Read Writ (2015) 28:1407–1425
DOI 10.1007/s11145-015-9576-x

Early prediction of reading comprehension within the simple view framework

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Published online: 30 July 2015

Abstract The simple view of reading proposes that reading comprehension is the product of word reading and language comprehension. In this study, we used the simple view framework to examine the early prediction of reading comprehension abilities. Using multiple measures for all constructs, we assessed word reading precursors (i.e., letter knowledge, phonological awareness, rapid naming) and oral language at the beginning of kindergarten and reading comprehension at the end of third grade. Word reading was also assessed at the end of second grade and served as a mediator. Structural equation modeling showed that precursors of word reading and language comprehension accurately predicted reading comprehension in both mediated and non-mediated models. The results have important implications for the early identification of reading comprehension difficulties.

Keywords Reading comprehension · Simple view of reading · Early identification

Introduction

The simple view of reading has provided a very useful framework for the study of reading and reading disorders. This view proposes that reading comprehension is the product of word recognition and language comprehension (Gough & Tunmer, 1986). Word recognition is the ability to read isolated words quickly, accurately and silently, and language comprehension is the ability to use linguistic knowledge to

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derive meaning from sentences and discourses. The simple view does not deny the complexities of these processes, but rather divides them into two somewhat separate sets of processes (Hoover & Gough, 1990). There is now a large and growing body of research that supports the simple view, both in English (Aaron, Joshi, & Williams, 1999; Hoover & Gough, 1990; Kershaw & Schatschneider, 2012; Kirby & Savage, 2008; Oakhill, Cain, & Bryant, 2003; Tilstra, McMaster, van den Broek, Kendeou, & Rapp, 2009) and other languages (de Jong & van der Leij, 2002; Kendeou, Papadopoulos & Kotzapoulou, 2013; Megherbi, Seigneuric, & Ehrlich, 2006; Protopapas, Simos, Sideridis, & Mouzaki, 2012). This work has documented the contributions of word recognition and language comprehension to reading comprehension, and how these contributions change across grades and/or skill levels (Catts, Hogan, & Adlof, 2005; Florit & Cain, 2011; Garcia & Cain, 2014); Language and Reading Research Consortium, 2015). It has also led to methods for classifying and intervening with children with reading disabilities (Aaron et al., 1999; Catts, Hogan, & Fey, 2003; Clarke, Snowling, Truelove, & Hulme, 2010).

The simple view also offers insight into the early identification of problems in reading comprehension. It suggests that difficulties in language development and/or problems in processes related to word recognition may foretell later deficits in reading comprehension. Whereas such a proposal can be derived from the simple view, few studies have directly examined it. Most studies of the simple view have taken concurrent measures of word recognition, language, and reading comprehension and examined their interrelationships. However, a few investigations have provided a prospective examination of reading development using this framework (de Jong & van der Leij, 2002; Kendeou, van den Broek, White, & Lynch, 2009; Storch & Whitehurst, 2002). In a longitudinal study, de Jong and van der Leij (2002) examined the precursors of word recognition and language comprehension. They reported that first-grade skills in phonological awareness and rapid naming predicted word recognition in both first and third grades. This effect, however, was time-limited in that word recognition precursors did not account for additional growth in word reading between first and third grades. On the other hand, listening comprehension in first grade explained unique variance in first-grade reading comprehension (after controlling for word recognition) as well as additional growth in reading comprehension through the third grade.

In another longitudinal study, Storch and Whitehurst (2002) examined what they called "code-related" and oral language precursors in the spring of preschool and kindergarten and assessed their relationship to word recognition, oral language, and reading comprehension at the end of first through fourth grades. Code-related precursors included measures of phonological awareness and print concepts. Oral language in preschool and kindergarten was assessed by vocabulary and narrative recall tasks, and in first through fourth grades, was measured by vocabulary tasks alone. Results indicated that code-related precursors and oral language ability were strongly related in preschool and became less associated in kindergarten, presumably after children had had more literacy experience. Further analyses showed that reading ability in first and second grades, assessed by tasks that required both reading accuracy and comprehension, was directly related to kindergarten code-related precursors (and indirectly to preschool predictors). Oral

language ability in preschool and kindergarten was highly predictive of oral language in first/second and third/fourth grades. Finally, Storch and Whitehurst found that in third/fourth grade, oral language was significantly related to reading comprehension after controlling for concurrent word reading accuracy and previous reading ability. Thus, these results suggest an indirect causal link between early language ability and later reading comprehension.

In a more recent study, Kendeou et al. (2009) also investigated the prediction of reading comprehension based on a model consistent with the simple view. Using a cross-sequential longitudinal design, they assessed oral language and code-related abilities in pre-kindergarten and kindergarten children and administered follow-up assessments of these same abilities 2 years later. Reading comprehension was also assessed for the older cohort in second grade. This design allowed for both cross-sectional and longitudinal data in a time-efficient manner. Results showed that for both cohorts oral language and code-related skills formed distinct clusters and that these clusters had longitudinal continuity. This continuity proved to be much greater for code-related skills than oral language. They also found that code-related and oral language skills were strongly related in preschool and became less so in kindergarten. In further analyses, they showed that kindergarten code-related and oral language skills were indirectly related to second grade reading comprehension. The relationship for code-related skills was mediated by second grade word recognition and the relationship for oral language was mediated by second grade language skills. Thus, this study combined with those cited above suggest that code-related and oral language skills develop early and are predictive of later reading comprehension.

