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Executive Functions and Morphological Awareness Explain the Shared Variance Between Word Reading and Listening Comprehension

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Abstract

Purpose: A large body of literature showed that word reading and listening comprehension—two proximal predictors of reading comprehension according to the simple view of reading—are related. Grounded on the direct and indirect effects model of reading (Kim, 2020a, 2020b, 2023), we examined the extent to which the relation is explained by domain-general cognitions or executive functions (working memory and attentional control) and emergent literacy skills (language and code-related skills including morphological awareness, phonological awareness, orthographic pattern recognition, letter naming fluency, and rapid automatized naming).

Method: Data were from English-speaking children in Grade 1 ($N = 372$; 52% boys; 60% White children, 26% African American children, 6% multiracial children, 6% Hispanic children, and 2% Asian American children).

Results: Results from structural equation models showed that word reading and listening comprehension were moderately related (.54). When working memory and attentional control were included as predictors, the relation became weaker (.39). When morphological awareness was additionally included, they were no longer related (.05). The other emergent literacy skills did not add explanatory power beyond executive functions and morphological awareness.

Conclusion: These results indicate that executive functions and morphological awareness largely explain the shared variance between word reading and listening comprehension for English-speaking beginning readers.

Keywords

word reading; listening comprehension; linguistic comprehension; executive; functions; simple view of reading

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Word reading and listening comprehension are two proximal predictors of reading comprehension (Gough & Tunmer, 1986). This idea, the simple view of reading, has been supported by a large body of studies across languages and writing systems (e.g., Adolf et al., 2006; Bianco et al., 2012; Catts et al., 2006; Foorman et al., 2018; Hoover & Gough,

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1990; Joshi et al., 2012; Kim, 2015a, 2017; L. W. Lee & Wheldall, 2009; Massonnié et al., 2018; Protopapas et al., 2012), including L2 learners (e.g., Kim, 2012; Mancilla-Martinez et al., 2011). In fact, studies using latent variables showed that word reading and listening comprehension explain the vast majority of variance in reading comprehension (Foorman et al., 2018; Kim, 2015a, 2017; Lonigan et al., 2018; Massonnié et al., 2018). One consistent pattern that emerged in this literature that has not garnered its due attention is a substantial positive relation between word reading and listening comprehension (Duke & Cartwright, 2021). In other words, word reading and listening comprehension are not independent but related. Then what explains the relation? Understanding sources of the relation between word reading and listening comprehension may reveal the nature and mechanisms among skills that contribute to reading skills. For example, if the relation between word reading and listening comprehension is due to the fact that they draw on a shared pool of skills and resources, then these skills and resources reveal explanatory mechanisms. On the other hand, if there is a unique relation between word reading and listening comprehension beyond their shared resources, this behooves a need for further theoretical understanding and investigations. Although the simple view of reading stated the roles of word reading and listening comprehension in reading comprehension, it did not specify the relation between them or mechanisms behind the relation, and to our knowledge, this question has not been addressed in prior work.

Our goal in the present study was to unpack sources of the relation guided by a theoretical model that specifies component skills of word reading and listening comprehension and the nature of their relations (Kim, 2017, 2020a, 2023). Specifically, we examined the extent to which executive functions or domain-general cognitive skills (working memory and attentional control) and emergent literacy skills (morphological awareness, phonological awareness, orthographic pattern recognition, letter naming fluency, and rapid automatized naming) explain the shared variance between word reading and listening comprehension, using data from English-speaking students in Grade 1.

Relation Between Word Reading and Listening Comprehension

Prior work on the simple view of reading focused on the independent contributions of word reading and listening comprehension to reading comprehension. Although it has not garnered much attention, an interesting pattern that has been consistently found in the literature is a substantial relation between word reading and listening comprehension (Catts, 2018; Duke & Cartwright, 2021). In Hoover and Gough's (1990) study with English-Spanish bilingual students, correlations between word reading and listening comprehension in English ranged from .42 in Grade 1 to .72 in Grade 4. In Kim and Wagner's (2015) longitudinal study with English-speaking students, the correlation ranged from .43 in Grade 1 to .53 in Grade 4. Lonigan and colleagues (2018) reported a correlation of .57 for students in Grades 3 to 5. Other studies reported comparable results for English-speaking children (Adlof et al., 2006; Foorman et al., 2018; Kim, 2020a; Metsala et al., 2021; Tunmer & Chapman, 2012) and adults (Braze et al., 2016), and emergent bilingual students (Barber et al., 2021).

Similarly, although varied, positive correlations were also found for students learning to read in languages other than English as follows: .39 to .53 for Greek-speaking students in Grades 3, 4, and 5 (Protopapas et al., 2012); .42 for Malay-speaking students in Grade 1 (L. W. Lee & Wheldall, 2009); .61 for Romanian-speaking students in Grade 2 (Dolean et al., 2021); .54 to .55 for Korean-speaking beginning readers (Kim, 2015b); .22 to .27 for French-speaking first graders (Massonnié et al., 2018); .76 for Chinese-speaking elementary grade students (Ho et al., 2017); and .35 and .47 for Chinese-speaking students in Grades 2 and 4, respectively (Joshi et al., 2012).

Sources of the Relation Between Word Reading and Listening Comprehension

The lexical quality hypothesis (also see the verbal efficiency hypothesis) states that the quality of knowledge about word forms is important for the reading process (Perfetti, 2007). Knowledge of word forms includes phonology, orthography, grammar, meaning, and constituent binding, and constituent binding refers to “connections that secure coherence among … the orthographic, phonological, and semantic representations” (Perfetti, 2007, p. 360). If different aspects of knowledge of word forms are interconnected or bound, then it is reasonable to speculate that word reading and listening comprehension would be related inasmuch as word reading and listening comprehension have a shared reliance on the different aspects of word form knowledge.

Another relevant theoretical framework is the direct and indirect effects model of reading (DIER; Kim, 2017, 2020a, 2020b, 2023) because it specifies the nature of relations among component skills of reading. DIER hypothesizes that the following skills and knowledge contribute to reading comprehension: word reading, text reading fluency, listening comprehension, background knowledge (content/world knowledge and discourse knowledge), social-emotions toward reading (e.g., beliefs, attitude, self-concept), higher-order cognitions and regulations (e.g., inference, reasoning, perspective taking, goal setting, monitoring, employing repair strategies), vocabulary, grammatical/syntactic knowledge, orthographic awareness, phonological awareness, morphological awareness, and domain-general cognitions or executive functions (e.g., working memory, inhibitory and attentional control, shifting). An important aspect of DIER is its specification of structural relations among skills and knowledge, such as hierarchical, interactive/bidirectional, and dynamic relations (see Kim, 2020a, 2020b, 2023 for details). Particularly germane to the present study is the hierarchical relations hypothesis, which specifies the pathways by which skills and knowledge are related to one another (see Figure 1). In other words, the relation between word reading and listening comprehension can be deduced from the structural relations hypothesized in DIER. In the section below we focus on the aspects of DIER that are directly relevant to the present study: component skills of word reading and listening comprehension and the nature of their relations.

