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The Role of Vocabulary in the Context of the Simple View of Reading

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The simple view of reading posits that reading comprehension can be decomposed into a print-specific component (concerning decoding and sight word reading) and a language comprehension component (concerning verbal and metalinguistic skills not related to print). One might properly consider lexical skills, indexed by vocabulary measures, part of the language component; however, vocabulary measures end up taking up substantial amounts of print-dependent reading comprehension variance, presumably because of the interrelations among semantic, orthographic, and phonological specification of lexical entries. In the present study we examined the role of vocabulary in the prediction of reading comprehension by testing alternative formulations within the context of the simple view. We used cross-sectional and (1-year) longitudinal data from 436 children in Grades 3–6 attending regular classrooms. We quantified the proportion of variance accounting for reading comprehension that could be attributed to vocabulary measures. We then tested a latent variable model positing a

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mediating position for vocabulary against a model with lexically based covariation among the simple view components. We discuss the results in an attempt to bring together the simple view with the lexical quality hypothesis for reading comprehension.

Vocabulary has been linked to the ability to understand written text since the early stages of reading comprehension research. Evidence that vocabulary instruction may directly improve text comprehension ability led to an enhanced role of vocabulary in curriculum development (Beck, Perfetti, & McKeown, 1982; Kameenui, Carmine, & Freschi, 1982; McKeown, Beck, Omanson, & Perfetti, 1983). Eventually, vocabulary was recognized as one of the essential components for developing reading comprehension in a report of the National Reading Panel (National Institute of Child Health and Human Development, 2000). The benefits of an extensive oral language vocabulary may extend far beyond reading comprehension and academic success (Beck & McKeown, 1991; Biemiller, 1999) onto vocational achievement and socioeconomic attainment (Hart & Risley, 1995; Snow, Burns, & Griffin, 1998).

The precise nature of the relation between vocabulary and comprehension remains unclear. In the present study, we examine individual differences in vocabulary measures and reading comprehension in the context of a prominent theoretical approach to the development of reading skill. We analyze concurrent and longitudinal data from elementary school children in an attempt to determine the relative contribution of vocabulary skills along with other print-related and non-print-related skills typically considered to account for reading comprehension.

VOCABULARY AND READING COMPREHENSION

Many researchers have recently attempted to explore potential causal relations between vocabulary and the development of reading comprehension. Vocabulary has been treated as a longitudinal predictor of reading comprehension (Muter, Hulme, Snowling, & Stevenson, 2004; National Institute of Child Health and Human Development Early Child Care Research Network, 2005; Ouellette & Beers, 2010; Sénéchal, Ouellette, & Rodney, 2006; Storch & Whitehurst, 2002; Verhoeven & van Leeuwe, 2008) or as a covariate in multivariate analyses and structural equation models (Braze, Tabor, Shankweiler, & Mencl, 2007; Goff, Pratt, & Ong, 2005; Protopapas, Sideridis, Mouzaki, & Simos, 2007; Tannenbaum, Torgesen, & Wagner, 2006; Wise, Sevcik, Morris, Lovett, & Wolf, 2007; Yovanoff, Duesbery, Alonzo, & Tindal, 2005). These studies have confirmed that vocabulary benefits both early decoding and mature reading.

The importance of vocabulary knowledge for reading comprehension achievement, especially in older children, is supported by many studies. Recently, Ouellette and Beers (2010) described the increasing role of oral vocabulary in the prediction of reading comprehension achievement in Grade 6, contrasted with a diminishing role of decoding skills. In an earlier study with Grade 4 students, Ouellette (2006) reported that measures of the breadth and depth of word knowledge together accounted for 28.5% of reading comprehension variance. In particular, vocabulary *depth* predicted comprehension outcomes beyond measures of vocabulary breadth and printed word recognition. In contrast, Tannenbaum et al. (2006) found that vocabulary *breadth* was more strongly related to reading comprehension. However, vocabulary breadth and depth were highly interrelated, and more than half of the comprehension variance explained by vocabulary measures was common between the two.

Muter et al. (2004) assessed the relative importance of language skills (such as vocabulary and morphosyntactic knowledge) as longitudinal predictors of word reading and reading comprehension in the first 2 years of school. By applying structural equation modeling on measures taken at three time points, they found that reading comprehension in Grade 2 was related to earlier language skills more than it was related to printed word recognition. A more recent longitudinal study, on a very large sample of Dutch children ($N = 2{,}143$) assessed six times throughout elementary school, showed that, as word identification ability naturally progressed, reading comprehension gradually relied more on vocabulary and listening comprehension (Verhoeven & van Leeuwe, 2008). The importance of vocabulary in predicting reading comprehension across grades is also supported by data from two independent school samples reported by Yovanoff et al. (2005).

Therefore, studies have consistently found a large and increasing proportion of reading comprehension variance attributed to vocabulary measures. Longitudinal studies are consistent with a causal relation.

Conceptually speaking, vocabulary skills may *directly* impact on reading comprehension through at least three hypothetical mechanisms. First, word knowledge may simply provide the means to comprehend the written material (*instrumentalist* hypothesis; Anderson & Freebody, 1981; Stahl & Fairbanks, 2006). Second, vocabulary measures may index a more basic, general language ability (*general aptitude* hypothesis). Third, scores on vocabulary measures reflect general, conceptual knowledge that is represented by words and enables text understanding (*general knowledge* hypothesis). However, vocabulary knowledge may impact on reading comprehension both directly, as implied previously, or indirectly, by supporting word recognition ability. This is discussed in more detail below.

THE CONTRIBUTION OF VOCABULARY TO WORD READING SKILLS

The majority of studies addressing this issue have considered vocabulary in relation to other language-related skills, such as phonological awareness. For instance, Storch and Whitehurst (2002) found a strong effect of vocabulary on code-related skills (phonological awareness, letter and sound identification, and reading) that nevertheless diminished from preschool to Grade 4. An indirect effect of preschool vocabulary on word recognition in Grade 1, through phonological processing ability, was also implied in a large-scale study of 1,137 children enrolled in the National Institute of Child Health and Human Development Study of Early Child Care and Youth Development (National Institute of Child Health and Human Development Early Child Care Research Network, 2005). Furthermore, direct significant paths between vocabulary and phonological processing skills were noted by Wise et al. (2007) among students with reading disabilities in Grades 2 and 3 (see also Sénéchal et al., 2006).

These findings do not necessarily indicate a direct facilitating effect of vocabulary on word identification skills during the early stages of reading acquisition. However, the relation between vocabulary and phonemic sensitivity in early years seems well established (Lonigan, 2007). This might signify an indirect pathway between vocabulary and word decoding ability through more efficient phonemic processing (Dickinson, McCabe, Anastopoulos, Peisner-Feinberg, & Poe, 2003; Lonigan, Burgess, & Anthony, 2000; Wagner et al., 1997). In contrast, for Grade 4 students, vocabulary directly predicts both decoding and word recognition (Ouellette, 2006).

Other studies have attempted to account for the impact of vocabulary on word recognition by considering vocabulary measures as a proxy for word-related semantic knowledge (Adams, 1990). According to Nation (2008), four different lines of evidence support this view: First, studies of reading inconsistent or exception words indicate a direct relation between word familiarity and lexical decision speed (Ferraro & Sturgill, 1998). Second, semantic properties of words such as imageability and ambiguity affect word recognition, suggesting semantic involvement in lexical processing (Balota, Cortese, Sergent-Marshall, Spieler, & Yap, 2004). Third, neural correlates of semantic access during word reading appear as early as 250–300 ms after stimulus onset, which is sufficiently early to impact on printed word recognition (e.g., Sereno & Rayner, 2003). Finally, acquired deficits in word recognition are observed in patients with predominant semantic impairments in oral language (Lambon Ralph & Patterson, 2005).

To conclude, there is ample evidence for an indirect role of vocabulary in supporting the development of reading comprehension by impacting print-related component skills (word recognition) and reading prerequisites (such as phonological processing). This role complements direct effects of vocabulary on comprehension and makes it difficult to disentangle distinct causal routes. To approach this problem, we consider the interrelations among the relevant variables in the context of a prominent and highly productive theoretical framework for reading comprehension.

VOCABULARY AND THE SIMPLE VIEW

The Simple View of Reading (henceforth, "the simple view") attributes reading comprehension outcomes to two partially independent sets of skills: print-dependent skills (word decoding and recognition) and print-independent oral language comprehension (Gough & Tunmer, 1986). Both factors have long been associated with reading comprehension outcomes. However, their relative weight may shift during the course of development, with general language skills becoming more crucial at higher grades, after word-level decoding skills have been established (Hoover & Gough, 1990; Vellutino, Scanlon, Small, & Tanzman, 1991; Yovanoff et al., 2005). A wealth of findings in several languages are broadly consistent with the simple view (de Jong & van der Leij, 2002; Hagtvet, 2003; Hoover & Gough, 1990), although a number of specific issues remain debated, such as the multiplicative or additive contribution of the two factors (Chen & Vellutino, 1997; Joshi & Aaron, 2000; Savage, 2006), the role of fluency or accuracy measures (Adlof, Catts, & Little, 2006; Johnston & Kirby, 2006; Joshi & Aaron, 2000), and the use of words or nonwords to assess the print-dependent component (Chen & Vellutino, 1997; Goff et al., 2005; Savage, 2006; Shankweiler et al., 1999).