The present study was undertaken to further examine the early precursors of reading comprehension using the simple view of reading as a framework. We assessed code-related precursors (referred to as word recognition precursors) and oral language abilities at the beginning of kindergarten and measures of reading comprehension at the end of third grade. As reported above, word recognition precursors such as phonological awareness and letter knowledge have sometimes been grouped together as a single construct (Kendeou et al., 2009; Storch & Whitehurst, 2002). However, research also suggests that word reading precursors represent somewhat independent constructs that account for unique variance in reading achievement (Catts, Nielsen, Bridges, Liu, & Bontempo, 2015; Schatschneider, Fletcher, Francis, Carlson, & Foorman, 2004; Vellutino, Scanlon, Zhang, & Schatschneider, 2008). Therefore, we administered multiple measures of several word recognition precursors (i.e., phonological awareness, letter knowledge, and rapid naming) and formed individual constructs for each. This allowed us to examine the interrelationship of these precursors as well as their association with oral language and subsequent reading comprehension. We also administered multiple measures of word recognition in second grade in order to examine its mediating effect on the relation between kindergarten predictors and reading comprehension. This was in keeping with Kendeou et al. (2009) who showed that code-related abilities had an effect on reading comprehension through their relationship with word recognition. In addition, we examined a model without word recognition in order to provide data concerning the direct relationship

between kindergarten predictors and later reading comprehension. Results of the latter model have the most relevance for early identification of reading comprehension problems since information about subsequent word recognition is not available in kindergarten. Thus, taken together this design allowed us to provide new and relevant information concerning the prediction of individual differences in reading comprehension.

Method

Participants

At the beginning of the study 366 kindergarten children were selected in two cohorts, 1 year apart. These children attended classes in a medium-sized school district in the Midwest. This district is diverse in terms of ethnicity (approximately 63 % Caucasian, 11 % African-American, 6 % Hispanic, 7 % American Indian/Alaskan native, 6 % Asian/Pacific Islander, and 7 % multiracial) and family SES (24 % free and 11 % reduced lunch). All kindergarteners in the district for whom English was not the primary language spoken in the home were administered the PreLAS2000 (Duncan & De Avila, 2000). Only those children who demonstrated proficiency in English (scored at level 3 or higher) were considered for recruitment into the study. Based on this criterion, we excluded 5 % of the children who were originally considered for the sample.

Because the present study was part of a larger study that involved an examination of response to intervention, our sample contained a higher percentage of children with increased risk for reading disabilities than occurred in the district as a whole. In the larger study, at-risk status was identified on the basis of their performance on two subtests from the *Dynamic Indicators of Basic Early Literacy Skills* (DIBELS; Good & Kaminski, 2002) that were administered to all district kindergarteners by school personnel in the first week of school. To be considered at risk, children had to perform in the "Some risk" or "At-risk" categories on both the letter name fluency and initial sound fluency subtests. We selected 263 children (150 boys, 113 girls) who met this risk definition and a random sample of 103 children (53 boys, 50 girls) who did not. Although our sample was biased toward more at-risk children, we were able to use a weighting procedure to reduce this bias and better assure that our results would be representative of an unbiased sample.

Between the administration of our test battery at the beginning of kindergarten and final assessment of reading at the end of third grade, 96 children (26 %) were lost from the study (74 lost by the end of grade 2 and an additional 22 by the end of grade 3). Most of the children moved out of the district (89) and were unavailable for testing. Other children were dropped because of parental request (3), later diagnosis of autism or other special needs (3), or excessive absences (1).

Measures and procedures

All participants were administered a battery of assessments at the beginning of kindergarten by trained examiners from our research team. This battery included measures that previously have been reported to be predictive of word reading outcomes (Catts et al., 2015; Schatschneider et al., 2004; van Weerdenburg, Verhoeven, van Balkom, & Bosman, 2009). These code-related measures included assessments of letter knowledge, phonological awareness, rapid naming, and nonword repetition. The assessment battery also included measures of oral language, specifically vocabulary and narration. Word reading was assessed at the end of second grade and reading comprehension was measured at the end of third grade.

Word-reading precursors

To assess word-reading precursors, we administered multiple measures of letter knowledge, phonological awareness, and rapid naming. We also administered a single assessment of non-word repetition.

Letter knowledge Letter Name Fluency subtest from the *Dynamic Indicators of Basic Early Literacy Skills* reading (DIBELS; Good & Kaminski, 2002) was administered by our team on three occasions at the beginning of kindergarten (approximately 2 weeks apart). For this measure, the participant is shown a stimulus card containing 11 rows of randomly presented upper- and lower-case letters. The child names as many letters as he/she can in 1 min. Test–retest reliability was found to be .91. The Letter Identification subtest of the *Woodcock Reading Mastery Tests-Revised: Normative Update* (WRMT-R: NU; Woodcock, 1998) was also administered. For this measure, the participant identifies various letters of the alphabetic that are presented in different fonts. The reliability of this measure is .91.

