational evidence of Roth et al. (2002), these analyses confirm an increased relevance of oral vocabulary through the early years of schooling (see also Sénéchal & LeFevre, 2002; Storch & Whitehurst, 2002; Whitehurst & Lonigan, 1998).

In considering the distinction between vocabulary breadth and depth, one should note that the studies that evaluate children's ability to orally define words, a more demanding semantic task that measures depth of vocabulary knowledge, report stronger associations with reading comprehension (e.g., Roth et al., 2002; Snow et al., 1995) than do studies that rely on measures of receptive vocabulary. Receptive vocabulary assessment typically involves single-word recognition to estimate the size of the lexicon, thus reflecting vocabulary breadth more so than depth of knowledge. These results, then, suggest an important role for depth of vocabulary knowledge beyond the influence of vocabulary size in Grades 1 and 2. That is, comprehending written text places more demands on vocabulary knowledge; thus, children who have more complete word knowledge should be at an advantage. In fact, Snow et al. (1995) suggested that the ability to provide oral definitions is the language (vocabulary) skill most associated with literacy acquisition.

The importance of depth of vocabulary knowledge to reading comprehension for older children was recently suggested by Nation and Snowling (2004). These investigators considered measures of vocabulary and performance on semantic tasks relative to reading comprehension in a sample of typical 8-year-olds and found each to predict substantial variance (25.2% and 15.1%, respectively) when entered into separate regression models following age, nonverbal intelligence, and phonological skills. The validity of their measures, however, was not evaluated, and performance on the vocabulary and semantic tasks were never considered together to distinguish between the role of vocabulary breadth and depth of vocabulary knowledge in reading comprehension. Thus, to date, the specific roles of vocabulary breadth and depth of vocabulary knowledge in reading comprehension in the middle elementary school years have yet to be directly evaluated.

THE PRESENT STUDY

It is argued here that the nature of the relations between vocabulary measures and reading skills can be better understood by considering the distinction between breadth and depth of knowledge within the oral vocabulary system, as reflected in performance on various oral-language tasks. In the present study, a sample of Grade 4 students was evaluated on measures of decoding, visual word recognition, and reading comprehension as well as for receptive and expressive single-word vocabulary to assess vocabulary breadth and semantic information to assess depth of vocabulary knowledge. In doing so, the present study is novel in its approach and can identify similarities and differences in the relations between vocabulary breadth and depth of vocabulary knowledge for each of the given reading skills, and thus it contributes to a better understanding of the underlying nature of any relations between these areas of oral and written language. This understanding in turn has direct relevance to theories of reading acquisition and approaches to literacy teaching.

Hypotheses

Although triangle computational models allow for an interaction of vocabulary knowledge and decoding, classic dual-route models do not, and developmental theory attributes decoding to phonological skills alone. In accordance with this focus on phonology, it is hypothesized that the association between oral vocabulary and decoding can be explained by the phonological encoding of items within the lexicon, thus establishing a relevance of vocabulary breadth to decoding. With respect to visual word recognition, computational models of word reading propose an active role for vocabulary knowledge, yet this seems at odds with developmental theories that connect sight-word acquisition to letter–sound correspondences and do not consider the importance of vocabulary knowledge (Ehri, 2005; Rack et al., 1994). In accordance with the suggestive results of Nation and Snowling (1998), Vellutino et al. (1995), and the research on adult populations reviewed earlier, it is hypothesized that depth of vocabulary knowledge is indeed relevant in visual word recognition. Finally, with respect to reading comprehension, it is hypothesized that vocabulary depth is critical, as the extent of an individual's word knowledge may facilitate or constrain efficient comprehension.

Method

Participants

Of the 85 Grade 4 students who participated in this project, 60 were included in the data analysis presented here. Children were excluded on the basis of a clinical diagnosis of attention-deficit disorder ($n = 2$), receiving English as a second language remedial services ($n = 3$), identifying no English spoken at home ($n = 6$), and having identified a language other than English as their dominant or preferred language ($n = 10$). Four children were also excluded, as their age was beyond that expected for this grade (i.e., greater than 10 years 5 months). The present study focused on Grade 4 students because the importance of vocabulary to reading may not be evident before efficient word recognition skills are acquired (Sénéchal et al., 2006), and the structural analyses of Storch and Whitehurst (2002) further highlighted the important role of both print and oral language at this stage of childhood development.

The final sample included 60 children between the ages of 9 years 5 months and 10 years 5 months (*M* = 9 years 10 months, *SD* = 3.53 months), 38 of whom were female. According to self-reports, all participants identified English as their preferred or dominant language, 49 came from homes in which English was the only language spoken, and 11 came from homes in which English and another language were spoken (of these children, 4 were exposed to Somali, 3 to Chinese, 2 to Arabic, 1 to Czechoslovakian, and 1 to Urdu). Children were recruited from six English schools in a Canadian urban center.