Executive Functions

According to DIER, word reading and listening comprehension are related because of their shared reliance on executive functions. Word reading and its component skills (i.e., phonological, orthographic, and morphological awareness; see the left side of Figure 1), and listening comprehension and its component skills (e.g., vocabulary, syntactic knowledge; higher order cognitions; see the right side of Figure 1; Kim, 2020a, 2020b, 2023) rely on executive functions. Executive functions—"a set of general-purpose control processes that regulate one's thoughts and behaviors" (Miyake & Friedman, 2012, p. 8)—refer to domain-general cognitions such as working memory, inhibitory and attentional control, and shifting (e.g., see Miyake et al., 2000; Miyake & Friedman, 2012). If executive functions contribute to component skills of word reading *and* component skills of listening comprehension, executive functions would explain at least some of the shared variance between word reading and listening comprehension. In other words, executive functions are a common contributor to both word reading and listening comprehension and their component skills, and therefore, executive functions should explain shared variance between word reading and listening comprehension (also see Duke & Cartwright, 2021; see Peng et al., 2018 for empirical evidence for the relation of working memory to phonological coding, decoding, vocabulary, and comprehension). With regard to the relation of executive functions to word reading, the following chains of relations are hypothesized in DIER (Kim, 2020a, 2020b, 2023): executive functions ➔ phonological, orthographic, and morphological awareness ➔ word reading (see Figure 1). Working memory is necessary for temporarily storing and simultaneously processing semantic, phonological, and orthographic information (H. L. Swanson & Howell, 2001; see Peng et al.'s, 2018, meta-analysis). Attentional control is also necessary for the perception and encoding of semantic, phonological, and orthographic stimuli to memory. Studies have shown that working memory and attentional control are related to word reading (e.g., Christopher et al., 2012; Deacon et al., 2009; H. L. Swanson & Howell, 2001), and component skills of word reading—phonological awareness, orthographic awareness, rapid automatized naming, and morphological awareness (e.g., Deacon et al., 2009).

Executive functions also support listening comprehension and its component skills such as vocabulary and syntactic knowledge because learning vocabulary, syntactic structures, and comprehending oral texts require holding, processing, and sustaining attention to linguistic information (e.g., Gathercole et al., 1992; Verhagen & Leseman, 2016). Studies have shown that working memory (Daneman & Merikle, 1996; Florit et al., 2011; Kendeou et al., 2008; Kim, 2015a, 2016, 2020a) and inhibitory control and attentional control (Kim, 2016; Kim & Phillips, 2014) are related to listening comprehension. Studies also revealed that working memory and attentional control are related to the skills that contribute to listening comprehension, such as vocabulary and morphosyntactic and syntactic knowledge (Gathercole et al., 1992; Kim, 2015a; Kim & Phillips, 2014; Verhagen & Leseman, 2016) as well as higher-order cognitions (e.g., inference; Calvo, 2004; Kim & Phillips, 2014; Moses, 2001).

Morphological Awareness

Another way by which word reading and listening comprehension are related is emergent literacy skills according to DIER (see Figure 1). In this study, we adopt the definition that emergent literacy skills include oral language skills and code-related skills (Snow et al., 1998; Storch & Whitehurst, 2002; Whitehurst & Lonigan, 1998, 2001), but focus specifically on knowledge and awareness of phonology, orthography (orthographic symbols and patterns), and morphology. Although these emergent literacy skills are widely recognized for their roles in word reading (National Early Literacy Panel, 2008; National Institute of Child Health and Human Development [NICHD], 2000; Snow et al., 1998), DIER posits that emergent literacy skills, especially morphological awareness, are important for the connection between word reading and listening comprehension because morphological awareness predicts word reading *and* component skills of listening comprehension—vocabulary, and morphosyntactic and syntactic knowledge (see Figure 1). Morphemes are the smallest unit of meaning, and as such, are the foundation of semantic processing. One's knowledge and awareness of morphemes and morphological structures, morphological awareness, is important to word reading because the English writing system is phonologically *and* morphologically based (Nagy et al., 2014). Often, what appear to be irregularities in English spelling are due to the morphological principle over phonological principle (e.g., the spelling of past tense with '-ed' when phonology does not reflect that, for example, *passed*). A large body of studies has shown the contribution of morphological awareness to word reading (Bowers et al., 2010; Goodwin & Ahn, 2013; J. Lee et al., 2023).

Morphological awareness is also an important source of vocabulary growth (e.g., Nagy et al., 2014). When children encounter unknown words (e.g., *lighthouse, popularity*), they can infer meanings of these words if they know the morphemes in these words (i.e., *light, house, popular*). In addition, as inflectional morphemes serve morphosyntactic functions and derivational morphemes often change part of speech, children with advanced morphological awareness would have greater morphosyntactic and syntactic knowledge (Nagy et al., 2014). By now, a robust body of studies has shown the relation of morphological awareness with vocabulary (e.g., Goodwin et al., 2020; Ho et al., 2017; Kieffer & Box, 2013; Kieffer & Lesaux, 2012; McBride-Chang et al., 2005, 2008; Nagy et al., 2006; see J. Lee et al., 2023 for a meta-analysis), and morphosyntactic and syntactic knowledge (e.g., Goodwin et al., 2020; Guo et al., 2011; Ho et al., 2017). If morphological awareness is related to vocabulary and morphosyntactic and syntactic knowledge, which, in turn, are related to listening comprehension, morphological awareness would relate to listening comprehension. Indeed, studies have shown a moderate relation between morphological awareness and listening comprehension (Ho et al., 2017; Kim et al., 2020; Metsala et al., 2021; see J. Lee et al., 2023 for a meta-analysis).

Phonological Awareness and Orthographic Awareness

Phonological awareness and orthographic awareness may also account for the shared variance between word reading and listening comprehension. According to the lexical restructuring hypothesis (Metsala & Walley, 1998), vocabulary is related with phonological awareness because segmental/phonemic representations of lexical items develop as vocabulary expands. If phonological awareness predicts word reading, and is related with vocabulary, which, in turn, predicts listening comprehension, phonological awareness may explain the shared variance between word reading and listening comprehension. In addition, DIER hypothesizes relations among morphological awareness, phonological awareness, and orthographic awareness (see connections among them in Figure 1), aligned with the triangle model (Adams, 1990) and the lexical quality hypothesis (Perfetti, 2007). Morphological awareness and phonological awareness are related to each other because morphological knowledge involves pairing with phonological representation (Kuo & Anderson, 2006) and both involve blending and segmenting varying linguistic units (e.g., Goodwin & Ahn, 2013). Pairing of morphemes with orthographic units (grapho-morphological knowledge) facilitates word reading and spelling (Kuo & Anderson, 2006), which renders a relation between morphological awareness and orthographic awareness. If phonological awareness and orthographic awareness are related to morphological awareness and predict word reading, and if morphological awareness predicts listening comprehension, they may account for the shared variance between word reading and listening comprehension.

Present Study

The goal of the present study was to examine the extent to which executive functions (working memory and attentional control) and emergent literacy skills (morphological awareness; phonological awareness; orthographic awareness, which includes letter knowledge and orthographic pattern recognition; and rapid automatized naming) explain the shared variance between word reading and listening comprehension for English-speaking children. Note that rapid automatized naming was included as part of emergent literacy skills given its consistent role in word reading across languages and writing systems (e.g., Caravolas et al., 2012; Compton, 2003; Ho et al., 2017).

We hypothesized that working memory and attentional control would explain the shared variance between word reading and listening comprehension. In other words, the magnitude of the relation between word reading and listening comprehension would be reduced once working memory and attentional control are included as predictors of word reading and listening comprehension. We also posited that morphological awareness would predict the relation between word reading and listening comprehension over and above working memory and attentional control. Letter naming fluency, orthographic pattern recognition, rapid automatized naming, and phonological awareness were hypothesized to predict word reading; and phonological awareness was also posited to be related to listening comprehension (see lexical restructuring hypothesis; Metsala & Walley, 1998) after accounting for executive functions.