Phonological awareness The Sound Matching subtest from the *Comprehensive Test of Phonological Processing* (CTOPP; Wagner, Torgesen, & Rashotte, 1999) is an untimed test of the ability to identify the sounds in words (i.e., phonological awareness). The participant is shown a series of stimulus cards, each with a target picture and three test pictures. The examiner provides the name of each picture and the participant is asked to identify which of the three test pictures starts or ends with the same sound as the target picture. Test–retest reliability is .83 and internal consistency is .93.

The *Dynamic Screening of Phonological Awareness* (Bridges & Catts, 2010), required the participant to delete a portion of a word and say the remaining word. Unlike static phonological awareness measures, in this dynamic task, the child is provided with feedback and instruction throughout the task. This feedback/instruction consists of standardized prompts. According to the test procedures, when a child gives a correct response, the response is acknowledged as so. Alternatively, when a child gives an incorrect response to an item, the examiner provides a series

of prompts until the item is answered correctly or the answer is given. The score for each item decreases by one point for each successive prompt that is needed. Test–retest reliability is .89 and internal consistency is .86.

The Initial Sound Fluency subtest from DIBELS (Good & Kaminski, 2002) was also administered to assess phonological awareness. For this measure, the participant is shown a series of stimulus cards containing four pictures. The examiner provides the names of the four pictures and asks the participant to identify the picture that begins with a particular sound. The child is also asked to produce the beginning sounds of words presented orally by the examiner. The amount of time taken to identify/produce the correct sounds is converted into the number of initial sounds correct in a minute. The published alternate form reliability was .72.

Rapid automatized naming (RAN) The Rapid Naming of Objects subtest from the CTOPP requires the participant to rapidly name pictured arrays of 6 common objects repeated 6 times in a random order. Two forms are presented and the number of seconds required to name the objects from each form is determined. The alternate-form reliability is .82.

Nonword repetition In this task (Dollaghan & Campbell, 1998), the participant is required to repeat 16 nonwords ranging from one to four syllables in length (four words at each length). Each of the nonwords was composed of early-developing phonemes and contained syllables that did not correspond to English lexical items. Nonwords were presented to children via headphones and a high-quality audio-recorder and participants' responses were recorded. An examiner scored the audio-recorded responses in terms of the number of consonants in error across the 16 words. A second examiner re-scored approximately 13 % of the data and inter-judge reliability was 93 %.

Oral language

The *Peabody Picture Vocabulary Test*-3 (Dunn & Dunn, 1997) was administered to assess children's recognition of the meaning of spoken words. The examiner read a list of words aloud and the participant was asked to select one of four pictures that corresponded to the meaning of the target word. Test procedures for establishing a basal and ceiling were followed. The split-half reliability is .94 for the age range corresponding to our sample. We also administered the *Picture Naming Vocabulary* subtest from the *Predictive Assessment of Reading* (PAR; Wood, Hill, Meyer, & Flowers, 2005). The participant is presented with a series of 35 pictures and asked to provide the name of each. Cronbach's alpha for this measure is .90.

The *Test of Narrative Language* (TNL; Gillam & Pearson, 2004) was administered to assess children's ability to comprehend narratives read aloud and to produce narratives with varying degree of visual support. The internal consistency is .88 and the test–retest reliability is .81.

Word recognition

Word recognition ability was assessed at the end of second grade by four measures. These included the Word Identification (WI) and Word Attack (WA) subtests from the *Woodcock Reading Mastery Tests-Revised: Normative Update* (WRMT-R: NU: Woodcock, 1998) and the Sight Word Efficiency (SWE) and Phonemic Decoding Efficiency (PDE) subtests of the *Test of Word Reading Efficiency: Second Edition* (TOWRE-2; Torgesen, Wagner & Rashotte, 2011). The WRMT-R: NU subtests are untimed measures of a participant's ability to accurately read words and pronounceable nonwords, whereas the TOWRE-2 subtests are timed measures of these skills. Both instruments have reported reliabilities >.90.

Reading comprehension

At the end of third grade, all participants were administered two measures of reading comprehension. The Reading Comprehension Measure (RCM) was an experimental measure similar in format to that found in informal reading inventories such as the *Qualitative Reading Inventory* (QRI-5; Leslie & Caldwell, 2011). This measure assessed children's ability to read, comprehend, and answer inferential and non-inferential questions about one expository passage (*The Puffin,* 167 words in length) and two narrative passages (*The New Boy,* 340 words; *The Frog in the Classroom,* 506 words). These passages were designed to be similar to those that third graders might encounter in school and were longer than the passages commonly found in standardized reading comprehension measures at this grade level. The passages were created by a research team member with expertise in early childhood literature and had a lexile score appropriate for third graders. The 13 inferential and 13 non-inferential questions were intended to assess how well children could comprehend the words/sentences in the text, make inferences, and create a mental representation of the text (Kintsch, 1998). Participants read each passage silently and notified the examiner when finished. Following the completion of each passage, the examiner asked 8 or 9 open-ended questions corresponding to the passage. Participants' responses to administered questions were audio-recorded. Trained examiners scored each audio-recorded response based on a rubric of acceptable answers. This rubric was created by the authors after carefully evaluating the appropriateness of a subset of responses by the participants. The total number of correct responses served as the raw score. Scorers were trained to 90 % or higher reliability before scoring assessments. In addition, approximately 10 % of the samples were scored by a second examiner and the inter-rater reliability was .93. Following the completion of data collection and scoring, Cronbach's alpha was calculated and found to be .86.