Tests and Measures

Nonverbal Intelligence

The complete Test of Nonverbal Intelligence—Third Edition was administered to all students (Brown, Sherbenou, & Johnsen, 1997). This test is administered without any verbal direction or input from the examiner. Students are presented with a series of patterns involving geometric shapes and are required to point to the shape that completes each pattern. In all, there are 45 items, with testing stopped following three consecutive errors.

Oral Vocabulary Measures

Four subtests of the Test of Word Knowledge (Wiig & Secord, 1992) were administered. This is a standardized test of vocabulary knowledge that is used in clinical language assessment and has very good reliability.

Receptive Vocabulary. In this subtest, students are shown four pictures and asked to point to the picture that matches a word spoken by the examiner. This procedure is the same as that for the more commonly used Peabody Picture Vocabulary Test (Dunn & Dunn, 1981) and correlates highly with performance on the Peabody Picture Vocabulary Test (Wiig & Secord, 1992). There are 42 items, with testing stopped following five consecutive errors.

Expressive Vocabulary. This subtest requires the student to verbally name pictured verbs and nouns, presented one at a time, using only single-word answers. There are 32 items, with testing stopped following five consecutive errors.

Word Definitions. In this subtest, a word is presented to the student in both written and spoken form, and the student is asked to provide a definition for the word. Feedback is given for practice trials only, and the student is encouraged to tell what the word means and to tell more about the word if his or her initial response is brief and/or vague. The first 16 (of 32) items of this subtest were administered to all participants to facilitate testing. Scoring was based on the number of important semantic features included, following guidelines outlined in the test manual, with 1 point given for each feature to a maximum score of 3 for each item. A complete definition must reference the appropriate semantic category and two or more unique features. Examples of scored responses are provided in the Appendix. The internal consistency reliability for this task was adequate (α = .75).

Synonyms. This subtest requires the student to select one of four words that is the synonym of a presented target word. All words are presented in written and spoken form. There are 42 items, with testing discontinued following five consecutive errors. Distractor items include antonyms, associated words, and members of the same semantic class.

Decoding

Decoding ability was assessed with the Word Attack subtest of the Woodcock Reading Mastery Tests—Revised (Woodcock, 1998). This subtest requires students to read pseudowords, which are scored according to regular phonics rules. There are 45 items, with testing halted following six consecutive failed items.

Visual Word Recognition

Participants were required to read aloud from an experimental word list adapted from Adams and Huggins (1985). The original list consisted of 50 items arranged in order of increasing difficulty. These words cannot be decoded by regular phonics rules and thus these orthographically complex words must be read by sight (Greenberg, Ehri, & Perin, 1997). Three words were removed from the original list because of a possible relation to French spelling rules, which children in this geographic area may be exposed to. The remaining 47 words were presented in a list format, and the student was requested to read each item aloud. Given the difficulty gradient of the list, testing was discontinued following seven consecutive errors. The list is presented in the Appendix. The internal consistency reliability for this task was excellent (α = .92).

Reading Comprehension

The Passage Comprehension subtest of the Woodcock Reading Mastery Tests—Revised (Woodcock, 1998) was administered. In this subtest, students are instructed to read a short passage silently, then to verbally provide an answer to a written sentence cloze that is based on the content of the passage. There are 68 items; a ceiling of four consecutive incorrect responses was implemented to facilitate testing. The internal consistency reliability for this task was very good (α = .85). According to the test's creators, when combined with word recognition subtests as a measure of total reading ability, performance correlates very well with similar composites from widely used assessment tools.

Procedure

Children were assessed individually in their schools. Each student was assessed in a single session of approximately 50–60 min total duration. Testing was conducted by one of five research assistants who were trained in the administration of all measures by both a registered speech language pathologist and a licensed elementary school teacher. Each testing session began with informal conversation to make the student feel at ease. Once the student was comfortable, the testing session began. All students received the same order of tasks: receptive vocabulary, expressive vocabulary, word definitions, synonyms, decoding, visual word recognition, reading comprehension, nonverbal intelligence.

Results

Following the theoretical distinction between vocabulary breadth and depth, two of the four oral vocabulary measures were interpreted to reflect vocabulary breadth as estimates of the number of stored vocabulary entries (Receptive Vocabulary, Expressive Vocabulary), whereas the other two tasks reflect depth of vocabulary knowledge (Word Definitions, Synonyms). This interpretation is based on the task demands of each subtest: The Receptive Vocabulary and Expressive Vocabulary subtests are single-word tests in which the participant must select from an array a picture that matches a single word spoken by the tester or label a picture, respectively. Performance on these tasks can be seen as estimates of the number of word forms stored in the lexicon (i.e., vocabulary breadth), although access to at least partial semantic knowledge is necessary to differentiate target words from the distractor pictures. The depth of knowledge for a particular word, however, is not necessarily assessed in such tasks. In contrast, identifying synonyms and providing definitions require elaborated

Table 1
Partial Correlations Among Variables (Controlling for Age)