In the context of the simple view, vocabulary knowledge may be viewed as part of the oral language (print-independent) factor, as it entails access to word meanings through spoken words. There is some support for this contention from a confirmatory factor analysis (Protopapas, Simos, Sideridis, & Mouzaki, 2012). Alternatively, vocabulary might constitute an external factor that interacts with the two components of comprehension without affecting the main causal structure for comprehension. This option is supported by findings reviewed in the previous section on the relation between vocabulary and word reading. However, there is evidence to suggest that vocabulary may constitute a component affecting reading comprehension directly and independently from both print-dependent (word recognition) and print-independent (aural language comprehension) measures, which seems difficult to reconcile with the simple view. In this context, vocabulary has been repeatedly found to account for unique reading comprehension variance after listening comprehension is statistically controlled (Braze et al., 2007; Goff et al., 2005; Ouellette & Beers, 2010; Seigneuric & Ehrlich, 2005). Therefore, unless there is a measurement issue that causes the oral language factor of the simple view to be poorly defined by the typical listening comprehension tests, these findings indicate that there is more to vocabulary than oral language, and therefore vocabulary can be viewed neither as a mere part of the print-independent component nor as an external variable having only indirect effects on reading comprehension.

Vocabulary was found to take up much or most of the reading comprehension variance associated with print-dependent measures, such as word accuracy and fluency, in a study of Grade 2–4 Greek children (Protopapas et al., 2007). This finding poses a substantial challenge to the simple view, because print-related variance going into reading comprehension was accounted for by a strictly oral measure, breaking down the all-important distinction among the two components in terms of oral language versus print. Protopapas et al. (2007) interpreted their finding as supporting a mediating role for vocabulary. Vocabulary was seen as indexing general lexical skills, developing interactively with both print-dependent orthographic representations and print-independent phonological and semantic representations of words. In this view, vocabulary measures do not assess simply the number of known words (breadth), or their explicit and specific knowledge (depth), but also more general aspects of lexical skill, including interconnectivity among orthographic, phonological, and semantic aspects of words, in line with the lexical quality hypothesis (Perfetti, 2007; Perfetti & Hart, 2001, 2002).

THE PRESENT STUDY

In sum, the role of vocabulary in the context of the simple view remains in question. Its importance in the prediction of reading comprehension is indisputable. However, it remains unclear whether vocabulary can (or should) be incorporated within the simple view as an additional factor distinct from both decoding and oral language. This question has great theoretical importance and carries significant implications for the simple view, which in principle recognizes only a print-dependent and a print-independent component. Considering the interrelations among individual skills and possible explanatory mechanisms in terms of cognitive processes, the aforementioned studies raise the possibility of a dual link relating vocabulary to reading comprehension. In this view, an indirect association, via word recognition, would be complemented by a more immediate connection, directly facilitating text understanding.

However, additional possible conceptualizations of these interrelations seem broadly consistent with the available findings. One option is the mediating role proposed by Protopapas et al. (2007), in which vocabulary carries the main predictive weight of reading comprehension and subsumes variance shared between comprehension and decoding as well as variance shared between comprehension and oral language. Another option would be to attribute the variance shared among predictors of reading comprehension to a lexically based covariation that can be modeled by a vocabulary construct. Each of these alternatives assumes either a direct or an indirect role for vocabulary in predicting reading comprehension, but not both.

The purpose of the present study is to examine and contrast these alternative formulations, both concurrently and longitudinally, within the context of the Greek orthography, which is much more transparent than English (Protopapas & Vlahou, 2009). The potential impact of orthographic transparency upon the development of reading skills is expected to have theoretical implications leading to a better understanding of the reading process itself (Share, 2008). Studies of languages varying in orthographic transparency suggest that more transparent orthographies facilitate earlier development and more efficient use of sublexical processes for reading (Ziegler & Goswami, 2005, 2006). Novice readers seem to acquire reading in a more effortless and timely manner in orthographies with higher consistency in grapheme–phoneme correspondences (Seymour, Aro, & Erskine, 2003).

In the following analyses we use a two-pronged approach to circumvent potential issues of construct validity and measurement. Specifically, we test the relative contribution of print-dependent and print-independent measures to reading comprehension variance using both multiple hierarchical regression and latent variable modeling. The latent constructs constitute theoretically meaningful skill dimensions to the extent that their indicator measures indeed covary along the hypothetical individual differences of interest. However, issues of measurement reliability and validity may affect the power of the latent constructs in accounting for reading comprehension variance. For example, there may be insufficient (or insufficiently reliable) shared variance of the indicators defining a construct to support substantial strengths of association with the dependent variable. Or the shared variance among the indicators may include covariation along dimensions not entirely aligned with the hypothetical construct of interest. Thus, the results of latent variable modeling are limited by the validity of the latent constructs as defined by the particular indicators. In order to reduce the risk of misinterpreting the relations among constructs because of issues of this sort, we also apply a series of hierarchical regressions, in which groups of variables are entered as individual predictors of the dependent variable, in predetermined order.

The critical difference is that, in multiple regression, all variance shared among the dependent variable and each individual independent variable is accounted for, whereas in latent variable modeling only the common variance shared among the indicator measures of each latent construct is used to predict the independent variable. Model fit alone cannot indicate poor definition of latent constructs, because the variance–covariance matrix may be sufficiently reproduced with a solution including very high error terms (low loadings). If the latent constructs are properly defined by their respective indicators, then there should be at most minor differences between the two statistical approaches, and the latent constructs may be trusted to express theoretically significant relations. In contrast, if there are issues of reliability or validity, then successive projection of the dependent variable onto the individual independent variables will reveal deviations from the findings based on the latent constructs, tempering any interpretations and generalizations thereof.

METHOD

Participants

Our data were derived from the University of Crete longitudinal study of the development of reading skills, a project that aimed to follow 600 Greek schoolchildren from Grades 2–4 through Grades 4–6. Details of recruitment and measures are reported in Sideridis, Mouzaki, Simos, and Protopapas (2006) and Protopapas et al. (2007); see Protopapas et al. (2012) for measure reliability information. Here we report data from 436 children in Grades 3–5 for whom complete data were available on all measures listed in "Measures." Table 1 shows the distribution of the children by sex and grade at the time of data collection. All children were fluent speakers of Greek, and none were in special education classes.

Procedures

The analyses presented here concern data collected in a 40-min session during the third wave of measurements (April 2006), with the following exceptions: Wechsler Intelligence Scales for Children (WISC–III) Block Design was only measured in Wave 1 (April 2005), Verbal Instructions was only measured in Wave 2 (November 2005), and Raven's Standard Progressive Matrices was only measured in Wave 5 (April 2007), at which point the 1-year longitudinal measurement of reading comprehension was also made.

Children were tested individually by specially trained research assistants in a quiet room at their school. The study was approved by the Ministry of Education (Paedagogical Institute, Research Department), and written consent was obtained from participants' parents.

TABLE 1 Total Number of Boys and Girls and Mean Age (in Months) by Grade

	Number of children		Age	
Grade	Boys	Girls	*M*	*SD*
3	72	76	105.8	3.9
4	71	79	117.3	3.7
5	64	74	129.3	3.9

Measures

Word reading accuracy was measured with the Test of Reading Performance (TORP; Sideridis & Padeliadu, 2000)–Subscale 5, which is a list of 40 printed words to be read aloud without time pressure.

Pseudoword reading accuracy was measured with TORP–Subscale 6, which is a list of 19 printed pseudowords to be read aloud without time pressure.

Word reading fluency was tested with a sheet of 112 printed words to be read aloud as quickly as possible within 45 s.

Pseudoword reading fluency was tested with a sheet of 70 printed pseudowords to be read aloud as quickly as possible within 45 s.

Reading comprehension was measured with TORP–Subscale 13, which includes six passages of increasing length and two to four multiple-choice questions after each passage.

Listening comprehension was tested with three passages presented orally by the experimenter, each followed by four multiple-choice comprehension questions.

Oral receptive language was also assessed with the Verbal Instructions scale, a variant of the Token test (Spreen & Benton, 1977) that includes 28 verbal commands of increasing complexity involving pointing to tokens varying in size, color, shape, and location.

Receptive vocabulary was tested with the Greek adaptation (Simos, Sideridis, Protopapas, & Mouzaki, 2011) of the Peabody Picture Vocabulary Test–Revised (PPVT–R; L. M. Dunn & Dunn, 1981), in which the child has to identify one picture out of four that best represents the word spoken by the examiner.

Expressive vocabulary was tested with the vocabulary subtest of the Greek standardization of WISC–III (Georgas, Paraskevopoulos, Bezevegis, & Giannitsas, 1997), in which children provide word definitions.

Nonverbal intelligence was tested with the Block Design subtest of the WISC–III, in which children recreate geometric designs using two-color blocks.

General intelligence was tested with a 16-item short form of Raven's Standard Progressive Matrices (Raven, 2004), in which one of six options best fits a visual design.