The *Measures of Academic Progress: Reading* (MAP) is a standardized computer adaptive test of reading (Northeast Evaluation Association, 2009) administered as part of the district's progress monitoring of student achievement. A primary component of this test is children's ability to read for understanding. Children read

short narrative or expository passages via a computer and answer multiple-choice questions that require literal, inferential, or evaluative understanding of the text. Some test items also tap word meaning. The marginal reliability is .95.

Analyses

Confirmatory factor analysis (CFA) was used to estimate the relations among the kindergarten word reading precursors (i.e., letter knowledge, phonological awareness, non-word repetition, RAN) and oral language to ensure that the kindergarten factors were adequately specified prior to inclusion in a more complex model. Structural equation modeling (SEM) was then employed to investigate the contributions of word reading precursors, oral language, and word recognition to reading comprehension. First, a mediation SEM model was used to test the mediating effect of second grade word recognition on the relationship between kindergarten precursors and third grade reading comprehension following methods outlined by Cheung and Lau (2008). Specifically, the MODEL INDIRECT command in Mplus (Muthen & Muthen, 1998–2012), which uses a Sobel test, was used to estimate all indirect effects. Next, a SEM model was estimated to examine the relationship between kindergarten predictors and third grade reading comprehension without the mediating effects of second grade word recognition.

Prior to estimating all SEM models, measurement models were evaluated to ensure that the specified factors resulted in adequate model fit. Model fit was evaluated using multiple indices, including Chi-square (χ^2), comparative fit index (CFI), Tucker–Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residuals (SRMR). RMSEA values below .08, CFI and TLI values equal to or >.95, and SRMR values equal to or <.05 are preferred for an excellent model fit (Hu & Bentler, 1999). There was minimal missing data from our sample (<.02 %), and therefore, full-information maximum likelihood was used for all analyses.

Lastly, because our sample contained a higher percentage of kindergarten children who were at-risk, sampling weights were calculated and applied to all analyses to ensure the representativeness of our results. All kindergarteners in the school district were administered DIBELS subtests during the first week of the school year to determine initial risk status. As a result, we were able to ascertain the percentage of children in the district who met our criteria for risk. Using the district rate (18.9 %) and the rate in our sample (69.3 %), we created a weighting variable that allowed us to convert raw scores or standard scores to z-scores that would have been expected if all children in the district had been assessed on our reading comprehension measures. Thus, although our sample contained a higher percentage of kindergarten children who were at risk than that found in the district, the scores of at-risk participants were given proportionally less weighting to ensure the representativeness of our results.

Results

Confirmatory factor analysis of kindergarten measures

A four factor CFA model of letter knowledge, phonological awareness, RAN, and oral language was estimated using the 13 kindergarten measures (see Fig. 1). In this model, nonword repetition was allowed to load on the phonological awareness factor. This model did not decrease model fit and was more parsimonious than that of a model that included nonword repetition as a single observed variable.[1] This more parsimonious model is also consistent with other research that has shown an overlap between phonological awareness and phonological memory (McBride-Chang, 1995; Wagner, Torgesen, Laughon, Simmons, & Rashotte, 1993). The four factor model demonstrated adequate fit to the data: χ^2 (59) = 101.22, $p < .001$, RMSEA = .05, CFI = .96, TLI = .95, SRMR = .05. All measures loaded significantly and strongly on their corresponding factors (λ ranged from .49 to .99). The resulting correlations among letter knowledge, phonological awareness, and oral language were strong and positive (r = .46–.67). The correlations among RAN and the other factors were moderate to strong and negative (r = .31–.52) because RAN was measured using time, higher scores represented slower performance.

Mediation SEM with grade 2 word recognition mediating kindergarten factors and grade 3 reading comprehension

Prior to conducting the SEM, the measurement model was evaluated to ensure that the specified factors resulted in adequate model fit. The two third grade reading comprehension measures were estimated as one factor and the four second grade word recognition measures as another factor. Model fit for the measurement model fell slightly below the threshold for excellent fit, but was still considered adequate: χ^2 (135) = 273.15, $p < .001$, RMSEA = .06, CFI = .93, TLI = .92, SRMR = .06. The indicators of reading comprehension (λ for MAP = .79 and λ for RCM = .67) and those for word recognition (λ for WI = .96, λ for WA = .87, λ for SWE = .82, and λ for PDE = .87) loaded significantly and strongly. Table 1 provides the factor correlations for the six factors included in this measurement model. As expected, letter knowledge and phonological awareness in kindergarten were more strongly correlated with second grade word recognition than was kindergarten oral language. Similarly, reading comprehension was more strongly correlated with second grade word recognition than kindergarten oral language.