Variable	1	2	3	4	5	6	7
1. Test of Nonverbal Intelligence	—						
2. Decoding	.369**	—					
3. Visual word recognition	.255*	.742***	—				
4. Reading comprehension	.324**	.606***	.597***	—			
5. Receptive vocabulary breadth	.164	.303**	.439***	.484***	—		
6. Expressive vocabulary breadth	.202	.114	.365**	.362**	.617***	—	
7. Depth of vocabulary knowledge (word definitions)	.230*	.166	.298*	.504***	.377**	.361**	—
M	100.62[a]	105.05[a]	27.63[b]	36.02[b]	11.22[c]	10.28[c]	35.63[b]
SD	15.63	10.47	8.48	5.11	2.46	2.43	4.90

[a] Standard score with $M = 100$ and $SD = 15$. [b] Raw score. [c] Standard score with $M = 10$ and $SD = 3$.
* $p < .05$. ** $p < .01$. *** $p < .001$.

word knowledge and thus are seen to reflect depth of vocabulary knowledge.

Given past suggestions that there may be a difference in the association between reading development and vocabulary breadth measured with receptive versus expressive tasks (Walley et al., 2003), performance on the receptive and expressive single-word vocabulary subtests were analyzed separately and interpreted as indicative of vocabulary breadth for perception and production, respectively. Although there may be debate whether these measures reflect a common lexicon or specialized lexicons for input–output, they were analyzed separately here on a purely exploratory rationale to evaluate past claims in the literature. As both measures are considered to reflect vocabulary breadth (see discussion of principal-components analysis below), analyzing performance on these tasks separately allows for a comparison of two commonly used single-word vocabulary tests. For vocabulary depth, it was intended to create a composite score combining word definitions and synonyms, which was based on the theoretical perspective of the present research and a task analysis of the assessment subtests. A principal-components analysis with varimax rotation was conducted with the four Test of Word Knowledge subtests to assess the validity of combining synonyms and definitions. Only one component was extracted using a default criteria of eigenvalues greater than 1.0 for the identification of components. This result was not serendipitous in that these measures all tap aspects of the construct of oral vocabulary. Examining the proportion of variance accounted for in this analysis revealed a plausible second component, however, accounting for a sizable 18.5% of the variance (eigenvalue = .75). When a second component was permitted to form, a clear separation of the Word Definitions subtest became apparent with a loading of .975 on this second component, whereas Receptive Vocabulary and Expressive Vocabulary loaded with simple structure on the first component (.849 and .844, respectively). The Synonyms task showed somewhat ambivalent loadings split between both components. Given the apparent ambiguous status of the Synonym subtest, it was dropped from further analyses to maintain the distinction between vocabulary breadth and depth of vocabulary knowledge, as supported by the principal-components analysis.[2]

The descriptive statistics and correlation coefficients among variables are reported in Table 1. Noteworthy from Table 1 are the moderate correlations among the vocabulary measures and the moderate to strong relations among the reading skills. In particular, decoding and visual word recognition were highly correlated ($r = .74$). Although the overall pattern of correlations suggests that the reading measures of decoding, visual word recognition, and reading comprehension are closely linked, these measures also appear to be distinct in that they show differential associations with the vocabulary measures. In particular, there appear to be greater associations between all vocabulary measures and visual word recognition than there are with decoding. These differences between the correlations of the vocabulary measures with visual word recognition and the same measures with decoding were statistically tested following the procedure recommended by Meng, Rosenthal, and Rubin (1992). The difference between correlation coefficients was significant ($p < .01$) for expressive vocabulary breadth and approached significance for receptive vocabulary breadth and depth of vocabulary knowledge ($p < .10$).

Separate fixed-order hierarchical regression analyses were conducted, with each reading measure serving as the response variable, to more fully evaluate the influence of vocabulary breadth and depth of vocabulary knowledge on each distinct reading skill. In each analysis, age and nonverbal intelligence were entered first into the equation. The vocabulary measures were first entered in this order: receptive vocabulary breadth, expressive vocabulary breadth, depth of vocabulary knowledge (word definitions). This was done to evaluate any role of expressive vocabulary breadth beyond that of receptive vocabulary and to evaluate the role of vocabulary knowledge depth beyond both measures of vocabulary breadth. The language variables were then entered into regression models in alternate order, so as to evaluate shared and unique variance contributions. Raw scores on all measures were converted into *z* scores before being entered into the regressions to standardize the variance of each measure. In addition, given the possible collinearity among variables, diagnostics were conducted for each set of regressions.

[2] Additional analyses revealed that performance on the Synonym subtest did not contribute unique variance to any reading measure when the other vocabulary measures were also considered.