Method

Participants and Sites

Data in the present study were from a larger study on primary grade students' reading development. The larger study included longitudinal data on text reading such as text reading fluency and reading comprehension, and these were reported (see Kim et al., 2021a, b). However, only Grade 1 data are used in the present study because emergent literacy skills were measured only in Grade 1. Some of the data used in the present study were reported earlier in a study that focused on prosodic sensitivity (Kim & Petscher, 2016). The sample included 372 first-grade children (52% boys) from 29 classrooms in 6 schools (3 urban and 3 semirural areas) in the Southeastern part of the United States. The mean age in the spring of Grade 1 was 6.79 years (SD = .60). Approximately half (52%) of the children were eligible for free and reduced lunch. The majority were White children (60%) and

African American children (26%) while the rest were composed of 6% multiracial children, 6% Hispanic children, and 2% Asian American children. Two children were classified as Limited English Proficiency.

Measures

Students were assessed on attentional control, working memory, morphological awareness, phonological awareness, orthographic awareness, letter naming fluency, rapid automatized naming, word reading, and listening comprehension. Unless otherwise noted, all the items were scored dichotomously, and reliability estimates are from the present sample.

Attentional Control—The Strengths and Weaknesses of ADHD Symptoms and Normal Behavior Scale (SWAN; J. M. Swanson et al., 2012) was used. SWAN is a behavioral checklist that includes 30 items that are rated on a 7-point scale ranging from a score of 1 (*far below average*) to 7 (*far above average*) to allow for ratings of relative strengths (above average) as well as weaknesses (below average). Higher scores represent greater attentional control. Teachers completed the SWAN checklist. Cronbach’s alpha was .99.

Working Memory—The listening span task (Daneman & Merikle, 1996; Gaulin & Cambell, 1994; Nouwens et al., 2021) was used. In this task, the child heard two to five brief statements composed of three-word simple sentences involving common knowledge (e.g., Are dogs blue?; Do frogs jump?; Do tables cry?). After each statement, the child was asked to identify whether each heard sentence is correct or not (Yes/No response). After hearing all the sentences, the child was asked to identify the last word in each of the sentences in the order they were heard. The child’s responses with correct last words in correct order were given credit whereas their responses on the veracity of the statements were not scored. There were four practice items, and 13 test items. The test discontinued after three consecutive incorrect responses. Cronbach’s alpha was .65.

Morphological Awareness—The Relatives task (Apel & Diehm, 2013) was used. The student heard a base word (e.g., cry) followed by a sentence with a missing word (e.g., *“Cry. The baby bumped his head, so he _______.”*), and was asked to complete the sentence using an inflected or derived form of the base word (e.g., *cried*). Items included inflectional morphemes (e.g., past tense, plural) and derivational morphemes (e.g., *happy, unhappy; help, helpful),* and one item involved irregular derivation (*mouse, mice*). There was one practice item and 40 test items. Cronbach’s alpha was .87.

Phonological Awareness—The Elision subtest of the Comprehensive Test of Phonological Processing (CTOPP; Wagner et al., 1999) was used. In this task, the student was asked to delete a sound and say what was left (e.g., delete /k/ from *cat*). Cronbach’s alpha was .90.

Orthographic Pattern Recognition—An orthographic choice task (Olson et al., 1994), also known as a wordlikeness task, was used to assess the students’ awareness of orthographic patterns and rules (e.g., consonant double, positional constraints). The student was presented with two pseudowords, one of which violated English orthography, and was asked to identify a word that looks like a real word (e.g., tibl – tible). There was one practice item and 53 test items. Cronbach's alpha was .82.

Letter Naming Fluency—The letter naming fluency subtest of the Dynamic Indicators of Basic Early Literacy Skills (DIBELS; Good et al., 2001) was used. The student was shown upper- and lower-case alphabet letters randomly arranged in 11 rows of 10 letters and was asked to name each letter and the number of correctly identified letters in a minute was calculated. Alternate-forms reliability was reported to range from .86 to .93 (Good et al., 2001).

Rapid Automatized Naming—The Rapid Letter Naming subset of the CTOPP (Wagner et al., 1999) was used. The student was shown a list of 6 letters randomly presented in a 9 by 4 matrix, and the time taken to read those letters in a minute was the score. Test-retest reliability was reported to be .97 (Wagner et al., 1999).

Word Reading—The Word Reading subtask of the Wechsler Individual Achievement Test-Third Edition (WIAT-III; Wechsler, 2009), the Letter Word Identification subtask of the Woodcock Johnson Achievement Test – Third Edition (WJ-III; Woodcock et al., 2001), and the Sight Word Efficiency (SWE) subtask of the Test of Word Reading Efficiency-2 (Torgesen et al., 2012) were used. In the first two tasks, the student was asked to read aloud (isolated) words of increasing difficulty. In the SWE task, the student was asked to read aloud words of increasing difficulty within 45 seconds. Cronbach's alpha estimates for the first two tasks were .95 and .91, respectively. Test-retest reliabilities for the SWE task for primary grade students ranged from .77 to .93 (Torgesen et al., 2012).

Listening Comprehension—The Listening Comprehension Scale of the Oral and Written Language Scales (OWLS-2; Carrow-Woolfolk, 2011) and the Oral Comprehension subtest of the WJ-III (Woodcock et al., 2001) were used. In the former task, the student was asked to point to the picture that best describes the heard sentences, which increased in complexity and number, and in the latter task, the student was asked to complete orally presented sentences (e.g., People sit in _____). Cronbach's alpha estimates were .75 and .93, respectively.

Reading Comprehension—The Reading Comprehension subtask of WIAT-III and the Passage Comprehension subtask of WJ-III were used. In the former task, the student was asked to read passages and answer multiple choice questions, and in the latter task, the student read sentences and short passages with blanks and was asked to fill in the blanks. Cronbach's alpha estimates were .86 and .81, respectively.

Procedures

In quiet spaces, students were individually assessed in several sessions of approximately 30 to 40 minutes per session. The order of assessment was as follows: rapid automatized naming, letter naming fluency, phonological awareness, morphological awareness, orthographic awareness, working memory, attentional control, word reading, listening comprehension, and reading comprehension.

Data Analysis

Latent variables were created for constructs that were measured with multiple tasks—word reading and listening comprehension. Then, a series of structural equation models shown in Figures 2a–2e were fitted to examine the relation between word reading and listening comprehension, and the contributions of executive functions (working memory and attentional control) and emergent literacy skills (i.e., morphological awareness, phonological awareness, orthographic awareness, letter naming fluency, and rapid automatized naming) to the relation between word reading and listening comprehension. Note that the models in Figures 2a to 2e specify hierarchical relations where executive functions predict emergent literacy skills, which predict word reading and listening comprehension, which, in turn, predict reading comprehension. In other words, emergent literacy skills are posited to mediate the relations of executive functions to word reading and listening comprehension. These model specifications are in line with the hierarchical relations hypothesis of DIER, but mediation of emergent literacy skills was not the primary focus in the present study. Instead, the primary question was whether executive functions and emergent literacy skills predict shared variance between word reading and listening comprehension.

The Figure 2a model included word reading and listening comprehension as predictors of reading comprehension without any predictors for word reading and listening comprehension (i.e., the simple view of reading). Figure 2b estimated the relation between word reading and listening comprehension after controlling for executive functions, attentional control and working memory. Figure 2c added morphological awareness to the Figure 2b model. Morphological awareness was included as a partial mediator in the relations of working memory and attentional control to word reading and listening comprehension based on DIER (i.e., working memory and attentional control ➔ morphological awareness ➔ word reading and listening comprehension; and working memory and attentional control ➔ word reading and listening comprehension). Figure 2d included the other emergent literacy skills (orthographic pattern recognition, letter naming fluency, rapid automatized naming, phonological awareness) and executive functions, but did not include morphological awareness. Figure 2e included executive functions and all the emergent literacy skills. Theoretically, the emergent literacy skills such as orthographic pattern recognition, letter naming fluency, rapid automatized naming, and phonological awareness are primarily predictors of word reading, not listening comprehension, although phonological awareness is also hypothesized to predict listening comprehension according to the lexical restructuring hypothesis (see above). To examine these hypotheses, their paths to listening comprehension, in addition to word reading, were included in the Figure 2d and Figure 2e models. In addition, children's biological sex and racial background were not included in the models because they were not statistically significant predictors of word reading and listening comprehension once all the executive functions and emergent literacy skills were included in the model.