RESULTS

Multiple Hierarchical Regressions

Data from all measures were used in these analyses. Apart from a transformation of word accuracy scores via an inverse function to reduce skewness, no other transformation or standardization was applied. No extreme outliers were identified. Table 2 lists the descriptive statistics by grade for this data set, as it was submitted to the regression analyses, and Table 3 displays the corresponding bivariate correlations among all variables below the diagonal.

The multiple hierarchical regressions aimed to determine the proportion of variance each group of measures shared with reading comprehension that was also shared with vocabulary. Analyses were conducted using the lm function in the R statistical package (R Development Core Team, 2005).[1] In every analysis, reading comprehension was the dependent variable and all other measures were independent variables. Concurrent reading comprehension was predicted in the first analysis and longitudinal (1-year ahead) reading comprehension was predicted in the second and third analyses. A set of control variables was always entered in Step 1 (age, WISC Block Design, and Raven's matrices). In the third analysis, concurrent reading comprehension was included as an autoregressor, along with the control variables.

Each group of predictor variables was entered into the equation in Step 2 to determine the total variance shared with reading comprehension and in Step 3, after the vocabulary measures, to determine the proportion of their total shared variance that was also shared by vocabulary and therefore taken up by it. In addition, each group of variables was entered in Step 4, following all other measures except vocabulary, to determine the unique variance contributed to reading comprehension when vocabulary was ignored and in Step 5, after vocabulary was also entered in the equation, to determine the truly unique variance contributed, taking vocabulary into account.

Tables 4–6 show the results of these analyses in each step, and Table 7 lists the parameters of the final regression models after all predictor variables were included. The total proportion of reading comprehension variance accounted for (multiple R^2) was .416 for the concurrent prediction, .398 for the 1-year longitudinal prediction without a concurrent autoregressor, and .451 for the longitudinal prediction with an autoregressor. With the exception of reading fluency measures, which did not contribute significantly once reading accuracy measures had been entered in the model, all other variable groups made significant unique contributions to the concurrent prediction of reading comprehension at the step they were entered (see Table 4). However, neither accuracy nor fluency of reading made significant unique contributions to the longitudinal prediction of reading comprehension, either with or without a concurrent autoregressor (see Tables 5 and 6). In the final equations, only listening comprehension and receptive vocabulary (PPVT–R) made significant unique contributions both concurrently and longitudinally (see Table 7). In particular, reading accuracy measures contributed significantly only to the concurrent prediction.

To facilitate comparisons across models, Table 8 shows the proportions of reading comprehension variance accounted for by each group of measures

[1]We thank Ioannis Dimakos for the R formula for calculating standardized regression coefficients.

TABLE 2 Descriptive Statistics for Each Measure Used in the Regression Analyses

	Grade 3				Grade 4				Grade 5			
Measure	*M*	*SD*	Skewness	Kurtosis	*M*	*SD*	Skewness	Kurtosis	*M*	*SD*	Skewness	Kurtosis
Reading comprehension	11.4	3.2	–0.58	–0.27	12.7	2.8	–0.99	1.00	13.6	2.8	–1.13	1.58
Reading comprehension (+1 year)	12.8	3.0	–0.93	0.73	13.1	3.1	–1.14	0.88	14.3	2.5	–1.23	1.59
Word reading accuracy	4.0	0.7	–0.68	0.19	4.3	0.7	–1.16	0.80	4.6	0.6	–1.45	1.59
Pseudoword reading accuracy	27.6	7.4	–0.15	–1.46	31.4	7.0	–0.97	–0.37	32.3	6.6	–1.25	0.36
Word reading fluency	52.3	12.1	–0.07	–0.36	61.2	13.2	–0.44	0.48	68.1	12.8	–0.17	0.20
Pseudoword reading fluency	25.1	6.8	–0.08	–0.40	29.7	8.3	–0.14	0.02	32.5	7.7	–0.03	0.13
Listening comprehension	9.5	1.7	–0.41	–0.75	9.7	1.8	–0.98	0.53	10.0	1.6	–0.86	0.69
Verbal Instructions	21.6	2.7	–0.59	–0.12	22.3	2.7	–0.31	0.00	23.1	2.8	–0.60	0.04
PPVT–R	118.8	15.4	–0.90	1.40	128.7	12.5	–0.69	1.58	134.3	11.3	–0.65	1.98
WISC–III Vocabulary	9.7	3.0	0.37	0.36	10.0	3.0	0.04	–0.51	9.2	3.4	0.05	–0.54
Raven's matrices short form	8.0	2.5	–0.18	–0.51	8.6	2.8	–0.33	–0.40	8.9	2.9	–0.14	–0.70
WISC–III Block Design	9.3	3.2	0.49	–0.56	9.4	3.3	0.15	–0.69	9.4	3.0	0.04	–0.80
Age (months)	105.8	3.9	0.71	1.41	117.3	3.7	0.51	1.20	129.2	3.6	–0.40	–0.24

Note. WISC–III Block Design measured a year earlier; Verbal Instructions measured 6 months earlier; Raven's matrices measured a year later, along with +1-year reading comprehension. PPVT–R = Peabody Picture Vocabulary Test–Revised; WISC–III = Wechsler Intelligence Scales for Children.

TABLE 3 Correlations (Pearson's *r*) Among Measures

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Reading comprehension	—	.57	.43	.34	.28	.28	.37	.36	.52	.52			
2. Reading comprehension (+1 year)	.56	—	.37	.31	.31	.29	.42	.37	.52	.49			
3. Word reading accuracy	.48	.39	—	.66	.50	.58	.25	.31	.35	.41			
4. Pseudoword reading accuracy	.36	.32	.69	—	.46	.51	.14	.25	.24	.32			
5. Word reading fluency	.33	.33	.57	.50	—	.77	.21	.19	.24	.33			
6. Pseudoword reading fluency	.32	.32	.63	.55	.79	—	.20	.22	.22	.30			
7. Listening comprehension	.36	.43	.28	.14	.22	.22	—	.25	.44	.44			
8. Verbal Instructions	.37	.37	.35	.29	.25	.27	.25	—	.42	.43			
9. PPVT–R	.55	.52	.45	.30	.35	.31	.42	.44	—	.64			
10. WISC–III Vocabulary	.48	.44	.36	.28	.25	.26	.41	.40	.53	—			
11. Raven's matrices short form	.27	.38	.24	.27	.15	.14	.26	.34	.35	.33	—		
12. WISC–III Block Design	.28	.28	.25	.21	.12	.12	.21	.30	.31	.36	.43	—	
13. Age (months)	.25	.21	.34	.27	.42	.34	.13	.20	.42	–.07	.17	.03	—

Note. Correlations between unstandardized variables, as used in regression analyses, below the diagonal; between standardized variables, as used in latent variable modeling, above the diagonal. PPVT–0R = Peabody Picture Vocabulary Test–Revised; WISC–III = Wechsler Intelligence Scales for Children.

TABLE 4 Results of Regression Analyses With Concurrent Reading Comprehension as the Dependent Variable

Step	Variables	Total R^2	ΔR^2	p
1	Age, WISC blocks, Raven	.154		
2	Word accuracy, pseudoword accuracy	.277	.124	.000
3	PPVT–R, WISC Vocabulary	.407	.129	.000
3	Listening comprehension, Verbal Instructions	.336	.059	.000
3	Word fluency, pseudoword fluency	.279	.002	.553
4	Listening comprehension, Verbal Instructions	.338	.058	.000
2	Word fluency, pseudoword fluency	.205	.052	.000
3	PPVT–R, WISC Vocabulary	.377	.172	.000
3	Word accuracy, pseudoword accuracy	.279	.074	.000
3	Listening comprehension, Verbal Instructions	.286	.081	.000
4	Word accuracy, pseudoword accuracy	.338	.051	.000
2	Listening comprehension, Verbal Instructions	.263	.109	.000
3	PPVT–R, WISC Vocabulary	.379	.117	.000
3	Word fluency, pseudoword fluency	.286	.023	.001
3	Word accuracy, pseudoword accuracy	.336	.074	.000
4	Word fluency, pseudoword fluency	.338	.001	.665
5	PPVT–R, WISC Vocabulary	.416	.078	.000
2	PPVT–R, WISC Vocabulary	.366	.212	.000
3	Word accuracy, pseudoword accuracy	.407	.041	.000
4	Listening comprehension, Verbal Instructions	.415	.009	.039
4	Word fluency, pseudoword fluency	.407	.000	.939
5	Listening comprehension, Verbal Instructions	.416	.009	.037
3	Word fluency, pseudoword fluency	.377	.012	.019
4	Word accuracy, pseudoword accuracy	.407	.029	.000
4	Listening comprehension, Verbal Instructions	.388	.011	.024
5	Word accuracy, pseudoword accuracy	.416	.028	.000
3	Listening comprehension, Verbal Instructions	.379	.014	.010
4	Word fluency, pseudoword fluency	.388	.009	.047
4	Word accuracy, pseudoword accuracy	.415	.036	.000
5	Word fluency, pseudoword fluency	.416	.000	.865