Table 2
Hierarchical Regression Analyses for Decoding

Variable and order	R^2	ΔR^2	ΔF	β
Model 1				
1. Age	.044	.044	2.68	−.237
2. Nonverbal IQ	.174	.130	8.99**	.342
3. Receptive vocabulary breadth	.232	.058	4.23*	.344
4. Expressive vocabulary breadth	.250	.018	1.31	−.175
5. Depth of vocabulary knowledge	.250	.000	0.02	.020
Model 2				
3. Expressive vocabulary breadth	.176	.002	0.10	−.175
4. Receptive vocabulary breadth	.250	.074	5.45*	.344
5. Depth of vocabulary knowledge	.250	.000	0.02	.020
Model 3				
3. Depth of vocabulary knowledge	.181	.007	0.46	.020
4. Expressive vocabulary breadth	.181	.000	0.01	−.175
5. Receptive vocabulary breadth	.250	.069	4.99*	.344

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

Decoding

The first series of analyses tested the hypothesis that vocabulary breadth explains the association between oral vocabulary and decoding, and results are presented in Table 2. In Model 1, receptive vocabulary breadth explained 5.8% of statistically significant unique variance in decoding performance after controlling for age and nonverbal intelligence. Expressive vocabulary breadth and depth of vocabulary knowledge were not significant factors in the analysis when entered after receptive vocabulary breadth. This pattern of results is consistent with the hypothesis as well as past reports of a role of receptive vocabulary in decoding performance and extends previous research in demonstrating no further role of expressive vocabulary breadth or influence of the depth of vocabulary knowledge. The variance inflationary factor value for receptive vocabulary breadth when entered into the regression model was 1.03; this value increased to 1.47 when expressive vocabulary was added to the model. These values are well below levels indicative of serious collinearity (Neter, Kutner, Nachtsheim, & Wasserman, 1996).

A second regression was run, with decoding as the response variable, this time changing the order of receptive and expressive vocabulary breadth measures. This was done to evaluate whether the variance accounted for by receptive vocabulary breadth was shared with the expressive measure, and results are presented as Model 2 in Table 2. When entered after only age and nonverbal intelligence, expressive vocabulary breadth still did not account for significant variance in decoding, but the receptive measure explained 7.4% of statistically significant unique variance in decoding performance after controlling for age, nonverbal intelligence, and expressive vocabulary depth. It appears that the inclusion of a measure of expressive vocabulary breadth as a control variable actually serves to increase the influence of receptive vocabulary breadth. This observation, together with the negative Beta weight for expressive vocabulary and the nonsignificant correlation between decoding and expressive vocabulary breadth, suggests that this measure is acting as a suppressor variable (Pedhazur, 1997). Thus, the variance shared between receptive and expressive vocabulary breadth is not pertinent to decoding; rather, decoding is predicted by breadth of receptive vocabulary alone. Entering depth of vocabulary knowledge into the regression before the vocabulary breadth measures did not alter the pattern of results (see Model 3 in Table 2).

Visual Word Recognition

The next set of analyses tested the hypothesis that depth of vocabulary knowledge is pertinent in visual word recognition. In these regression models, decoding performance was added to the control variables to account for any potential role of decoding skill in visual word recognition. The inclusion of this additional control variable increases the stringency of the regressions, as now the test is only for the role of the vocabulary variables beyond their already demonstrated influence on decoding. The resulting models are presented in Table 3. Most striking within these analyses is the impressive variance in visual word recognition that is accounted for by decoding proficiency: Here the control variables account for 56.3% of the total variance. Still, receptive vocabulary breadth predicts an additional 5.0% of statistically significant unique variance in visual word recognition, and expressive vocabulary breadth accounts for 3.6% of the total variance, beyond that accounted for by the combination of the control variables and receptive vocabulary breadth (Model 1). These results demonstrate that although decoding and visual word recognition are closely linked, they appear to be distinct processes at this stage in devel-

Table 3
Hierarchical Regression Analyses for Visual Word Recognition

Variable and order	R^2	ΔR^2	ΔF	β
Model 1				
1. Age	.025	.025	1.48	.309
2. Nonverbal IQ	.088	.063	3.95*	−.088
3. Decoding	.563	.475	60.80***	.722
4. Receptive vocabulary breadth	.613	.050	7.08**	.058
5. Expressive vocabulary breadth	.649	.036	5.53*	.229
6. Depth of vocabulary knowledge	.655	.007	1.06	.094
Model 2				
4. Expressive vocabulary breadth	.645	.082	12.76***	.229
5. Receptive vocabulary breadth	.649	.004	0.54	.058
6. Depth of vocabulary knowledge	.655	.007	1.06	.094
Model 3				
4. Depth of vocabulary knowledge	.596	.033	4.49*	.094
5. Receptive vocabulary breadth	.625	.029	4.23*	.058
6. Expressive vocabulary breadth	.655	.030	4.68*	.229
Model 4				
3. Depth of vocabulary knowledge	.147	.059	3.87*	.094
4. Receptive vocabulary breadth	.210	.063	4.36*	.058
5. Expressive vocabulary breadth	.265	.055	4.03*	.229
6. Decoding	.655	.390	60.14***	.722

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

opment: Oral vocabulary appears to play a role beyond decoding, and most important, expressive vocabulary levels are relevant. Contrary to the present hypothesis, however, depth of vocabulary knowledge was again not a significant factor when entered last into the model. The variance inflationary factor values for receptive and expressive vocabulary breadth when both entered into the regression model were 1.71 and 1.68, respectively, once again well below levels indicative of serious collinearity.