The estimated SEM included direct effects of kindergarten predictors on third grade comprehension as well as indirect effects on third grade reading comprehension through second grade word recognition (see Fig. 2). Model fit indices suggested excellent model fit: χ^2 (80) = 120.44, $p < .01$, RMSEA = .04, CFI = .97,

[1] A Chi-square difference test was conducted to compare model fit for a CFA model that estimated nonword repetition as an indicator of phonological awareness or as a single observed variable distinct from all other factors. The latter model had adequate fit, χ^2 (56) = 98.85, $p < .001$, RMSEA = .05, CFI = .96, TLI = .95, SRMR = .05, but was not significantly different from that of the more parsimonious model, $\Delta\chi^2$ (3) = 2.37, p = .50.

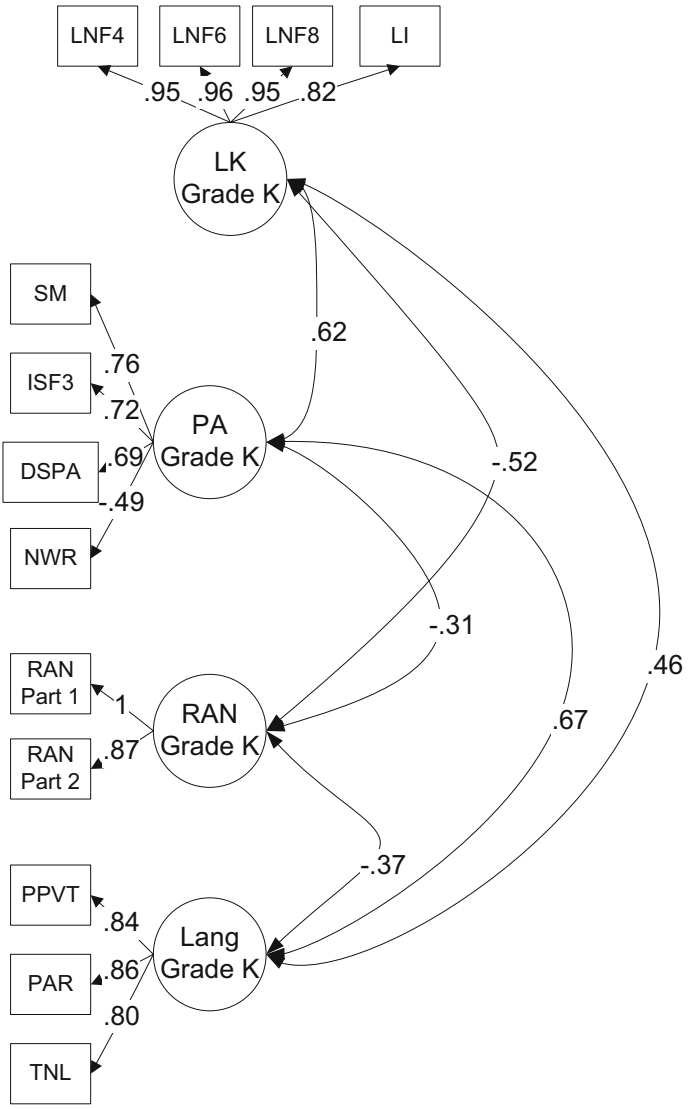

Fig. 1 Standardized parameter estimates for the Kindergarten confirmatory factor analysis. The letter knowledge (LK) factor consists of estimates from Letter Naming Fluency (LNF) administered at weeks 4, 6, and 8, and Letter Identification (LI). The phonological awareness (PA) factor consists of estimates from Sound Matching (SM), Initial Sound Fluency (ISF), *Dynamic Screening of Phonological Awareness* (DSPA), and Non Word Repetition (NWR). The rapid automatized naming (RAN) factor consists of estimates from two forms of the RAN task. The oral language (Lang) factor consists of estimates from the *Peabody Picture Vocabulary Test* (PPVT), the *Predictive Assessment of Reading* (PAR), and the *Test of Narrative Language* (TNL). All parameters are significant at $p < .001$

TLI = .96, SRMR = .05. Results from the mediation SEM show that kindergarten letter knowledge and phonological awareness positively and significantly predicted second grade word recognition, whereas RAN and oral language did not significantly

Table 1 Factor correlations by grade

Factor/grade	1	2	3	4	5	6
1. Letter knowledge/grade K	–					
2. Phonological awareness/grade K	.62***	–				
3. RAN/grade K	−.52***	−.31**	–			
4. Language/grade K	.46***	.67***	−.37**	–		
5. Word reading/grade 2	.63***	.62***	−.40***	.49***	–	
6. Reading comprehension/grade 3	.62***	.69***	−.54***	.73***	.85***	–