Note. Increasing step numbers in successive rows refer to subsequent steps in the same hierarchical analysis; identical step numbers refer to an alternative analysis with only the last step modified; decreasing step numbers refer to an alternative analysis retaining only preceding steps up to the indicated number. WISC = Wechsler Intelligence Scales for Children; PPVT–R = Peabody Picture Vocabulary Test–Revised.

that are shared with vocabulary measures. Focusing on significant contributions only, it is evident that vocabulary measures share more than a third of every other contribution. Of the total variance shared between reading comprehension and other measures, vocabulary took up two thirds or more in both the concurrent and longitudinal prediction, without the autoregressor, and about half when the autoregressor was included. Of the variance contributed by each variable group, vocabulary again accounted for half or more,

TABLE 5 Results of Regression Analyses With Future (1-Year Later) Reading Comprehension as the Dependent Variable, Without an Autoregressive Variable (Concurrent Reading Comprehension)

Step	Variables	Total R^2	ΔR^2	p
1	Age, WISC blocks, Raven	.185		
2	Word accuracy, pseudoword accuracy	.252	.067	.000
3	PPVT–R, WISC Vocabulary	.357	.106	.000
3	Listening comprehension, Verbal Instructions	.345	.094	.000
3	Word fluency, pseudoword fluency	.265	.013	.023
4	Listening comprehension, Verbal Instructions	.352	.087	.000
2	Word fluency, pseudoword fluency	.242	.057	.000
3	PPVT–R, WISC Vocabulary	.360	.118	.000
3	Word accuracy, pseudoword accuracy	.265	.023	.001
3	Listening comprehension, Verbal Instructions	.340	.098	.000
4	Word accuracy, pseudoword accuracy	.352	.012	.022
2	Listening comprehension, Verbal Instructions	.314	.129	.000
3	PPVT–R, WISC Vocabulary	.377	.063	.000
3	Word fluency, pseudoword fluency	.340	.026	.000
3	Word accuracy, pseudoword accuracy	.345	.031	.000
4	Word fluency, pseudoword fluency	.352	.007	.111
5	PPVT–R, WISC Vocabulary	.398	.046	.000
2	PPVT–R, WISC Vocabulary	.339	.155	.000
3	Word accuracy, pseudoword accuracy	.357	.018	.003
4	Listening comprehension, Verbal Instructions	.393	.035	.000
4	Word fluency, pseudoword fluency	.365	.007	.093
5	Listening comprehension, Verbal Instructions	.398	.033	.000
3	Word fluency, pseudoword fluency	.360	.020	.001
4	Word accuracy, pseudoword accuracy	.365	.005	.204
4	Listening comprehension, Verbal Instructions	.393	.033	.000
5	Word accuracy, pseudoword accuracy	.398	.005	.160
3	Listening comprehension, Verbal Instructions	.377	.038	.000
4	Word fluency, pseudoword fluency	.393	.015	.005
4	Word accuracy, pseudoword accuracy	.393	.015	.005
5	Word fluency, pseudoword fluency	.398	.005	.171

Note. Increasing step numbers in successive rows refer to subsequent steps in the same hierarchical analysis; identical step numbers refer to an alternative analysis with only the last step modified; decreasing step numbers refer to an alternative analysis retaining only preceding steps up to the indicated number. WISC = Wechsler Intelligence Scales for Children; PPVT–R = Peabody Picture Vocabulary Test–Revised.

resulting in substantial reduction of the (significant) contribution of both reading accuracy and listening comprehension (there was no significant contribution of reading fluency). Note that vocabulary reduced the significant unique longitudinal contribution of reading accuracy from a small $\Delta R^2 = .012$ to a nonsignificant $\Delta R^2 = .005$, whereas the comparable proportional reduction in the concurrent contribution (from .051 to .028) did not result in

TABLE 6 Results of Regression Analyses With Future (1-Year Later) Reading Comprehension as the Dependent Variable, With Concurrent Reading Comprehension as an Autoregressive Variable

Step	Variables	Total R^2	ΔR^2	p
1	Age, WISC blocks, Raven, Reading comprehension	.374		
2	Word accuracy, pseudoword accuracy	.384	.010	.029
3	PPVT–R, WISC Vocabulary	.420	.036	.000
3	Listening comprehension, Verbal Instructions	.429	.045	.000
3	Word fluency, pseudoword fluency	.393	.010	.035
4	Listening comprehension, Verbal Instructions	.435	.042	.000
2	Word fluency, pseudoword fluency	.392	.019	.002
3	PPVT–R, WISC Vocabulary	.427	.035	.000
3	Word accuracy, pseudoword accuracy	.393	.001	.655
3	Listening comprehension, Verbal Instructions	.434	.042	.000
4	Word accuracy, pseudoword accuracy	.435	.001	.616
2	Listening comprehension, Verbal Instructions	.423	.049	.000
3	PPVT–R, WISC Vocabulary	.440	.018	.001
3	Word fluency, pseudoword fluency	.434	.011	.016
3	Word accuracy, pseudoword accuracy	.429	.007	.084
4	Word fluency, pseudoword fluency	.435	.006	.116
5	PPVT–R, WISC Vocabulary	.451	.016	.003
2	PPVT–R, WISC Vocabulary	.415	.042	.000
3	Word accuracy, pseudoword accuracy	.420	.005	.171
4	Listening comprehension, Verbal Instructions	.446	.026	.000
4	Word fluency, pseudoword fluency	.427	.007	.073
5	Listening comprehension, Verbal Instructions	.451	.024	.000
3	Word fluency, pseudoword fluency	.427	.012	.014
4	Word accuracy, pseudoword accuracy	.427	.000	.870
4	Listening comprehension, Verbal Instructions	.449	.023	.000
5	Word accuracy, pseudoword accuracy	.451	.001	.598
3	Listening comprehension, Verbal Instructions	.440	.025	.000
4	Word fluency, pseudoword fluency	.449	.009	.031
4	Word accuracy, pseudoword accuracy	.446	.005	.140
5	Word fluency, pseudoword fluency	.451	.005	.135

Note. Increasing step numbers in successive rows refer to subsequent steps in the same hierarchical analysis; identical step numbers refer to an alternative analysis with only the last step modified; decreasing step numbers refer to an alternative analysis retaining only preceding steps up to the indicated number. WISC = Wechsler Intelligence Scales for Children; PPVT–R = Peabody Picture Vocabulary Test–Revised.

nonsignificance. Vocabulary greatly reduced (by 42.9%–84.5%) the significant unique contribution of listening comprehension as well, but there was always a significant residual (from $\Delta R^2 = .009$ in the concurrent prediction up to $\Delta R^2 = .033$ in the longitudinal prediction without the autoregressor and $\Delta R^2 = .024$ with the autoregressor).

TABLE 7 Final Multiple Linear Regression Models for the Concurrent and Longitudinal Prediction of Reading Comprehension

	B	SE_B	*z*	*p*	*β*
Concurrent reading comprehension					
(Intercept)	−5.599	1.572	−3.562	.000	
Age (months)	0.018	0.015	1.227	.221	.059
WISC–III Block Design	0.044	0.042	1.034	.302	.045
Raven's matrices short form	−0.018	0.049	−0.366	.714	−.016
Word reading accuracy	0.867	0.257	3.373	.001	.202
Pseudoword reading accuracy	0.021	0.023	0.914	.361	.049
Word reading fluency	0.004	0.014	0.301	.763	.019
Pseudoword reading fluency	−0.013	0.025	−0.535	.593	−.035
Listening comprehension	0.163	0.076	2.138	.033	.092
Verbal Instructions	0.071	0.049	1.455	.146	.064
PPVT–R	0.051	0.012	4.440	.000	.244
WISC–III Vocabulary	0.191	0.052	3.698	.000	.194
Future reading comprehension, no autoregressor					
(Intercept)	−1.803	1.523	−1.184	.237	
Age (months)	−0.007	0.014	−0.485	.628	−.024
WISC–III Block Design	0.014	0.041	0.351	.726	.015
Raven's matrices short form	0.158	0.048	3.290	.001	.148
Word reading accuracy	0.169	0.249	0.679	.498	.041
Pseudoword reading accuracy	0.027	0.022	1.228	.220	.067
Word reading fluency	0.018	0.013	1.358	.175	.087
Pseudoword reading fluency	0.003	0.024	0.130	.896	.009
Listening comprehension	0.340	0.074	4.601	.000	.200
Verbal Instructions	0.073	0.047	1.534	.126	.069
PPVT–R	0.047	0.011	4.226	.000	.235
WISC–III Vocabulary	0.084	0.050	1.687	.092	.090
Future reading comprehension, with autoregressor					
(Intercept)	−0.195	1.478	−0.132	.895	
Age (months)	−0.012	0.014	−0.886	.376	−.042
WISC–III Block Design	0.002	0.039	0.046	.963	.002
Raven's matrices short form	0.163	0.046	3.553	.000	.152
Concurrent reading comprehension	0.287	0.045	6.390	.000	.301
Word reading accuracy	−0.080	0.241	−0.331	.741	−.020
Pseudoword reading accuracy	0.021	0.021	1.001	.318	.052
Word reading fluency	0.017	0.013	1.326	.185	.082
Pseudoword reading fluency	0.007	0.023	0.302	.763	.019
Listening comprehension	0.293	0.071	4.127	.000	.173
Verbal Instructions	0.052	0.045	1.150	.251	.049
PPVT–R	0.033	0.011	2.975	.003	.162
WISC–III Vocabulary	0.030	0.049	0.608	.543	.031

Note. The dependent variable is indicated above the corresponding set of rows in italics. Significant predictors ($p < .05$) are shown in boldface. WISC–III = Wechsler Intelligence Scales for Children; PPVT–R = Peabody Picture Vocabulary Test–Revised.