Although not the primary question in the present study, for models that include working memory and attentional control (the Figures 2b to 2e models), it was tested whether the executive functions were directly related to reading comprehension after controlling for word reading and listening comprehension. It was hypothesized according to DIER and recent evidence (e.g., Dolean et al., 2021; Kim, 2017) that the relations of executive functions and emergent literacy skills to reading comprehension would be completely mediated by word reading and listening comprehension, provided similar or equivalent measurement of listening comprehension and reading comprehension. Results confirmed this hypothesis. Furthermore, it was tested whether the emergent literacy skills were directly related to reading comprehension over and above word reading and listening comprehension. As shown in Table A1 in Appendix, they were not directly related to reading comprehension although there was a statistically significant suppression effect of morphological awareness on reading comprehension. Further analysis showed that the suppression effect is due to listening comprehension as the suppression effect of morphological awareness on reading comprehension was no longer present when the Figure A1 model in Appendix was fitted without listening comprehension (results not shown). Lastly, results were essentially the same when the models were fitted *without* reading comprehension (see Online Supplemental Materials). All the models were estimated using full information maximum likelihood in Mplus 8 (Muthén & Muthén, 2013).

Model fit was evaluated using multiple indices, including a chi-square and associated p-value, the comparative fit index (CFI; > .95 as excellent), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR; < .05 as excellent; Kline, 2016). Note that the models in Figure 2 were not alternative models where competing structural relations with the same variables were specified, and therefore, model fit comparisons are not the focus in evaluating these models. Instead, the focus is changes in the magnitude of the relation between word reading and listening comprehension as a function of included predictors.

Results

Descriptive Statistics and Preliminary Analyses

Missing data were as follows: SWAN (3.5%), working memory (2.7%), morphological awareness (7.5%), phonological awareness (7.5%), orthographic pattern recognition (29%), letter naming fluency (7.8%), rapid automatized naming tasks (7.5%), WJ-III Oral Comprehension (2.4%), OWLS Listening Comprehension (2.4%), WJ-III Letter Word Identification (2.4%), WIAT-III Word Reading (2.4%), Sight Word Efficiency (2.4%), WJ-III Passage Comprehension (2.4%), and WIAT-III Word Reading (2.4%). The high missingness in orthographic awareness was due to the fact that one of the schools and two classrooms in the other schools were not available for this task. Not surprisingly, Little's test of missing completely at random was statistically significant: χ^2 (117) = 213.70, $p < .001$. In other words, the hypothesis that the data were missing completely at random was rejected. Further analysis revealed no statistically significant differences in all the included variables between children who had missing data on the orthographic pattern recognition task and those who did not except for the working memory task. Children's mean performance on the working memory task was statistically significantly higher for those who had missing data on the orthographic pattern recognition task than those who did not ($d = .21$, $p < .001$).

Table 1 shows descriptive statistics. In the tasks where standard scores are available (i.e., phonological awareness, word reading, and listening comprehension), the sample students' mean performances were in the average range. Distributional properties were all adequate. The RAN task had mild skewness (1.77) and kurtosis (5.52), and studies have shown that maximum likelihood estimation is robust to mild skewness and kurtosis (West et al., 1995). Subsequent analyses were conducted using raw scores.

Table 2 shows bivariate correlations. Word reading and listening comprehension measures were moderately related (.33 ≤ *r*s ≤ .39). Working memory and attentional control were weakly to moderately related to word reading and listening comprehension measures (.27 ≤ *r*s ≤ .46). Morphological awareness was moderately related to word reading (.50 ≤ *r*s ≤ .56), and fairly strongly related to listening comprehension (.63 ≤ *r*s ≤ .68). Phonological awareness and orthographic pattern recognition were moderately to fairly strongly related to word reading (.53 ≤ *r*s ≤ .63) and weakly to moderately related to listening comprehension (.29 ≤ *r*s ≤ .38). Letter naming fluency and rapid automatized naming were moderately related to word reading (|.37| ≤ *r*s ≤ |.52|) and weakly related to listening comprehension (|.16| ≤ *r*s ≤ |.19|). Emergent literacy skills were weakly to moderately related to each other (|.24| ≤ *r*s ≤ |.54|). Word reading and listening comprehension were moderately to strongly related to reading comprehension (.49 ≤ *r*s ≤ .79).

Relation Between Word Reading and Listening Comprehension

Measurement models were fitted for word reading and listening comprehension. Loadings for all the indicators were strong and statistically significant (see Figure 2). The structural equation models shown in Figure 2 were fitted to the data to examine the relation of executive functions and emergent literacy skills to the relation between word reading and listening comprehension. All the models had good fit to the data (see Table 3). In the baseline model without predictors of word reading and listening comprehension (Figure 2a), word reading and listening comprehension had a positive and moderate relation (.54, $p < .001$). As expected, word reading and listening comprehension were positively related to reading comprehension. Approximately 95% of variance in reading comprehension was explained by word reading and listening comprehension.

When working memory and attentional control were added as predictors of word reading and listening comprehension (Figure 2b), the relation between word reading and listening comprehension was weaker than the baseline model, but still remained moderate (.39, $p < .001$). Working memory was weakly related to word reading and moderately related to listening comprehension. Attentional control was moderately related to word reading and listening comprehension. Totals of 27% of variance in word reading and 30% of variance in listening comprehension were explained.

When morphological awareness was included (Figure 2c), word reading and listening comprehension were no longer related (.05, $p = .56$). Morphological awareness was moderately related to word reading and strongly related to listening comprehension over and above working memory and attentional control. Totals of 41% of variance in word reading and 73% of variance in listening comprehension were explained by morphological awareness, working memory, and attentional control.

When the other emergent literacy skills, but not morphological awareness, were included (Figure 2d), the relation between word reading and listening comprehension was weak (.22, $p = .003$). Word reading was independently predicted by phonological awareness, orthographic pattern recognition, letter naming fluency, rapid automatized naming, and attentional control. Listening comprehension was independently predicted by phonological awareness, working memory, and attentional control. Totals of 64% of variance in word reading and 40% of variance in listening comprehension were explained by the included predictors.

When all the emergent literacy skills, working memory, and attentional control were included, word reading and listening comprehension were not related (.06, $p = .46$). Word reading was independently predicted by morphological awareness, orthographic pattern recognition, letter naming fluency, rapid automatized naming, phonological awareness, and attentional control. Listening comprehension was independently predicted by morphological awareness and working memory. Totals of 66% of variance in word reading and 73% of variance in listening comprehension were explained by the included predictors.

Discussion

In this study, we examined the extent to which executive functions (working memory and attentional control) and emergent literacy skills explain the shared variance between word reading and listening comprehension, using data from English-speaking students in Grade 1. While prior work on the simple view of reading primarily focused on the dissociability of word reading and listening comprehension and their independent contributions to reading comprehension, literature consistently showed a positive and moderate relation between word reading and listening comprehension (see the literature review above). In the current study, we explored sources of their relation grounded on DIER (Kim, 2020a, 2020b, 2023) and the lexical quality hypothesis (Perfetti, 2007). DIER posits that executive functions are necessary for word reading and listening comprehension, and their component skills (e.g., morphological, phonological, and orthographic skills for word reading; vocabulary and syntactic knowledge, and higher-order cognitive skills for listening comprehension). Furthermore, emergent literacy skills, morphological awareness in particular, are posited to be related to word reading, and to vocabulary, morphosyntactic, and syntactic knowledge, which, in turn, are important to listening comprehension. Hence, the shared variance between word reading and listening comprehension is largely due to executive functions and emergent literacy skills.