*** $p < .001$; ** $p < .01$

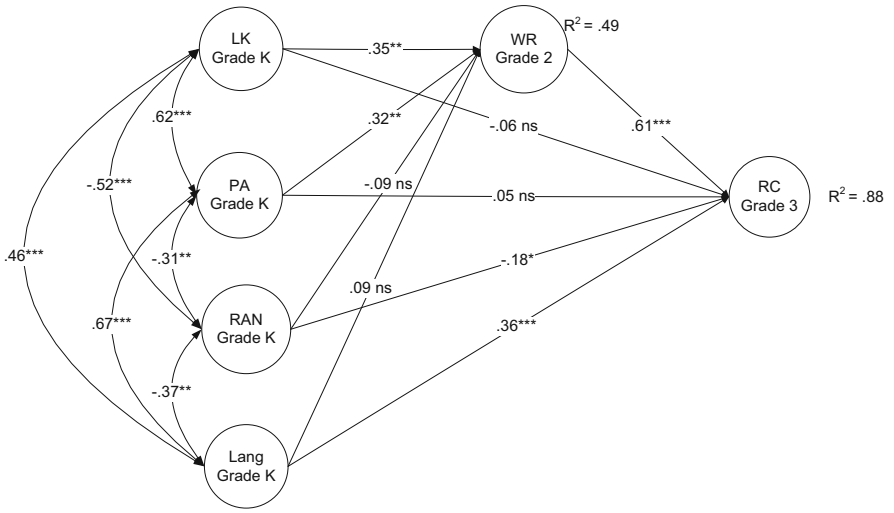

Fig. 2 Standardized parameter estimates for the final mediation structure equation model. Kindergarten factors include letter knowledge (LK), phonological awareness (PA), rapid automatized naming (RAN), and oral language (Lang). The Grade 2 mediating factor includes estimates of word identification, word attack, sight word efficiency, and phonemic decoding efficiency. Grade 3 reading comprehension is the outcome factor that includes estimates of reading comprehension and the reading subtest from the MAP. ***$p < .001$; **$p < .01$; *$p < .05$

predict second grade word recognition. However, RAN and oral language showed direct and significant predictions of third grade reading comprehension. Further, results from a Sobel test indicated that letter knowledge and phonological awareness had a significant indirect effect on reading comprehension through word recognition ($z = .21$, $p < .01$ for letter knowledge and $z = .20$, $p < .05$ for phonological awareness). In all, the kindergarten predictors accounted for 49 % of the variance in second grade word recognition and all kindergarten and second grade factors accounted for 88 % of the variance in third grade reading comprehension.

SEM with kindergarten factors predicting third grade reading comprehension

The above SEM model examined the relationship between kindergarten predictors and third grade reading comprehension with the mediation of second grade word recognition included. We were also interested in the direct effects of the kindergarten predictors without the consideration of second grade word recognition. Such a model provides data most relevant to the early prediction of reading comprehension prior to the onset of formal instruction in word recognition. The estimated SEM specified the kindergarten factors (letter knowledge, phonological awareness, RAN, and oral language) as predictors of third grade reading comprehension (see Fig. 3). Model fit for the SEM was identical to the model fit from the measurement model, χ^2 (80) = 120.44, $p < .01$, RMSEA = .04, CFI = .97, TLI = .96, SRMR = .05. Figure 3 illustrates that kindergarten factors of phonological awareness, RAN, and oral language significantly and uniquely contributed to the prediction of reading comprehension in third grade and account for 79 % of the variance. In contrast, letter knowledge did not contribute significantly or uniquely to the prediction of reading comprehension after controlling for the relations among the other kindergarten predictors.

Discussion

In this study, we used the simple view of reading as a framework for the longitudinal prediction of reading comprehension. We administered multiple measures of word reading precursors and oral language ability at the beginning of kindergarten and examined the interrelationship between these constructs. Our results indicated that word reading precursors were, for the most part, moderately related to each other. The strongest relationship was found between phonological awareness and letter knowledge. Research has often found these skill domains to be associated in preschool or kindergarten and it is not uncommon for them to be linked together within the same construct in longitudinal studies. In fact, in two of the studies reviewed above, phonological awareness and letter knowledge were grouped together in constructs referred to as decoding skills or code-related skills (Kendeou et al., 2009; Storch & Whitehurst, 2002). However, our results that are described in more detail below showed that phonological awareness and letter knowledge were at least partially independent and accounted for unique variance in word recognition. Thus, in this sense, they can be considered separate constructs.

Findings also indicated that word-reading precursors and oral language ability were associated at the beginning of kindergarten. The strongest relationship was found between phonological awareness and oral language. This correlation was of comparable strength regardless of whether or not nonword repetition, which has been found to be associated with oral language (Bishop, North, & Donlan, 1996), was included as an indicator of phonological awareness. Storch and Whitehurst (2002) reported a similar size correlation between phonological awareness and oral language in their preschool sample (assessed toward the end of the school year).