Latent Variable Modeling

All measures except WISC–III Vocabulary and WISC–III Block Design standard scores were converted to *z* scores separately for each grade, then collapsed across grades. Word accuracy was transformed via an inverse function to reduce skewness. Table 3 shows the correlations among the

TABLE 8 Variance Proportions (ΔR^2) and Percentage Taken Up by Vocabulary, for Each Group of Measures, in Accounting for Reading Comprehension

	Total variance			Unique variance		
	Step 2	Step 3	% to vocabulary	Step 4	Step 5	% to vocabulary
Concurrent reading comprehension						
Word accuracy, pseudoword accuracy	.124***	.041***	66.9	.051***	.028***	45.1
Word fluency, pseudoword fluency	.052***	.012*	76.9	.001	.000	100.0
Listening comprehension, Verbal Instructions	.109***	.014*	87.2	.058***	.009*	84.5
PPVT–R, WISC Vocabulary	.212***				.078***	
Future reading comprehension, no autoregressor						
Word accuracy, pseudoword accuracy	.067***	.018**	73.1	.012*	.005	58.3
Word fluency, pseudoword fluency	.057***	.020**	64.9	.007	.005	28.6
Listening comprehension, Verbal Instructions	.129***	.038***	70.5	.087***	.033***	62.1
PPVT–R, WISC Vocabulary	.155***				.046***	
Future reading comprehension, with autoregressor						
Word accuracy, pseudoword accuracy	.010*	.005	50.0	.001	.001	0.0
Word fluency, pseudoword fluency	.019**	.012*	36.8	.006	.005	16.7
Listening comprehension, Verbal Instructions	.049***	.025***	49.0	.042***	.024***	42.9
PPVT–R, WISC Vocabulary	.042***				.016**	

Note. Total variance refers to the early entry of the corresponding variables, after the control variables (i.e., Step 2 [before vocabulary] or Step 3 [after vocabulary]). Unique variance refers to late entry (i.e., Step 4 [before vocabulary] or Step 5 [after vocabulary]). Total and unique vocabulary variance are shown for comparison. The dependent variable is indicated above the corresponding set of rows in italics. See Tables 4–7 for the full results. PPVT–R = Peabody Picture Vocabulary Test–Revised; WISC = Wechsler Intelligence Scales for Children.

*$p < .05$. **$p < .005$. ***$p < .0005$.

standardized variables above the diagonal. No indication of multicollinearity was evident.

Latent variable modeling (Bentler, 2004; G. Dunn, Everitt, & Pickles, 1993) was implemented as a method to evaluate how various combinations of latent variables related to vocabulary, fluency, accuracy, and listening comprehension are predictive of reading comprehension. Evidence for model fit involved (a) a nonsignificant model chi-square (Hu & Bentler, 1995), (b) unstandardized residuals not exceeding 5% (i.e., root mean square error of approximation [RMSEA]; Hu & Bentler, 1998b), (c) a chi-square to degrees of freedom ratio <2.0 (Jaccard & Wan, 1992), (d) a goodness-of-fit index (GFI) and comparative fit index (CFI) above .950 (Hu & Bentler, 1998a), and (e) significance of structural paths. A model was deemed acceptable only if all five criteria were met. Choice among well-fitting models was guided by chi-square difference tests. The level of significance was set at $\alpha = .05$. All models were run using EQS 6.1 (Bentler, 2004).

After determining the best fitting grade-independent latent variable model for each theoretical hypothesis based on data from the entire sample, we specifically tested grade invariance using multigroup analysis. Equality constraints were imposed on structural parameters across grades, and the resulting models were tested against models with unrestricted parameters, fit independently for each grade. Chi-square tests indicated no significant differences between corresponding restricted and unrestricted models; therefore, only the pooled analyses are reported here, including data from children in all grades analyzed together.

MEASUREMENT MODEL

A measurement model was tested first, to evaluate the significance of indicator loadings in defining the latent constructs. Measures were assigned to latent constructs as indicated in Figure 1. The following constructs were defined: L=oral language; A=reading accuracy; F=reading fluency; V=vocabulary; R3=concurrent (Wave 3) reading comprehension; R5=longitudinal (Wave 5) reading comprehension. Each latent construct was defined by two indicator measures. Because only one reading comprehension test was administered, each of the two indicators was composed of the total number of correct responses to the questions of three (out of six) passages. The analysis showed that all measurement paths were significant, with loadings exceeding the customary threshold of .4; therefore, all indicators were defining their construct in stochastic terms.

STRUCTURAL LATENT VARIABLE MODEL WITH THE MEDIATING ROLE OF VOCABULARY

This model tested the hypothesis that vocabulary was the main predictor of reading comprehension by taking up all contributions of listening comprehension and of reading accuracy and fluency. In order to assess this hypothesis, we

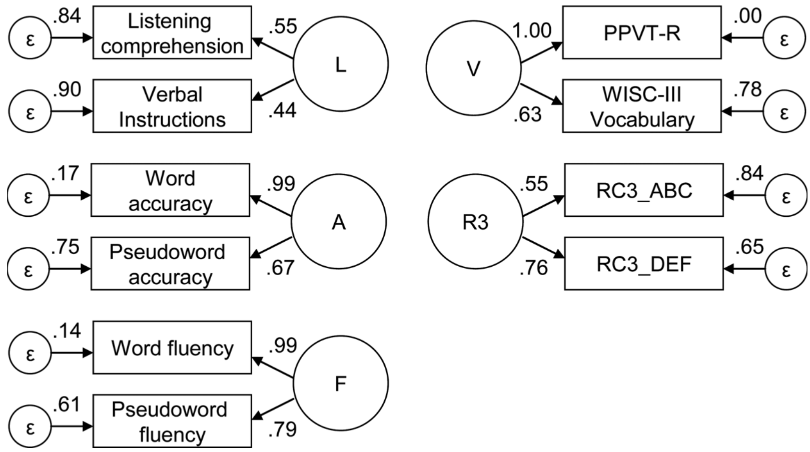

FIGURE 1 Measurement model displaying standardized indicator loadings and corresponding error variances for each latent variable included in the structural analyses. RC3_ABC and RC3_DEF refer to the sum of correct responses to questions on the first three and the last three passages, respectively, of the reading comprehension test. L=oral language; A=reading accuracy; F=reading fluency; V=vocabulary; R3=concurrent (Wave 3) reading comprehension; PPVT–R=Peabody Picture Vocabulary Test–Revised; WISC–III=Wechsler Intelligence Scales for Children.

constrained contributions of reading accuracy and fluency to reading comprehension to be indirect (see Figure 2a).

This bare mediation model did not fit the data well, meeting only two of the five criteria ($\chi^2 = 97.646$, $df = 30$, $p < .0001$, CFI = .959, GFI = .960, RMSEA = .072 [confidence interval (CI) = .056–.088]). It was subsequently tested against models enriched with direct paths from fluency, accuracy, and listening comprehension to reading comprehension, to determine whether the addition

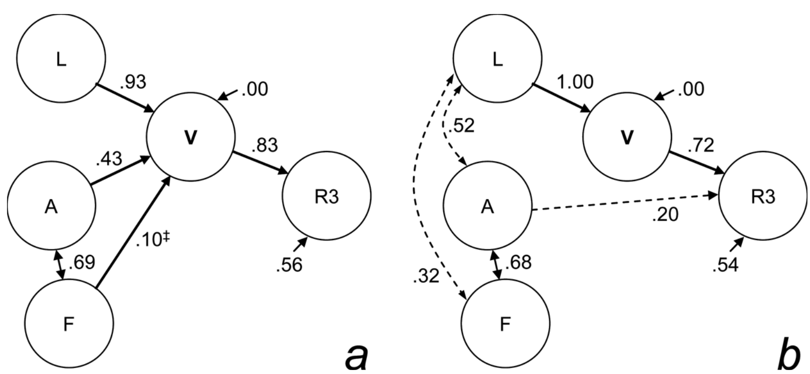

FIGURE 2 Structural model with a mediating role for vocabulary. (a) Poorly fitting pure mediation model, with all component skills indirectly affecting concurrent reading comprehension via vocabulary. (b) Well-fitting model, after the addition of a direct path from accuracy to comprehension and covariation among oral language and print components. Standardized coefficients are shown. L = oral language; A = reading accuracy; F = reading fluency; V = vocabulary; R3 = concurrent (Wave 3) reading comprehension. ‡$p > .05$.