In the present study, word reading and listening comprehension were moderately related (.54), which is convergent with prior work (e.g., Dolean et al., 2021; Foorman et al., 2018; Ho et al., 2017; Joshi et al., 2012; Kim, 2015b, 2020a; L. W. Lee & Wheldall, 2009; Lonigan et al., 2018). Also in line with previous work (Daneman & Merikle, 1996; Deacon et al., 2009; Kendeou et al., 2008; Kim, 2015a, 2016, 2020a; Kim et al., 2018), working memory and attentional control were related to both word reading and listening comprehension, explaining 26% and 29% of variance in word reading and listening comprehension, respectively. When it comes to the focal relation of interest in this study—word reading and listening comprehension—inclusion of working memory and attentional control reduced the magnitude of the relation to .39 from .54. These findings indicate that working memory and attentional control indeed explain some of the shared variance between word reading and listening comprehension. These results are in line with a meta-analysis which showed the relation of working memory to decoding and comprehension (Peng et al., 2018).

A striking result in this study is the role of morphological awareness in substantially explaining the shared variance between word reading and listening comprehension, beyond working memory and attentional control. When morphological awareness was included over and above executive functions, morphological awareness was moderately related to word reading and strongly related to listening comprehension. Morphological awareness explained an additional 14% of variance in word reading and an additional 43% of variance in listening comprehension over the model with working memory and attentional control only. Importantly, word reading and listening comprehension were no longer related once morphological awareness was accounted for. When all the emergent literacy skills were included in the model (Figure 2e), morphological awareness was the only one that was independently related to both word reading *and* listening comprehension over and above the other emergent literacy skills and executive functions. The relation of morphological awareness to word reading is convergent with previous studies (e.g., Bowers et al., 2010; Goodwin & Ahn, 2013; J. Lee et al., 2022). The relation of morphological awareness to listening comprehension is also in line with previous studies (Ho et al., 2017; Kim et al., 2020). Overall, these results support the hypothesis that the relation between word reading and listening comprehension is largely explained by their shared reliance on morphological awareness, indicating that morphological processing and awareness underpin both word reading and comprehension processes (Duke & Cartwright, 2021; Kim, 2020a, 2020b; Levesque et al., 2021; Nagy et al., 2014).

We also hypothesized that the other emergent literacy skills such as phonological awareness and orthographic awareness might explain the shared variance between word reading and listening comprehension, given their relations with morphological awareness (Lyster et al., 2020; McBride-Chang et al., 2005, 2008). They were related to both word reading and listening comprehension bivariately (see Table 2). Furthermore, when phonological awareness, orthographic pattern recognition, letter naming fluency, and rapid automatized naming were included as predictors of word reading and listening comprehension, they explained the shared variance between word reading and listening comprehension such that the magnitude of the relation was reduced to .22 from .54. Phonological awareness was independently related to both word reading and listening comprehension. However, once morphological awareness was accounted for (Figure 2e), the other emergent literacy skills did not further explain the shared variance between word reading and listening comprehension. These results suggest that their contributions to listening comprehension largely overlap with that of morphological awareness, and their primary unique contributions are to word reading. This was observed in the independent contributions of phonological awareness, orthographic pattern recognition, letter naming fluency, and rapid automatized naming to word reading, but not to listening comprehension (Figure 2e). Emergent literacy skills together explained additional variance in word reading by 25% over the model that included morphological awareness, working memory, and attentional control (i.e., from 41% in Figure 2c to 66% in Figure 2e).

The findings of this study support theoretical models/frameworks that expand the simple view of reading, particularly those that explicitly discuss the interconnected nature of relations such as DIER (Kim, 2020a, 2020b, 2023). According to DIER, skills and knowledge that contribute to reading comprehension have specific structural relations. One case in point is the relation between word reading and listening comprehension, the focal relation in the present study: Word reading and listening comprehension are related because they are built on shared skills, namely executive functions and emergent literacy skills (especially morphological awareness). These findings advance our theoretical understanding and precision by unpacking component skills of word reading and listening comprehension and the relations among component skills (Kim, 2020a, 2023). These results show that word reading and listening comprehension draw on shared skills—executive functions and morphological awareness may act as a bridge connecting word reading and listening comprehension—although some component skills make greater contributions to word reading versus listening comprehension.

Although not the main focus of the present study, the results also expand our understanding of the hierarchical nature of relations (Kim, 2020a, 2020b, 2023), that is, executive functions support emergent literacy skills, which, in turn, support word reading and listening comprehension, which, in turn, support reading comprehension. As shown in Figure 2e, emergent literacy skills partially mediated the relations of working memory and attentional control to word reading and listening comprehension, and word reading and listening comprehension completely mediated the relations of executive functions and emergent literacy skills to reading comprehension (see also Appendix). Note though that mediation can be examined more rigorously with longitudinal and experimental data, and therefore, future studies with such designs are needed for causal evidence on mediation.

Given the correlational nature of the data, causal inferences are limited. The causal role of morphological awareness in vocabulary and decoding/word reading is robust according to accumulated evidence (see systematic review and meta-analysis; e.g., Bowers et al., 2010; Goodwin & Ahn, 2013), but causal evidence on its role in listening comprehension is sparse, and therefore, future studies with experimental designs are needed. Nonetheless, the present results, together with a large body of previous correlational and experimental studies, suggest several implications for practice. The moderate magnitude of the relation between word reading and listening comprehension for beginning readers implies that some beginning readers' performance levels in word reading and listening comprehension will covary or be relatively similar (e.g., high word reading and high listening comprehension; average word reading and average listening comprehension) while other individuals will have discrepancy between word reading and listening comprehension (e.g., average in word reading but high in listening comprehension or the other way around). Our results suggest that individuals' similar relative performance levels in word reading and listening comprehension may be explained by their executive functions and morphological awareness.

Results of the present study indicate that morphological awareness is a high-leverage skill that is important for the development of both word reading *and* listening comprehension, and therefore, explicit and systematic instruction on morphological awareness likely improves both word reading and listening comprehension, and ultimately reading comprehension. Studies have shown that quality instruction on morphological awareness improves children's morphological knowledge, vocabulary, decoding, and spelling skills (Bowers et al., 2010; Goodwin & Ahn, 2013), and effects are particularly large for younger students in preschool to Grade 2, and struggling readers (Bowers et al., 2010). Literacy instruction in primary grades typically devotes attention to phonological awareness and grapheme-phoneme correspondences while instructional attention to morphological structures tends to be delayed until upper elementary grades. The findings of the present study highlight a need for explicit and systematic instruction on morphological awareness even in primary grades.

On the other hand, discrepancies in performances on word reading and listening comprehension are likely explained by other factors. For example, phonological awareness, orthographic pattern recognition, letter name knowledge, and rapid automatized naming are important to word reading (see Figure 2d); therefore, individuals with relative strengths in these emergent literacy skills are likely to be stronger in word reading. In contrast, individuals with relative strengths in skills that contribute to comprehension (e.g., higher-order cognitions such as inference and perspective taking; Florit et al., 2011; Kendeou et al., 2008; Kim, 2015a, 2016) are likely to have relative strengths in listening comprehension. These results indicate the importance of identifying students' skill in word reading and listening comprehension *and* their component skills, and providing differentiated instruction based on identified needs (e.g., Catts et al., 2006; Connor et al., 2013).