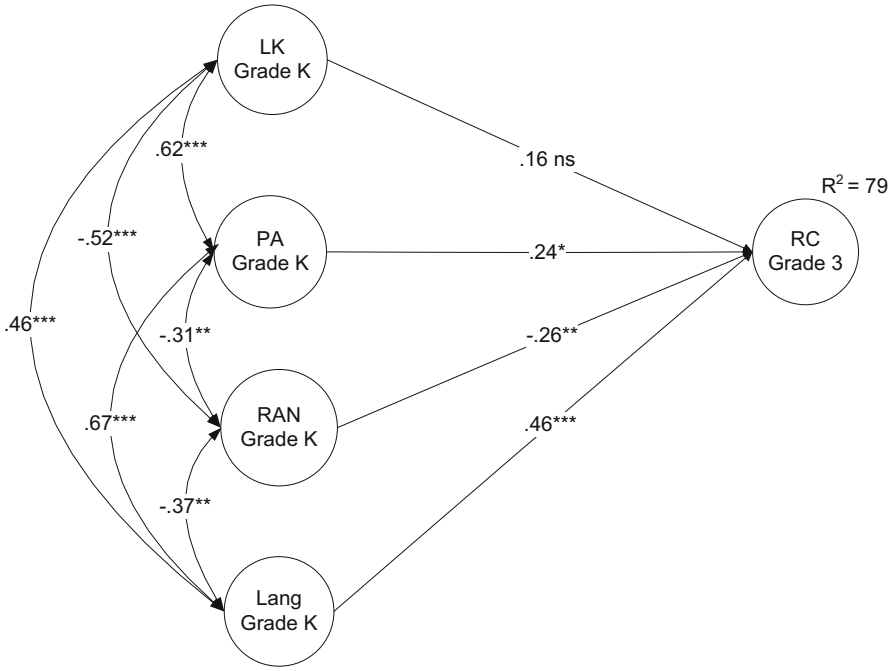

Fig. 3 Standardized parameter estimates for the structural equation model with Kindergarten factors predicting Grade 3 reading comprehension. The letter knowledge (LK) factor includes measures of Letter Naming Fluency and Letter Identification. The phonological awareness (PA) factor includes measures of Sound Matching, Initial Sound Fluency, phonological awareness, and nonword repetition. The RAN factor includes two forms of RAN tasks. The oral language (Lang) factor includes the PPVT, a picture naming task, and the *Test of Narrative Language*. These four factors measured in Kindergarten predict the Grade 3 reading comprehension factor that includes a researcher developed measure of reading comprehension and the reading subtest of the MAP. ***$p < .001$; **$p < .01$; *$p < .05$

Also, in a recent study, Foorman and colleagues found that latent measures of phonological awareness and oral language in kindergarten were highly correlated (r = .89) and were best modeled as a single second order factor in their prediction of listening comprehension (Foorman, Herrara, Petscher, Mitchell, & Truckenmiller, 2015). These results suggest that children's early phonological awareness is at least, in part, a reflection of their general language ability. Indeed, the emergence of phonological awareness has been linked to language development, specifically vocabulary development. The lexical restructuring hypothesis (Metsala & Walley, 1998), for instance, proposes that as more words are added to the lexicon, there is greater specification of phonological units, and in turn, increased awareness of the phonemes in words.

The close association between phonological awareness and oral language ability during the preschool years may also help explain some findings in children with developmental language or reading impairments. Specifically, several studies have reported that preschool children with a specific language impairment who go on to develop good word-reading skills often have deficits in phonological awareness

(Catts & Adlof, 2011; Bishop, McDonald, Bird, & Hayiou-Thomas, 2009). This would be unexpected if phonological awareness was purely a phonological skill that served as a foundation for word recognition. However, given an association between phonological awareness and oral language ability, it is not surprising that children who have significant oral language impairments might also show early deficits in phonological awareness regardless of their later word-reading abilities. Others have also reported somewhat comparable findings in children with a specific comprehension deficit (Catts, Adlof, & Weismer, 2006; Elwér, Keenan, Olson, Byrne, & Samuelsson, 2013; Nation, Cocksy, Taylor, & Bishop, 2010). These children have poor reading comprehension despite good word-reading skills. Nevertheless, in preschool or kindergarten, they have been reported to have poor phonological awareness skills that are in line with deficits in oral language.

The latter results in no way undermine the connection between phonological awareness and word recognition. Although related to oral language during preschool and kindergarten, phonological awareness is still a unique predictor of word recognition. Indeed, our findings, which are discussed below, bear this out. Phonological awareness emerges in the preschool years and plays a causal role in learning to decode words, especially in less transparent orthographies (Adams, 1990; Anthony & Francis, 2005). This relationship is also reciprocal in that phonological awareness is influenced by word recognition abilities (Hogan, Catts, & Little, 2005; Morais, Cary, Alegris, & Bertelson, 1979). As a result, it would be expected that as children begin to learn to read, that phonological awareness becomes more closely linked with word recognition and less with oral language. Indeed, both Storch and Whitehurst (2002) and Kendeou et al. (2013) found that the association between phonological awareness and oral language was reduced by the end of kindergarten.