of the direct paths resulted in enhanced model fit. Among several alternatives considered, the addition of a direct path between reading accuracy and reading comprehension resulted in significant model improvement, losing 1 *df* while gaining approximately 9 chi-square points (compared to the cutoff of 3.84 for 1 *df*). However, this model failed to fulfill all criteria for acceptable fit ($\chi^2 = 88.395$, $df = 29$, $p < .0001$, CFI = .964, GFI = .963, RMSEA = .069 [CI = .052–.085]). An acceptable fit could be achieved only after covariations were added among listening comprehension and reading accuracy and fluency ($\chi^2 = 35.080$, $df = 27$, $p = .137$, CFI = .995, GFI = .984, RMSEA = .026 [CI = .000–.048]). The inclusion of these unanalyzed covariations almost eliminated the need for the direct path from reading accuracy to comprehension, as the resulting fit was acceptable after the direct effect of reading accuracy was removed ($\chi^2 = 44.540$, $df = 28$, $p = .025$, CFI = .990, GFI = .980, RMSEA = .037 [CI = .013–.056]), even though it was significantly worse ($\Delta\chi^2 = 9.46$, $df = 1$, $p = .002$). Finally, we dropped the direct effects of accuracy and fluency on vocabulary (retaining the direct effect of accuracy on comprehension) after they failed to gain statistical significance, without affecting the fit of the model ($\chi^2 = 36.998$, $df = 29$, $p = .146$, CFI = .995, GFI = .983, RMSEA = .025 [CI = .000–.047]), resulting in the modified model shown in Figure 2b. Eliminating the direct effect of accuracy on comprehension from this model resulted in significantly worse ($\Delta\chi^2 = 8.562$, $df = 1$, $p = .003$) but still acceptable fit ($\chi^2 = 45.560$, $df = 30$, $p = .034$, CFI = .991, GFI = .980, RMSEA = .035 [CI = .010–.054]).

Structural latent variable model with lexically based covariation

This model (depicted in Figure 3a) tested the hypothesis that reading comprehension is a function of listening comprehension, in addition to reading accuracy and fluency, while each of these predictor variables is influenced by vocabulary.

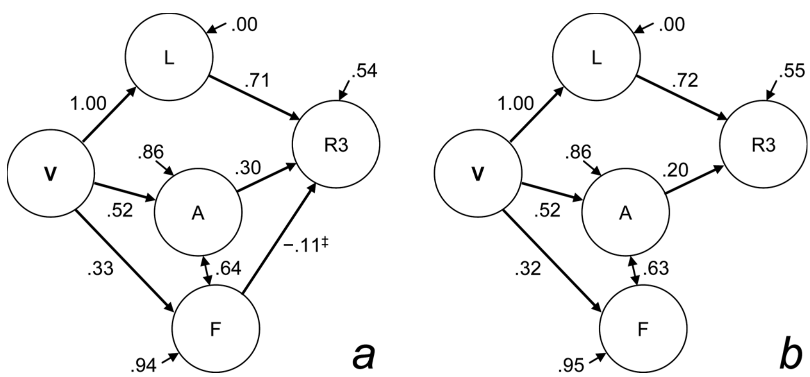

FIGURE 3 Well-fitting structural models with lexically based covariation for the concurrent prediction of reading comprehension. (a) Full model, including all paths. (b) reduced model, after the nonsignificant path from fluency to comprehension was dropped. Standardized coefficients are shown. L = oral language; A = reading accuracy; F = reading fluency; V = vocabulary; R3 = concurrent (Wave 3) reading comprehension. ‡$p > .05$.

In this conceptualization, vocabulary has a more global, but nevertheless indirect, effect on reading comprehension. This model fit the data well (χ^2=34.957, *df*=28, *p*=.171, CFI=.996, GFI=.984, RMSEA=.024 [CI=.000–.046]). Dropping the nonsignificant direct effect of fluency on comprehension did not affect the excellent fit of the model (χ^2=36.998, *df*=29, *p*=.146, CFI=.995, GFI=.983, RMSEA=.025 [CI=.000–.047]), resulting in the model of Figure 3b, which was equivalent to the augmented mediation model shown in Figure 2b.

Longitudinal stability of lexically based covariation

To test whether the role of accuracy, fluency, and listening comprehension in predicting reading comprehension is similar in concurrent and longitudinal prediction, we evaluated the best fitting lexically based covariation model after replacing concurrent reading comprehension indicators with 1-year longitudinal indicators (from Wave 5 reading comprehension assessment) while retaining the indicators of the predictor latent constructs (from Wave 3). The results indicated that the model fit the data adequately (χ^2 = 65.598, *df* = 29, *p* = .00012, CFI = .978, GFI = .972, RMSEA = .054 [CI = .037–.071]). However, the structural path linking reading accuracy to reading comprehension was of miniscule magnitude and not significant. Dropping it did not cause the model fit to deteriorate ($\Delta\chi^2$ = 2.028, *df* = 1, *p* = .154), resulting in acceptable fit (χ^2 = 67.626, *df* = 30, *p* = .00010, CFI = .977, GFI = .971, RMSEA = .054 [CI = .037–.071]). Thus, in this model future reading comprehension was directly influenced by listening comprehension only (see Figure 4).

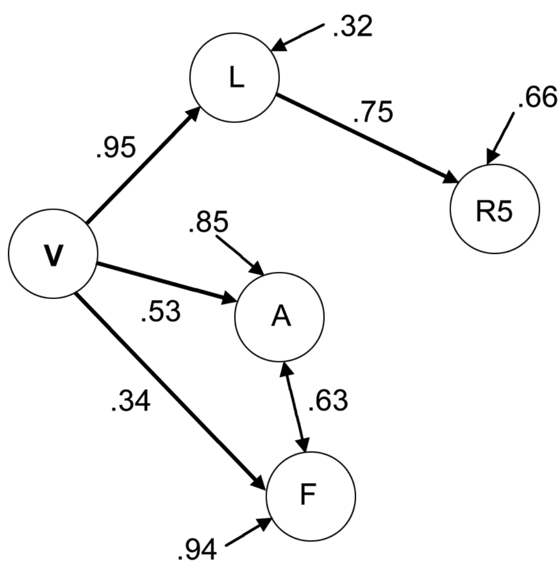

FIGURE 4 Well-fitting structural model with lexically based covariation for longitudinal (1-year) prediction of reading comprehension, including only significant paths. Standardized coefficients are shown. L = oral language; A = reading accuracy; F = reading fluency; V = vocabulary; R5 = longitudinal (Wave 5) reading comprehension.

DISCUSSION

The purpose of this study was to examine the role of vocabulary in the context of the simple view of reading, that is, in the concurrent and longitudinal prediction of reading comprehension by print-dependent (decoding) and print-independent (oral language) skills. The results of latent variable modeling are largely consistent with the view that vocabulary can be treated as part of the oral language component, as might be expected considering the aural administration of the vocabulary tests, which did not involve reading or writing. The results are also broadly consistent with the simple view in that both print-dependent and print-independent skills accounted independently for significant amounts of reading comprehension variance. Although vocabulary does share most variance that is common between reading comprehension and the other predictors, and greatly reduces their unique contribution, a minor yet significant direct contribution was identified from the print-dependent component to concurrent comprehension. Nevertheless, the theoretical distinctiveness of the two components of the simple view appears undermined by their strong empirical interrelations observed at the latent level and by the common variance at the measure level in the multiple regressions. The acceptable fit of the mediation model (see Figure 2) without a direct link from accuracy to comprehension should also be taken into account when considering the relative importance of the print-specific component.

Validity of Oral Language Constructs

An important aspect of the current analyses, causing substantial difficulty in interpretation, stems from the statistical equivalence between the latent constructs of oral language and vocabulary. As suggested elsewhere (Protopapas et al., 2012), there are two possible causes for this finding: The first is that vocabulary indeed constitutes part of a single valid oral language construct. If this is the case, then it remains to investigate why vocabulary measures account for unique reading comprehension variance after oral language is controlled, as has been found in previous studies (Braze et al., 2007; Ouellette & Beers, 2010) and was also the case in our regression analyses. Ouellette and Beers (2010) put forth the possibility that the observed unique contribution reflects a measurement artifact reflecting the fact that "current assessment tools for vocabulary are more accurate indices of the construct under study than are assessment measures of listening comprehension which are often largely dependent upon memory" (p. 204).

The second possible explanation for the statistical equivalence between the two latent constructs is that the common variance among the oral language measures lies along a vocabulary dimension because listening comprehension of passages or instructions are not very good indicators of the listening comprehension construct. This interpretation is somewhat supported by the relatively low loadings of the oral language indicators compared to those of the other latent constructs. However, it may be premature to reach a definitive conclusion, because the reliability of (at least one of) the oral language measures is also lower than the reliability of most other measures; therefore, the comparatively lower loadings may not necessarily indicate poor construct validity.

Whatever the cause of the near identity between the two constructs (vocabulary and listening comprehension) might be, it may complicate the results of the latent variable modeling with respect to the role of vocabulary, because oral language may stand as a proxy for vocabulary in the structural model and vice versa. That is, the good fit of the lexically based covariation model may not be interpreted as consistent with a lack of a direct effect of vocabulary on reading comprehension, because the direct effect of oral language is identical with a direct effect of vocabulary because of their fully shared variance. Likewise, the poor fit of the mediation model cannot be interpreted as consistent with a requirement for a direct effect of oral language, because the direct effect of vocabulary is already contributing as much oral language variance as possibly available. Therefore, the range of interpretations that can be confidently precluded or reached on the basis of our findings, with respect to the role of vocabulary, is necessarily limited by the failure of the latent constructs to demonstrate proper divergent validity.