The hierarchical structural relations shown in the mediated relations suggest a need for a systematic approach to building strong foundations in lower-level skills to support development of higher-order skills (Kim, 2020a,2020b, 2023). One consequence of hierarchical structural relations is upward cascading effects—weak foundational skills increase vulnerability in higher-order skills. For example, support for sustained attention is necessary as a building block for developing emergent literacy skills. In turn, quality teaching of emergent literacy skills builds a strong foundation for word reading *and* listening comprehension. This focus on systematically building foundations is in line with a call for early identification of students' needs and prevention of reading difficulties (Catts & Hogan, 2021; Catts & Petscher, 2022) to start the virtuous cycle of skills development (e.g., the interactive/bidirectional relations hypothesis; Kim, 2020a).

Limitations, Future Directions, and Conclusion

The present findings are from English-speaking children in Grade 1, and generalizability of the findings is limited to a similar population. Therefore, the study should be replicated and extended with children in various developmental phases of reading, and those who speak and learn to read in languages other than English. Morphology plays a critical role in word reading in writing systems where morphology is systematically reflected in spelling, such as a morphophonological writing system (e.g., English, Greek, Korean; McBride-Chang et al., 2005, 2008; Protopapas et al., 2012) and a morphosyllabic writing system (e.g., Chinese;

Ho et al., 2017; Kim et al., 2020; McBride-Chang et al., 2005, 2008). In writing systems where this is not the case (shallow orthographies such as Finnish), morphological awareness would not be as critical for word reading, and thus, the role of morphological awareness in the shared variance between word reading and listening comprehension would be limited (Kim, 2020a). Word reading and listening comprehension are still posited to be related in shallow orthographies because of their shared reliance on executive functions. Future studies are warranted to examine these hypotheses.

As noted above, there was substantial missingness in the orthographic pattern recognition task due to unavailability of one of the schools as well as two classes from additional schools. Although full information maximum likelihood estimation which is robust with moderate missingness was used in the analysis, a future replication is needed. In addition, future studies with a larger number of clusters can account for the nesting structure of the data—children were nested within classrooms which were nested within schools. An additional limitation is that observed variables were used for predictors of word reading and listening comprehension. For example, a single task was used for morphological awareness. Previous studies have shown that morphological awareness is a multidimensional construct that includes inflectional, derivational, and compound morphemes and receptive and productive aspects (Nagy et al., 2014). In the present study, items included inflectional and derivational morphemes, but not compound morphemes. Future studies with multiple tasks need to replicate the present study.

Similarly, attentional control and working memory were measured by single tasks. SWAN is a rating scale and previous studies have shown that teacher rated SWAN validly captures attentional control, including ADHD symptoms (e.g., Arnett et al., 2013; Arrington et al., 2014; Little et al., 2016; Sáez et al., 2012). Attentional control has been also widely measured by direct cognitive measures although their relation to language and cognitive skills are less consistent (Arrington et al., 2014; Kim & Phillips, 2014). A future study that includes both types of attentional control measures would be useful. Working memory was also measured using a single task, and the reliability of working memory was less than optimal (.65). The working memory task (listening-span task) involved comprehension of simple sentences (e.g., Apples are red) and asked children to identify the last words in heard sentences. This approach captures the ability to hold and process information simultaneously, and has been widely used (e.g., Daneman & Merikle, 1996; Gaulin & Campbell, 1994; Nouwens et al., 2021). However, although children's responses on the veracity of the statements were not scored and only their recall of final words was scored, the linguistic nature of the task might have influenced the present results. This point was examined in previous meta-analyses, and results suggest different patterns of relation with word reading/decoding versus listening comprehension. For listening comprehension, verbal working memory (e.g., listening-span task) was more strongly related with language comprehension ($r = .41$) than was nonverbal working memory (e.g., numerical or arithmetic span task; Daneman & Merikle, 1996). In contrast, the relation of working memory to decoding was not different as a function of the type of working memory (verbal, numerical, or visuospatial; Peng et al., 2018). Future studies using multiple measures of varying nature of working memory are warranted.

Another direction for future studies is inclusion of additional skills and knowledge, such as vocabulary, syntactic knowledge, and higher-order cognitive skills. As noted above, the comprehensively specified hypothesized pathways by which the emergent literacy skills, morphological awareness in particular, are related to listening comprehension are via vocabulary, morphosyntactic, and syntactic knowledge, and higher-order cognitions (e.g., inference). That is, the following chains of relations are posited: morphological awareness ➔ vocabulary, syntactic knowledge ➔ higher-order cognitions ➔ listening comprehension. Future work can examine this hypothesis.

Overall the present study revealed that the shared variance between word reading and listening comprehension is predicted by executive functions and emergent literacy skills. Although word reading and listening comprehension both independently contribute to reading comprehension, they are both undergirded by executive functions and emergent literacy skills. Especially notable is morphological awareness as a key connector between word reading and listening comprehension, suggesting that semantic processing plays a role in both word reading and listening comprehension.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Appendix

To investigate whether working memory, attentional control, morphological awareness, orthographic pattern awareness, letter naming fluency, rapid automatized naming, and phonological awareness are directly related to reading comprehension over and above word reading and listening comprehension, the Figure A1 model shown below was fitted. Model fit was excellent: $\chi^2(81.10)$, $p < .001$; CFI = .99, RMSEA = .05 [.04, .07], SRMR = .019. Given that the Figure 2e model is nested within the Figure A1 model, a chi-square difference test was conducted, which yielded $p = .01$ ($\Delta\chi^2 = 18.47$, $\Delta df = 7$). This result suggests that the Figure A1 model is a better fitting model than the Figure 2e model. However, as shown in Table A1, this was primarily driven by the suppression effect of morphological awareness on reading comprehension (−.40, $p = .008$). The suppression effect is also observed in the inflated path coefficient from listening comprehension to reading comprehension as shown in Table A1 (.74) from .36 in Figure 2e. Hence, the more parsimonious Figure 2e model is chosen.

Table A1

Standardized Path Estimates for the Figure A1 Model

Variable	Estimate	*p* value
Word Reading	.74	< .001
Listening Comprehension	.74	< .001
Working Memory	−.00	.95
Attentional Control	−.01	.76
Morphological Awareness	−.40	.008
Orthographic Pattern Awareness	−.03	.58
Letter Naming Fluency	−.00	.90
Rapid Automatized Naming	−.03	.43
Phonological Awareness	.03	.53

Note. Estimates are of direct relations to reading comprehension.

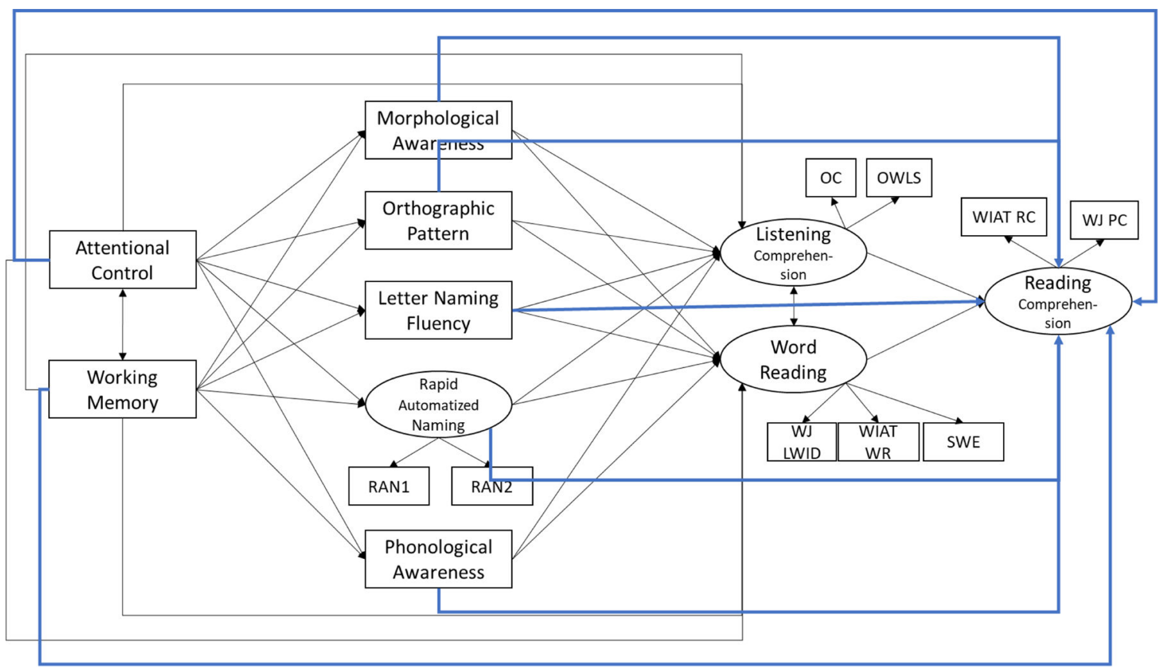

Figure A1.
Model Where Executive Functions and Emergent Literacy Skills are Allowed to Directly Relate to Reading Comprehension Over and Above Word Reading and Listening Comprehension
Note. Blue pathways are direct paths to reading comprehension.