Prediction of reading comprehension

A primary aim of our study was to investigate how well kindergarten word reading precursors and oral language predicted third-grade reading comprehension. In the first model, which was more of a theoretical model, we included word recognition in second grade as a mediating variable. Results showed that simple view components in kindergarten along with second-grade word recognition accounted for nearly 90 % of the variance in third-grade reading comprehension. Letter knowledge and phonological awareness were found to be indirectly related to reading comprehension through their unique associations with second-grade word reading ability. This is consistent with previous longitudinal studies of the simple view (Kendeou et al., 2009; Storch & Whitehurst, 2002) as well as a very large literature that has documented the connection between phonological awareness and letter knowledge in kindergarten and word recognition/reading comprehension in the early school grades (Al Otaiba et al., 2011; Catts, Fey, Zhang, Tomblin, 2001; Elbro, Borstrom, & Petersen, 1998; Schatschneider et al., 2004; O'Connor & Jenkins, 1999; Vellutino et al., 2008).

Other results showed that oral language and rapid naming had a direct association with reading comprehension in third grade. Based on the simple view, one would

predict that early measures of oral language would add to the prediction of subsequent reading comprehension. Other studies have reported a relationship between preschool or kindergarten language abilities and later reading comprehension (Catts, Fey, Zhang, & Tomlin, 1999; Nation et al., 2010; NICHD Early Child Care Research Network, 2005) and at least one other investigation has found this to be the case after controlling for subsequent word recognition abilities (Olson et al., 2011). The finding that rapid naming had a direct unique association with reading comprehension was unexpected. We had included rapid naming as a word reading precursor and expected that its impact on reading comprehension would be mediated by its association with word recognition (Wolf, Bally, & Morris, 1996). Of course, rapid naming is, in part, a measure of expressive language, and as such, could have a direct relationship to reading comprehension. However, we would not expect it to account for much unique variance in a model that also included a broader language construct composed of expressive and receptive measures. An alternative explanation for the direct relationship of rapid naming to reading comprehension may be found in the association between rapid naming and ADHD. Studies have reported that children with ADHD have deficits in rapid naming, especially color and object naming (Carte, Nigg, & Hinshaw, 1996). Rapid naming of colors or objects may require more semantic processing than naming letters or digits, and thus, may be more susceptible to distraction caused by attention shifting (Tannock, Martinussen, & Frijters, 2000). If rapid naming of objects were, in part, a marker for ADHD, than its unique relationship to reading comprehension could be explained on the basis of attentional resources. Recent research suggests that attentional deficits in children with ADHD can cause limitations in working memory that can lead to difficulties in building coherent mental representations during reading (Miller et al., 2013).

In a second model, we investigated the relationship between simple view components in kindergarten and reading comprehension in third grade without the mediating effects of word recognition in second grade. This model has more practical implications for the early prediction of reading comprehension prior to the onset of formal instruction in word recognition. Results showed that word reading precursors and oral language accounted for nearly 80 % of the variance in reading comprehension. Whereas this model explained less variance then the first model, it is noteworthy that it accounted for considerable variance across nearly 4 years, with no mediating factors. The strongest predictor in this model was oral language followed by phonological awareness and rapid naming. The contributions of letter knowledge failed to reach significance in this model. These results combined with those from the other model indicate that word reading precursors are related to later reading comprehension but should be modeled separately to better understand their relation to oral language and reading comprehension.

Implications for early identification

These results have implications for the early identification of problems in reading comprehension. They suggest that components of the simple view should be included in early screening batteries designed to identify children at risk for reading

disabilities. It has been quite common for many years to include word-reading precursors such as letter knowledge, phonological awareness, and in some cases, rapid naming in screening batteries (Good & Kaminski, 2002; Foorman et al., 1998). Assessments of oral language have been included in screening batteries much less often (but see Foorman, Torgesen, Crawford, & Petscher, 2009; Wood et al., 2005). Our results suggest that such measures can add much to the identification of children who are at risk for problems in reading comprehension. Numerous other studies have documented the association between language problems in preschool or kindergarten and difficulties in reading comprehension (Catts et al., 2006; Elwér et al., 2013; Nation et al., 2010). Because reading comprehension problems may not appear until the third or fourth grade (Catts, Compton, Tomblin, & Bridges, 2012), early screening, particularly with language assessments, is critical to identifying at-risk children and providing them with timely intervention. Currently, it is not clear what type of oral language assessment might be the most predictive of later problems. Recent research indicates that in preschool or kindergarten language ability may be a unitary construct (Language and Reading Research Consortium, in press). Nevertheless, some measures such as expressive vocabulary or sentence repetition may be better predictors than others (Catts et al., 2001; Wood et al., 2005). Once identified, early language intervention may be able to reduce the incidence of reading comprehension problems. Recently, Clarke et al. (2010) found that an extended oral language intervention improved vocabulary and reading comprehension in 8- and 9-year old children with reading comprehension deficits. However, additional studies are needed to better document the effectiveness of early language intervention on reading comprehension.

Acknowledgments This study was supported by an Institute of Education Sciences Grant (R324 A080118). We would like to thank the Lawrence, Kansas public school district for their participation in this research study.

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