Concurrent Predictors of Reading Comprehension

In the concurrent regression analysis, three groups of significant independent predictors of unique reading comprehension variance were identified, namely reading accuracy (words only), oral language (listening comprehension only), and vocabulary (both measures). This is consistent with the results of the latent variable modeling, taking into account the aforementioned latent equivalence, because both the mediation and the lexically based covariation alternatives require direct paths from both a print-dependent and a print-independent latent in order to maximize fit. The significant unique contribution of vocabulary measures to reading comprehension is consistent with recent findings with Grade 3–5 Australian children (Goff et al., 2005) and Grade 4 Canadian children (Ouellette, 2006), among others.

As noted, the fit of the bare mediation model (see Figure 2a) could be improved by adding a direct path between accuracy and comprehension. This result seems to run counter to the previous findings of Protopapas et al. (2007), in which the corresponding path was not significant and was dropped without deterioration in the fit of the model. This apparent contradiction is important because it concerns the same cohort (tested 1 year later) and a similar analysis of a highly overlapping set of measures. There are only minor differences in the measures: In the previous study, a spelling task was used as an additional indicator of accuracy, a second word fluency measure was an additional indicator of fluency, and the comprehension scores were parceled by passage into more than two indicators. There was no oral language component in the previous analysis. These differences do not appear to justify a qualitative difference in the results. However, the appearance of a qualitative difference may be misleading, as it seems to be due to a quantitative difference in estimation, leading to marginal changes in the significance of the paths. In the previous study, the standardized coefficient of the direct path from accuracy to comprehension was .090, not significant at $\alpha = .05$, and the standardized coefficient of the direct path from fluency to comprehension was –.056, not significant. In the current study, the corresponding paths were .199 ($p = .003$) and –.114 ($p = .155$), respectively. The indicator loadings in the previous study were .780 for word reading accuracy, .734 for nonword reading accuracy, and .769 for spelling. In the current study, they were .892 for word reading accuracy and .738 for nonword reading accuracy. All of these are quite substantial loadings and were justifiably interpreted as leading to proper definition of the latent construct. However, if the latent construct in the current study happened to be defined somewhat more reliably than in our previous investigation, by being better aligned with the word reading accuracy measure, perhaps more of the construct variance was available to contribute to reading comprehension, warranting a reinterpretation of the observed structural relations. This goes on to demonstrate that a statistical definition of construct validity, on the basis of "sufficiently high" loadings alone, is unlikely to provide a firm basis for definitive interpretations.

The most important reason the bare mediation model (see Figure 2a) failed to fit well was the lack of modeled covariation between the print-dependent and print-independent constructs, forcing the accuracy factor to contribute to the vocabulary mediator only variance not shared with oral language. Adding a covariation among the two components rendered nonsignificant the path from accuracy to vocabulary and brought the model fit within the acceptable range, indicating that vocabulary accounts largely for common variance shared among the purported print-independent and print-dependent components. Taking into account that, in the regression analyses, vocabulary takes up about half of the variance contributed to reading comprehension by reading accuracy, as well as most of the variance contributed by listening comprehension, these results together indicate that most of the variance that is relevant for the concurrent prediction of reading comprehension is shared among the simple view components and very little is independently contributed by either one. This finding is problematic for the conceptualization of the simple view, because this view theoretically requires a notable distinctiveness among the two components (Hoover & Gough, 1990; Tunmer & Hoover, 1992). The problem here is not that there is little variance from the print-dependent component in the concurrent prediction of reading comprehension, because a relatively diminished role for decoding, compared to the oral component, is expected in the age range of our sample. The issue is that much of the existing predictive variance is not unique to the print-dependent component but is shared by purely oral measures such as vocabulary. As previously argued (Protopapas et al., 2007), this empirical picture seems more consistent with a theoretical view emphasizing interrelations, rather than dissociations, among the predictive components.

One such view is the lexical quality hypothesis (Perfetti, 2007; Perfetti & Hart, 2001, 2002). In this framework, the theoretical focus is shifted away from the two component skills/factors of the simple view toward a more integrated interpretation of reading skill based on the quality of the mental representations of words (lexical knowledge). These representations include detailed knowledge about word form and meaning as reflected by the specificity of its orthographic, phonological, semantic, and syntactic components. According to this notion, the source of variability among readers lies primarily in the quality of lexical representations, and reading outcomes are explained as a function of experience with words at both oral (Nation & Snowling, 2004) and written (Stanovich, West, & Cunningham, 1991) levels. In this model, vocabulary, as knowledge of word meanings, is strongly interdependent with other written and oral language processes and affects reading comprehension through word representations.

In our results, the very high association between vocabulary measures and reading comprehension is consistent with a conceptualization of vocabulary as indexing lexical skills more generally and not simply word knowledge. A lexical skills construct, of the highest importance for reading comprehension under the lexical quality hypothesis, is also theoretically expected to overlap greatly with constructs expressing individual word-level skills, based on orthographic and phonological representations and processes. Therefore, the high associations between vocabulary and reading comprehension, as well as between vocabulary and reading accuracy, are both naturally accounted for under the lexical quality framework, if we consider vocabulary measures to index lexical skill.

Longitudinal Predictors of Reading Comprehension

In the longitudinal regression analyses, whether with or without an autoregressor, only listening comprehension and (one measure of) vocabulary contributed unique reading comprehension variance. This is also consistent with the corresponding results of the latent variable modeling, again taking into account the latent equivalence, because removing the direct paths from the print-dependent components did not significantly reduce the acceptable fit of the lexically based covariation model.

In comparison, Seigneuric and Ehrlich (2005) found that Grade 1 vocabulary and Grade 2 working memory had additional effects on the Grade 3 reading comprehension of French schoolchildren after the autoregressive effect of reading comprehension had been accounted for. They concluded that “as word recognition becomes automated throughout grade levels, the direct predictive weight of linguistic-comprehension variables such as vocabulary and working memory capacity increases concomitant with the decrease in the association of decoding skills with reading comprehension" (p. 642). This is consistent with our findings, taking into account that we tested much older children, presumably with much more automated word recognition skills.

In a longitudinal study of Dutch children in Grades 1 through 6, Verhoeven and van Leeuwe (2008) found significant contributions of word reading accuracy to reading comprehension 1 year later only in Grades 1 and 5. These findings suggest that any correlations observed between word reading and future reading comprehension in intermediate grades may be reflecting early effects that are effectively removed by the inclusion of an autoregressor in the longitudinal prediction. Similarly, in Verhoeven and van Leeuwe's study, listening comprehension significantly predicted future reading comprehension directly only in Grade 1. This finding stands in contrast to the significant unique variance in our Wave 5 reading comprehension that was accounted for by Wave 3 listening comprehension, even when an autoregressor was included in the regression analysis.

Verhoeven and van Leeuwe (2008) reported the strongest and most consistent longitudinal effects on reading comprehension from vocabulary, with standardized coefficients of .29, .36, and .28, in Grades 1, 3, and 5, respectively. Even though these results are not directly comparable to ours, because they used a reading instead of an oral vocabulary measure in the higher grades, their findings are indicative of the stable and irreducible importance of word knowledge for the development of reading comprehension. Verhoeven and van Leeuwe also found significant longitudinal effects of vocabulary on listening comprehension and vice versa, somewhat consistent with our difficulty in disentangling the two constructs (in the latent variable modeling) and with the effects of the individual corresponding measures (in the regressions). To the extent that our oral language and vocabulary constructs are inseparable, the finding that indicators of both are unique longitudinal predictors of reading comprehension may be interpreted as broadly consistent with the combined effects of listening comprehension on vocabulary and of vocabulary on reading comprehension reported by Verhoeven and van Leeuwe.

Reading Accuracy and Fluency

It may come as a surprise that word reading fluency failed to contribute significant unique variance to reading comprehension, especially when taking into account the significant contribution of word reading accuracy. The Greek orthography is relatively transparent in the feedforward direction, that is, for reading (Protopapas & Vlahou, 2009), occupying second place, after Finnish, in the list of European languages with simple syllabic structure in order of transparency (Seymour et al., 2003). Children seem to acquire basic decoding skills much more rapidly than in less transparent languages (notably, English;

Seymour et al., 2003; Ziegler & Goswami, 2006), apparently leading to ceiling accuracy performance in typical simple word and nonword reading tasks. This leads many researchers to conclude that reading accuracy poses no problems for Greek readers past Grade 1 and sometimes to altogether omit it from assessment. In contrast, reading fluency is consistently found to be the most reliable and significant predictor of reading difficulties in Greek throughout the span of reading development (Porpodas, 1999; Protopapas & Skaloumbakas, 2007, 2008). Yet reading fluency did not contribute significant unique variance to reading comprehension in the present study.