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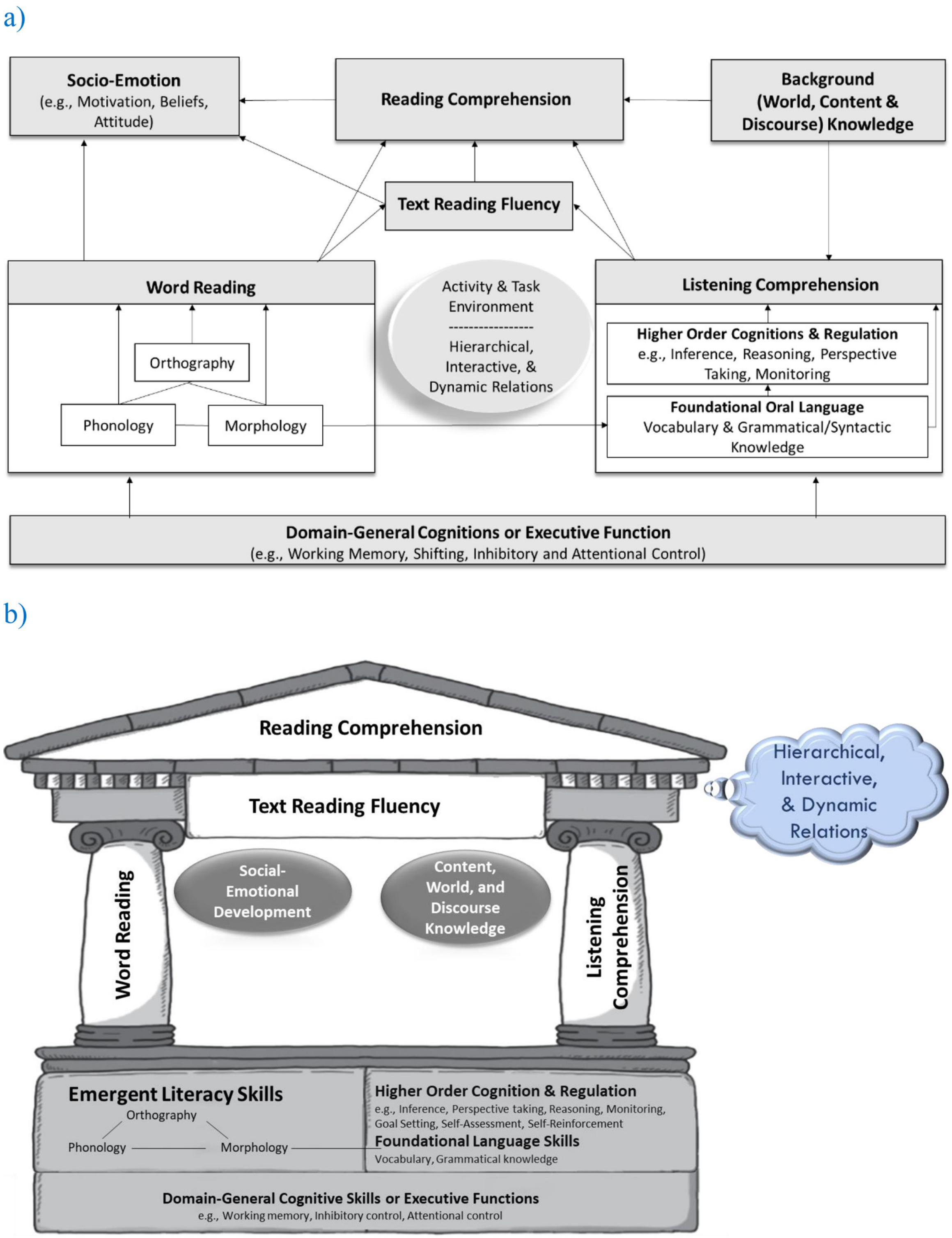
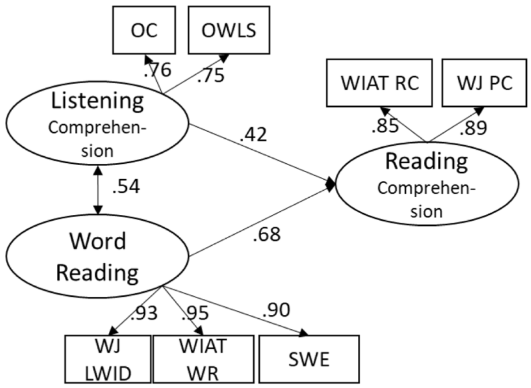


Figure 1.

The Direct and Indirect Effects model of Reading (DIER, Kim, 2020a, 2020b, 2023). Note. Figure 1a and Figure 1b represent the same ideas, but Figure 1b is a heuristic reexpression of Figure 1a that highlights the hierarchical relations hypothesis.

a)