The regression for visual word recognition was repeated but with the order of receptive and expressive vocabulary breadth measures reversed. This was done to evaluate shared and unique contributions of these variables, and results are presented as Model 2 in Table 3. In this model, expressive vocabulary breadth explains 8.2% of statistically significant unique variance in visual word recognition after controlling for age, nonverbal intelligence, and decoding. Receptive vocabulary breadth no longer accounts for unique variance when entered into the model after expressive vocabulary breadth. Thus, when entered first, expressive vocabulary breadth subsumes the contribution of receptive vocabulary.

A third regression was run, with visual word recognition as the response variable, and is presented as Model 3 in Table 3. Depth of vocabulary knowledge was entered into the model before the breadth measures in order to evaluate any shared contributions of vocabulary depth and breadth. It is interesting to note that depth of vocabulary knowledge predicted 3.3% of statistically significant unique variance in visual word recognition after controlling for age, nonverbal intelligence, and decoding. Expressive vocabulary breadth accounted for an additional 3.0% of the variance when entered last. Thus, the contribution of the expressive vocabulary breadth measure is now split between the measures of vocabulary depth and breadth. Consistent with the present hypothesis, then, visual word recognition does appear related to both vocabulary breadth and depth of vocabulary knowledge.

It should be noted that these regressions are stringent in that decoding skills are considered prior to the vocabulary measures. As such, these models may understate the full extent to which oral vocabulary predicts visual word recognition. A final regression model was thus evaluated, with the vocabulary measures entered before decoding performance. This final model (see Model 4 in Table 3) clearly shows that the unique variance attributed to all measures of vocabulary breadth and depth increases when decoding performance is removed as a control variable. All measures were significant and accounted for a combined 17.7% of the variance in visual word recognition.

Reading Comprehension

The final set of regression analyses tested the hypothesis that depth of vocabulary knowledge is important in explaining the relation between oral vocabulary and reading comprehension. For these analyses, both decoding and visual word recognition scores were first entered as control variables to isolate any influence of oral vocabulary above and beyond its already demonstrated role in word-reading proficiency. As presented in Table 4, the first model shows that the control variables accounted for 42.9% of the total variance, with receptive vocabulary breadth explaining an additional 6.1% of statistically significant unique variance in reading comprehension. The pattern of influence of expressive vocabulary breadth and depth of vocabulary knowledge, however, is markedly different from that observed in the previous regressions for decoding and visual word recognition. With reading comprehension as the response variable, expressive vocabulary breadth does not account for statistically significant unique variance, but depth of vocabulary knowledge does (an additional 8.0% of unique variance when entered last in the equation). Thus, consistent with the present hypothesis, depth of vocabulary knowledge plays a role in reading comprehension, beyond the association explained by conventional measures of vocabulary size or breadth. The variance inflationary factor values for the vocabulary variables were all below 2.0, whereas those for decoding and visual word recognition were higher at 2.61 and 2.48, respectively. These higher values reflect the correlation between decoding and word recognition yet are not so high as to jeopardize interpretation of regression values (Neter et al., 1996).

Table 4
Hierarchical Regression Analyses for Reading Comprehension

Variable and order	R^2	ΔR^2	ΔF	β
Model 1				
1. Age	.000	.000	0.01	.010
2. Nonverbal IQ	.105	.105	6.69*	.035
3. Decoding	.379	.274	24.74***	.428
4. Visual word recognition	.429	.050	4.80*	.094
5. Receptive vocabulary breadth	.491	.061	6.51*	.150
6. Expressive vocabulary breadth	.497	.006	0.68	.067
7. Depth of vocabulary knowledge	.577	.080	9.90**	.324
Model 2				
5. Expressive vocabulary breadth	.471	.042	4.24*	.067
6. Receptive vocabulary breadth	.497	.026	2.77	.150
7. Depth of vocabulary knowledge	.577	.080	9.90**	.324
Model 3				
5. Depth of vocabulary knowledge	.550	.121	14.53***	.324
6. Receptive vocabulary breadth	.575	.025	3.10	.150
7. Expressive vocabulary breadth	.577	.002	0.29	.067
Model 4				
3. Depth of vocabulary knowledge	.300	.195	15.58***	.324
4. Receptive vocabulary breadth	.390	.090	8.10**	.150
5. Expressive vocabulary breadth	.390	.000	0.00	.067
6. Decoding	.574	.184	22.99***	.428
7. Visual word recognition	.577	.003	0.38	.094

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

A second regression was run, with reading comprehension as the response variable, this time changing the order of receptive and expressive vocabulary breadth measures. This was done to evaluate whether the variance accounted for by receptive vocabulary breadth was shared by expressive vocabulary breadth, and results are presented as Model 2 in Table 4. When entered after the control variables, expressive vocabulary breadth accounted for 4.2% of the significant variance in reading comprehension, but the receptive measure did not predict any unique variance when entered next. For reading comprehension, then, the variance predicted by expressive and receptive measures of breadth is shared. Depth of vocabulary knowledge contributes to reading comprehension beyond these measures. When entered into the regression equation before the vocabulary breadth measures, depth of vocabulary knowledge subsumes the variance attributed to measures of breadth and predicts 12.1% of the significant variance in reading comprehension, leaving both receptive and expressive vocabulary breadth measures as nonsignificant factors (Model 3).