A similar picture with respect to reading accuracy and fluency is seen in German. For example, Wimmer and Mayringer (2002) did not take reading errors into account, "as reading accuracy was close to ceiling" (p. 273). Landerl and Wimmer (2008) reviewed the development of word accuracy and fluency in German and Dutch, the transparency of which is not very different from that of Greek, and suggested that there may be little room for improvement in accuracy past Grade 2. Consistent with this interpretation, their own data showed no difference between Grade 4 and Grade 8 in reading accuracy, despite very large gains in reading fluency. They concluded that word recognition speed is not only "a relevant and highly stable indicator of reading skills" but also "the only indicator [discriminating] reading skill levels in consistent orthographies" (p. 150). Therefore, it may be reasonable to expect little useful variance in reading accuracy for Greek children in the higher elementary grades.

The highly reliable and useful accuracy variance observed in our study with children in Grades 3–5 stands in contrast to such expectations. However, it is not empirically atypical: Reliable accuracy variance has been observed with Greek children in Grade 7, distinguishing children with reading disability from the general population (Protopapas & Skaloumbakas, 2007). The factor structure of word and nonword reading skills, including speed and accuracy, has been found to be very stable between Grades 3–4 and 7, with word and nonword accuracy loadings of .82 and .72, respectively, in Grades 3–4, down to .69 and .65, respectively, in Grade 7 (Protopapas & Skaloumbakas, 2008).

Therefore, one may conclude that it is not only possible but potentially very useful to measure reading accuracy in languages with transparent orthographic systems. However, to do this properly, psychometrically adequate tests are needed, as with any other construct under measurement. Clearly, simple stimuli one or two syllables long, such as those typically used in English, are inappropriate. More complex stimuli, such as longer and lower frequency words and multisyllabic nonwords with consonant clusters, may be necessary in order for items to function differentially and bring out the relative decoding difficulties among children. Our data suggest that there is something about reading accuracy that is not captured by the most obviously important and reliable reading fluency. This unknown aspect of accuracy evidently expresses a significant domain of individual differences and is uniquely related to reading comprehension and to lexical skills. Therefore, accuracy should not be lightly brushed aside in transparent orthographies, no matter how high the performance of children with simpler stimuli.

Measuring Vocabulary and Comprehension

Recently, diversity in vocabulary measurement has been conceptualized through a typological distinction into breadth and depth. Vocabulary breadth concerns the number of known words ("number of lexical entries"), whereas vocabulary depth refers to the amount of knowledge about each word ("the extent of semantic representation"; Ouellette, 2006). Exploiting this distinction in the prediction of reading comprehension for Grade 4 Canadian children, Ouellette (2006) found that the PPVT, a measure of receptive vocabulary breadth, accounts for unique decoding variance; picture naming, a measure of expressive vocabulary breadth, accounts for unique irregular word reading variance; whereas word definitions, a measure of vocabulary depth, accounts for unique reading comprehension variance after decoding and irregular word reading are controlled. Following up, Ouellette and Beers (2010) found the PPVT (but not vocabulary depth) to predict reading comprehension after they accounted for phonological, decoding, irregular word, and listening skills in Grade 6 but not in Grade 1. They considered their findings to suggest a picture that is "more complex than may be expected according to an independent construct interpretation of the simple view" (p. 201).

Our findings are not directly amenable to interpretation according to the breadth/depth dichotomy. Not only was this not a design factor in our study, but the validity of the hypothesized vocabulary constructs remains uncertain while the classification of individual measures is not entirely uncontroversial. For example, Tannenbaum et al. (2006) considered that "measures such as the Wechsler Intelligence Scale for Children and the Peabody Picture Vocabulary Test assess breadth of word knowledge" (p. 382). In a confirmatory factor analysis, they converged on a two-factor model of Breadth and Depth/Fluency and then found that 62% of the variance in reading comprehension could be attributed to these two factors. However, Depth/Fluency made little independent contribution, because it was very highly correlated with Breadth. Moreover, the format of WISC Vocabulary being a definition of words provided by the experimenter renders questionable its status as either an expressive measure (as children are not required to produce the test words) or an indicator of breadth (as definition tasks are often considered to measure depth instead; cf. Ouellette, 2006; Ouellette & Beers, 2010).

The method for assessing reading comprehension may also affect its estimated relation with vocabulary. In a study of Grade 2 Norwegian children, Hagtvet (2003) evaluated comprehension ability for both oral and written language using both story retelling and a cloze task. When comprehension was assessed via story retelling, oral expressive vocabulary was shown to be a strong predictor of both oral and reading comprehension, phonological awareness was a weak predictor, and morphosyntactic knowledge did not account for any comprehension variance. In contrast, when comprehension was assessed with a cloze task, phonological awareness and morphosyntactic knowledge both accounted for unique variance in both oral and reading comprehension, whereas vocabulary did not. Cutting and Scarborough (2006) evaluated three different comprehension measures that differed in the number of sentences contained in each passage and the type of comprehension questions (multiple choice vs. open ended). The results showed important contributions of decoding and listening comprehension to reading comprehension, but the strength of the associations varied depending on the type of reading comprehension measure. Francis et al. (2006) also reported differential patterns of relations of different reading comprehension tests with measures of word-level skills, narrative language production, and memory.

The complex picture of interrelations among skills related to reading comprehension is further complicated by difficulties in properly defining the critical constructs under study. The measurement of reading comprehension is unlikely to be easily resolved, not simply for practical reasons of task format and type of question, but because we still lack a firm understanding of what "comprehension" really means. Methodological shortcomings such as moderate reliability, which is often encountered even after the best attempts at putting together a comprehension assessment instrument, may be due to inherent contradictions in the definition of the construct. For example, comprehension questions often include items geared toward assessing memory for passage content, inference based on the passage content, as well as pragmatic inferences based on preexisting knowledge. All of these may be legitimate aspects of successful passage comprehension, so the inclusion of disparate items is justified. However, to the extent that these aspects of comprehension may be partly separate and relying on distinct cognitive abilities and processes, it may prove impossible to define a single, valid, and meaningful reading comprehension construct.

Limitations

Perhaps the most obvious limitation of our study is that it was conducted in a Greek-speaking population; therefore, the findings may not be directly generalizable to languages with very different structures or orthographic systems. As noted previously, orthographic transparency greatly affects the rate of reading development, and this effect may potentially extend to predictive relations among differentially developing skills. However, structural relations among constructs tend to replicate even among languages with substantial differences in orthographic transparency, despite differences in rates of attainment. For example, phonological awareness predicts spelling development similarly in Czech, Norwegian/Swedish, and English (Caravolas, Volín, & Hulme, 2005; Furnes & Samuelsson, 2010). Moreover, our results on the predictive relations among reading comprehension components closely mirror previous results in English, Dutch, and other languages. Therefore, although all findings must be replicated with different populations and measures before reaching final conclusions, there is at present no indication that findings for Greek may be somehow aberrant or unlikely to generalize.

Another limitation of our study concerns the proper definition and validation of main constructs, especially vocabulary and reading comprehension. Both of these require clarification before real progress can be made in measuring them. Instrumental distinctions such as expressive versus receptive and breadth versus depth constitute a reasonable starting point, however more process-oriented approaches may be required for further progress, with justified theoretical commitment on the lexical representations and their role in the development and expression of reading comprehension. It is difficult to imagine an individual differences approach alone, partitioning variance among predictors, shedding much light on these issues. More cognitive research, including computational modeling, is needed to try and understand how passage information is processed in combination with internal information (lexical, pragmatic, or other) in order to achieve a state of comprehension. In the end, the attempt to fully disentangle individual isolated effects on reading comprehension may prove futile if the development of all skills is so closely interrelated and interactive that unresolvable methodological issues of sampling and measurement become prominent.

It should also be kept in mind that a substantial proportion of reading comprehension variance remained unaccounted for by the measures administered in our study, as is typically the case in studies of this sort. At least some of this unaccounted variance must be reliable, as indicated by the increased total longitudinal reading comprehension variance accounted for when an autoregressor was included. "Considerable unexplained variance in all regression models" was similarly noted by Ouellette and Beers (2010, p. 205). To address this unexplained variance, Ouellette and Beers proposed considering other potentially important processes such as inference making (Cain & Oakhill, 1999). Integration skills, comprehension monitoring, and working memory may also help address this gap (Cain & Oakhill, 2006; Cain, Oakhill, & Bryant, 2004).

Conclusions

Our goal in this study was to examine the role of vocabulary in the context of the simple view of reading. The results of latent variable modeling and regression analyses, taken together, indicate that vocabulary is a strong concurrent and longitudinal predictor of reading comprehension over and above measures of word reading and oral language comprehension, consistent with previous studies in Greek and other languages and with expectations for the age range tested. The statistical equivalence between our oral language and vocabulary latent constructs prevents us from distinguishing between a mediating and common-covariation role for vocabulary. However, the large amount of reading comprehension variance, attributed to word reading and oral language measures, that is taken up by vocabulary indicates that it may be preferable to conceptualize a lexical skill domain, emphasizing interrelations rather than distinctions among components, and to investigate the role of different vocabulary and comprehension measures within a common assessment framework.

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