It should be noted again, however, that these models are stringent in that they include decoding and word recognition as control variables. The last model was recreated but with the vocabulary measures entered before decoding and visual word recognition to evaluate the full extent of the predictive role of oral vocabulary in reading comprehension. This last regression is presented as Model 4 in Table 4 and does in fact show an increased contribution of both vocabulary depth and breadth in predicting reading comprehension: Together, the vocabulary measures account for 28.5% of the variance in reading comprehension. Further, decoding skill accounts for additional unique variance beyond that predicted by the vocabulary measures.[3]

Discussion

The present study examined the nature of the relations among components of oral vocabulary, decoding, visual word recognition, and reading comprehension. Receptive vocabulary breadth alone predicted decoding performance, whereas expressive vocabulary breadth predicted visual word recognition, and depth of vocabulary knowledge contributed to visual word recognition through its association with expressive vocabulary and directly predicted reading comprehension beyond the measures of vocabulary breadth.

To better understand the shared and unique contributions of the different vocabulary measures, one must give consideration to the theoretical basis for these tasks. That is, as acknowledged earlier, single-word vocabulary tests reflect vocabulary breadth, yet some degree of semantic knowledge is also reflected. Likewise, performance on tasks of oral definitions is taken to reflect depth of knowledge yet, to some extent, may also reflect vocabulary breadth. An examination of the shared and unique contributions of these variables in predicting reading performance can thus delineate influences of vocabulary breadth and depth of vocabulary knowledge.

Regardless of what order the vocabulary variables were entered into the regressions for decoding, only receptive vocabulary breadth predicted significant variance. It thus appears that the relation between decoding and oral vocabulary is primarily a function of the size of the receptive lexicon, which is what is estimated in such receptive vocabulary tests. Given that representations within the lexicon are hypothesized to contain information regarding the word's phonology (Levelt et al., 1999), the ability to encode detailed phonological representations within the receptive lexicon may explain the association between oral vocabulary and reading that has been reported in the past (Dickinson et al., 2003; Scarborough, 2001; Sénéchal et al., 2006). That is, children encode phonological representations in the process of adding new items into the lexicon, and these differentiated representations may be implicated in successful word decoding. This interpretation both extends, and is in accordance with, theory that stresses the importance of phonological representations in decoding (Sénéchal, Ouellette, & Young, 2004; Swan & Goswami, 1997) and makes an explicit connection among vocabulary breadth, phonological representations, and decoding (Walley et al., 2003). As such, the present results do not support an interaction of vocabulary depth, or meaning, and phonology in decoding as possible in triangle models of word reading (Plaut et al., 1996).

A different pattern of shared and unique contributions of the vocabulary variables emerges from the analyses for visual word recognition. Here, receptive and expressive measures of vocabulary breadth shared variance that explained visual word recognition, and expressive vocabulary breadth predicted performance beyond the effect of receptive vocabulary breadth. The question that arises is why would an expressive measure be more sensitive to the role of vocabulary breadth in visual word recognition than a receptive one? One explanation lies in the underlying differences in the demands of these expressive and receptive vocabulary tasks. That is, single-word expressive vocabulary tasks require the participant to retrieve a specific lexical entry and activate its phonology. Although these search and retrieve processes present a greater memory demand than do processes of spoken word perception involved in receptive vocabulary measures, the memory component of the task is specific to the language system and subsumed under word retrieval processes. Efficiency in word retrieval may be related to the strength of underlying representations (Storkel & Morrisette, 2002), retrieval pathways, and/or organization of the lexicon (Newman & German, 2002). The storage and retrieval of printed word forms may well depend on similar factors. Thus, the association between vocabulary breadth and visual word recognition may be explained by the ability to encode, organize, and/or retrieve underlying (word-specific) phonological representations, factors that are more pertinent in expressive vocabulary tasks.

Word retrieval processes involved in picture naming may also be dependent on depth of vocabulary knowledge and organization within the semantic system (Nation, Marshall, & Snowling, 2001). The significance of vocabulary depth when entered into the regression model before measures of breadth suggests that both phonological and semantic factors may be involved in visual word recognition; a single-word expressive vocabulary measure may well reflect both phonological and semantic factors. This suggests that depth of vocabulary knowledge is important in visual word recognition and should be given more consideration in developmental theory. Although direct connections between orthographic representations or spelling and pronunciation have been proposed as the basis of sight-word reading (Compton, 2002), both phonological and semantic processes may be necessary in establishing (and retrieving) the original representations. Thus, the encoding of orthographic representations and associated phonology may be related to the ability to encode both phonemic and semantic information and to subsequently access and retrieve this information. This is in accordance with Laing and Hulme (1999), who demonstrated independent contributions of phonology and semantics in the early stages of sight-word acquisition in training young children to associate printed cues with spoken words as well as with past reports of concomitant difficulties in semantic processing and visual word recognition (Nation & Snowling, 1998; Vellutino

[3] Additional analyses combining decoding and visual word recognition into a composite of word reading yielded similar results to those reported for all regression models.

et al., 1995), models of skilled word recognition (Coltheart, 2005; Seidenberg & McClelland, 1989), and studies with adult neurogenic patients (Funnell, 1996; Graham et al., 1994; Patterson & Hodges, 1992).

Within the sample of typically developing Grade 4 students reported here, decoding and visual word recognition were closely associated with each other. Students who were strong decoders also tended to be proficient whole-word readers. This is in accordance with other recent studies (Aaron et al., 1999) and developmental theories that link decoding proficiency to sight-word acquisition (Ehri, 1997; Rack et al., 1994; Share, 1995). Yet, the present results clearly support the validity of these distinct reading skills, as each reading measure had a unique pattern of relations with the vocabulary components of oral language assessed here. There was also substantial unexplained variance remaining in visual word recognition after controlling for decoding skill, and a role of vocabulary in word recognition beyond its association with decoding. It should also be noted that both decoding and visual word recognition made independent contributions to reading comprehension. Separate constructs of decoding and visual word recognition are consistent with leading computational models of reading (Coltheart, 2005; Harm & Seidenberg, 2004).

In the present study, reading comprehension was related to both vocabulary breadth and depth of vocabulary knowledge, as reflected in the performance on the various vocabulary measures. Although both decoding and visual word recognition are related to reading comprehension in accordance with theory that links comprehension to word recognition proficiency (Perfetti, 1985; Shankweiler et al., 1999), there appears to be an important role of oral language beyond word recognition processes, as suggested by a simple view of reading (Gough & Tumner, 1986). The shared contributions among the vocabulary measures in predicting reading comprehension, together with the demonstrated role of vocabulary knowledge depth beyond the measures of vocabulary breadth, suggest that phonological factors are less relevant here than are semantic knowledge and organization. This, in turn, lends credence to the hypothesized connection between depth of vocabulary knowledge and reading comprehension and clarifies the nature of reported connections between vocabulary and reading comprehension (Muter et al., 2004; Nation & Snowling, 2004; Roth et al., 2002; Sénéchal et al., 2006; Share & Leiken, 2004; Snow et al., 1995). In accordance with this view, Nation and Snowling (1999) have suggested that comprehension may be linked to the speed or efficiency of semantic access; semantic access is dependent on the representations, organization, and connections within the semantic system. Likewise, models of reading comprehension often link textual comprehension to an individual's knowledge and ability to establish semantic representation (e.g., Kintsch, 1998).

The present results are consistent with both a comprehensive language approach that highlights ongoing connections between oral and written language development (Dickinson et al., 2003) and a phonological processing perspective of reading development (Wagner & Torgesen, 1987; Whitehurst & Lonigan, 1998). By evaluating distinct reading skills and examining vocabulary breadth and depth of vocabulary knowledge, the present study suggests oral vocabulary is related to word recognition through phonology and semantic representation and is further related to reading comprehension through depth of semantic knowledge. As children progress through the first few years of schooling, more demands are placed on rapid word recognition and reading comprehension processes, and thus it reasons that the relations between oral vocabulary and reading become more evident as children progress through the elementary school years (Sénéchal et al., 2006; Storch & Whitehurst, 2002).

Limitations and Directions for Future Research

The present study is novel in its approach in distinguishing between vocabulary breadth and depth of vocabulary knowledge. In doing so, important explanations of the relation between facets of vocabulary and distinct reading skills have been offered. It should be noted, however, that the present sample size may be considered small relative to the number of variables included in the regression analyses. In addition, phonological skills beyond pseudoword decoding were not evaluated in the present study. Given relations in development between vocabulary breadth and phonological processing (Walley et al., 2003), it may be questioned whether the variance in the different aspects of reading attributed to vocabulary breadth would be as substantial as that reported here if further phonological processing skills were controlled for. Conversely, it may be queried whether a more difficult reading comprehension task (than the cloze procedure used here) would show even greater reliance on depth of vocabulary knowledge. Nonetheless, the present study demonstrates an important role of vocabulary breadth and depth in various reading skills.

In the present study, depth of vocabulary knowledge was assessed with clinically used tasks involving definitions and synonyms. These are clearly offline tasks insofar as they require reflection and metalinguistic processes. For future study, it would be of interest to evaluate whether a similar pattern of results would be obtained using measures of online semantic processing that could be obtained through priming paradigms. Nation and Snowling (1999) reported subtle differences in semantic priming effects for a small group of children classified as poor comprehenders. An evaluation of semantic priming within a larger sample of typically developing readers would further clarify the nature of the association between depth of vocabulary knowledge and distinct reading skill acquisition. It is also of interest to evaluate the relations between vocabulary measures and reading skills at different ages to more fully understand the developmental trajectory of the complex relations between oral and written language components. For instance, it is of interest to evaluate whether depth of vocabulary knowledge plays as significant a role in reading comprehension as reported here, for younger children with less established decoding and word recognition skills.

It should also be noted that available estimates of vocabulary grade levels place many of the irregular words used in the present study beyond a Grade 4 level (Dale & O'Rouke, 1981), yet the students here did very well with reading these words. This performance may be attributed to the overall strengths of the sample on measures of language and reading, the potentially outdated estimates of grade level available, and/or the fact that the students were assessed near the end of Grade 4 and thus may have been closer to Grade 5 norms. It would be worthwhile for future research to consider the depth of knowledge for the words used on the reading measures, thus examining word-specific relations between word knowledge and visual word recognition. Finally, the suppressive effect of expressive vocabulary in decoding performance reported here and the ambivalent loading of the synonyms task between measures of vocabulary breadth and depth in a principal-components analysis are worthy of further study, especially considering that synonym tasks are used in both educational and research assessment (e.g., Nation & Snowling, 2004).

Implications

The present results have important implications for literacy teaching. In particular, the present study makes two important points that must be considered in teaching: Reading involves decoding, visual word recognition, and comprehension, and oral vocabulary includes breadth and depth of knowledge. Reading instruction must therefore consider the acquisition of these distinct reading skills and the importance of increasing both the number of words in a student's vocabulary and the extent of word knowledge for these words. Accordingly, a teaching emphasis on phoneme awareness and phonics should not be at the expense of vocabulary enrichment. The present results suggest that a combination of vocabulary enrichment and phoneme awareness should be considered along with the teaching of word recognition skills; developmental theory suggests that initial attention be directed toward decoding, with attention shifted to efficient sight-word reading as reading demands increase and decoding proficiency is established.

Vocabulary development involves phonological and semantic growth, both of which are reported here as relevant to word reading and comprehension processes. The presently reported role of vocabulary depth in reading comprehension suggests that comprehension may benefit from teaching focused on depth of word knowledge and semantic organization: teaching of word definitions (and ensuring complete definitions are learned), words with multiple meanings, varied contextual use of vocabulary items, and word relations to expand and organize the semantic system. There are also important implications for at-risk populations. For instance, it has been reported that low-income students show a gap between decoding and comprehension that is especially prevalent by Grade 4 (Chall, Jacobs, & Baldwin, 1990). Considering that low-income children are at a disadvantage for vocabulary (Dickinson et al., 2003), the present results suggest that a lack of depth in vocabulary knowledge may explain the dissociation between decoding and comprehension. This is especially relevant given that early gaps in vocabulary persist throughout the elementary school years (Biemiller, 2005). Although past intervention studies designed to teach vocabulary words to improve reading comprehension have reported inconsistent outcomes (Eldredge, Quinn, & Butterfield, 1990), the present results suggest that depth of vocabulary knowledge may be an important missing component in previous training studies. Intervention studies incorporating exercises to increase vocabulary size as well as depth of semantic knowledge would thus prove informative.

In summary, the present discussion has argued in favor of thorough language assessment to differentiate between vocabulary breadth and depth of vocabulary knowledge. In this respect, there is a scarcity of developmental research that specifically examines semantic skills beyond vocabulary size and their role in typically developing reading skills. The present study provides initial evidence of the role of vocabulary breadth or phonologically encoded lexical representations in word reading and comprehension along with an additional influence of semantic knowledge in visual word recognition and comprehension processes.

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Appendix

Word Definitions Sample Scoring

Scoring guidelines and samples for word definitions task. Scoring rules and definition components are offered for each test item in the Test of Word Knowledge examiner's manual. Examples are provided here for clarity.

Magician. Definition components: person, performs/does, magic/tricks

0 = no required elements: "I don't know"; "music"

1 = 1 component: "a guy"; "magic"

2 = 2 components: "does tricks"; "magic guy"

3 = 3 components: "a guy who performs magic"; "a person who does tricks"

Irregular Word Reading List (in order of presentation)

iron	prove	guitar	pint	ukelele
island	rhythm	veins	deny	suede
break	truth	chorus	vague	
busy	stomach	scent	tomb	
sugar	blind	deaf	drought	
touch	wounded	mechanic	trough	
none	calf	dough	depot	
heights	sweat	rely	bough	
whom	sword	ninth	aisle	
tongue	anchor	react	ache	
lose	echo	recipe	yacht	

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