OC
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WIAT RC
WJ PC
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Listening
Comprehen-
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Reading
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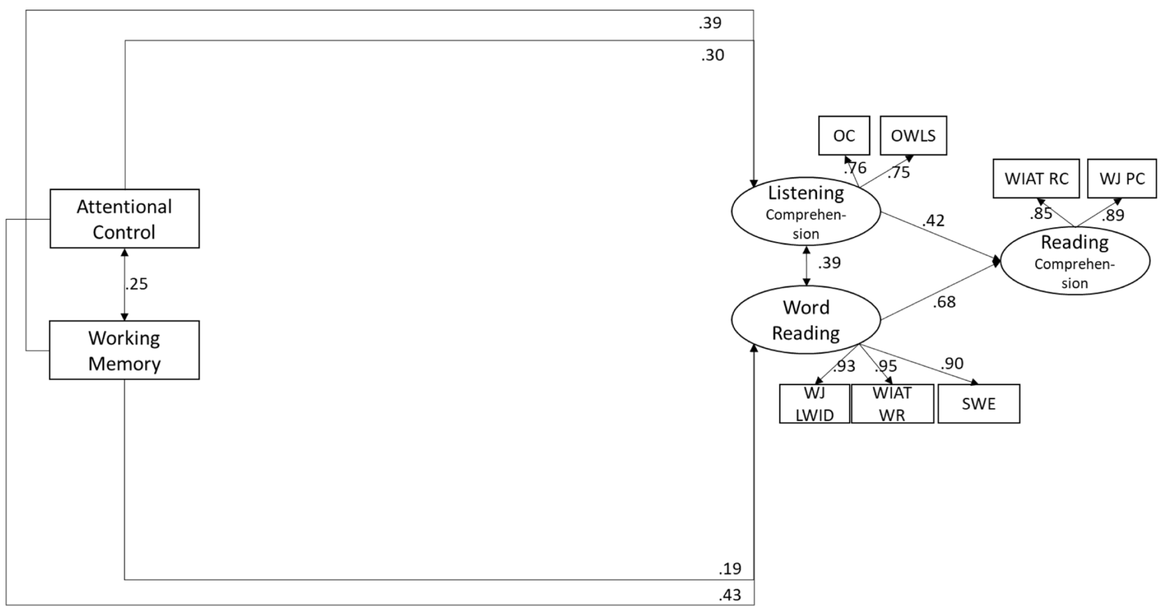
b)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sion
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Working
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WIAT
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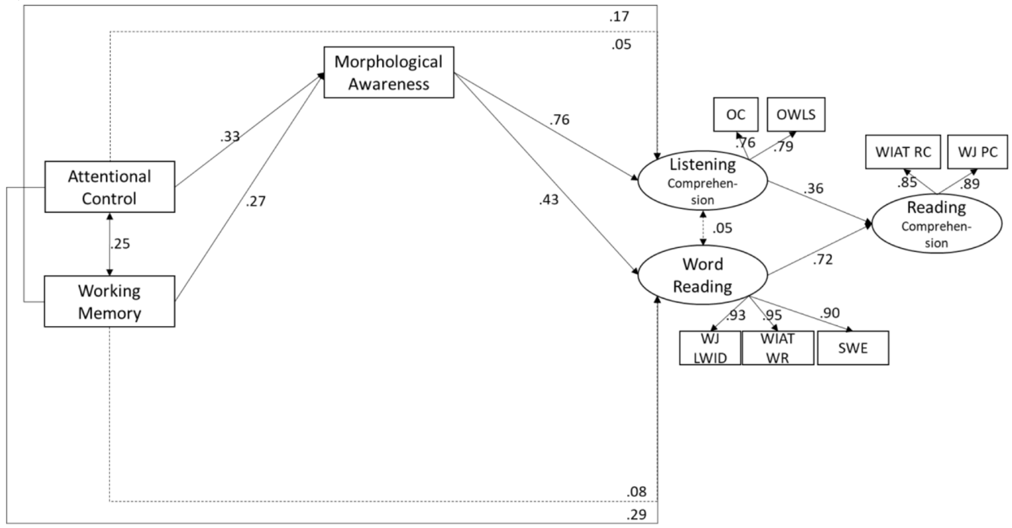
c)


Morphological Awareness
Attentional Control
Working Memory
Listening Comprehension
Word Reading
Reading Comprehension
OC
OWLS
WIAT RC
WJ PC
WJ LWID
WIAT WR
SWE
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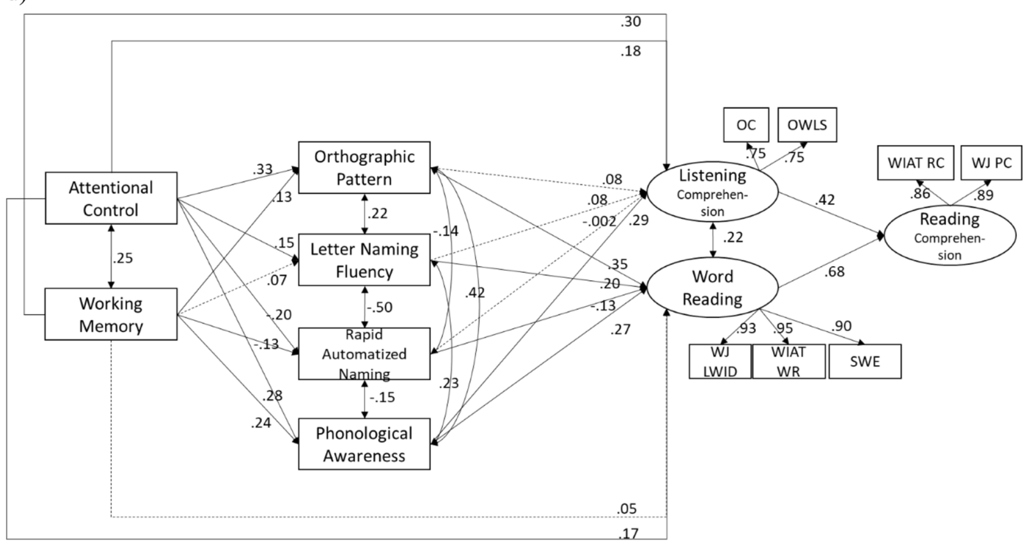
d)


Attentional Control
Working Memory
Orthographic Pattern
Letter Naming Fluency
Rapid Automatized Naming
Phonological Awareness
Listening Comprehension
Word Reading
Reading Comprehension
OC
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WIAT RC
WJ PC
WJ LWID
WIAT WR
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.30
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e)

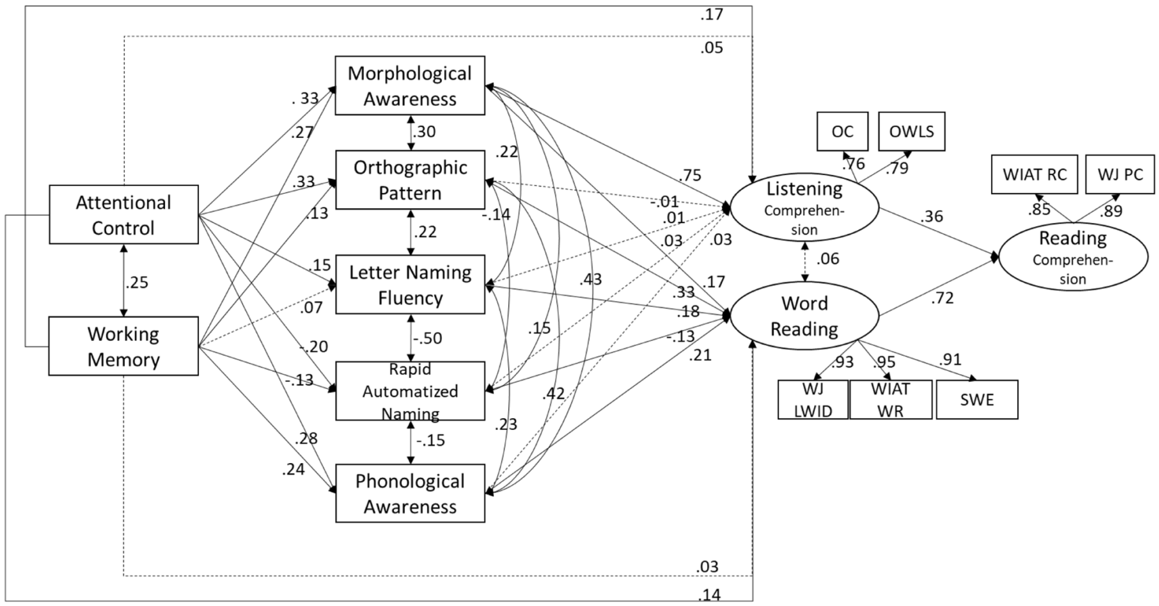

Figure 2.

Standardized Path Coefficients for the Relations of Executive Functions and Emergent Literacy Skills to Word Reading and Listening Comprehension and the Relation Between Word Reading and Listening Comprehension

Note. Solid pathways are statistically significant, whereas dotted pathways are not.

Table 1

Descriptive Statistics

Variable	Mean	*SD*	Min	Max	Skewness	Kurtosis
Working Memory	2.70	1.77	0	9	0.35	−0.22
SWAN	76.05	22.19	18	126	0.13	−0.12
Elision	7.78	4.18	0	20	0.94	0.91
Elision SS	10.36	2.94	2	19	0.27	1.13
Orthographic Pattern	25.23	6.45	9	39	0.32	−0.51
Letter Naming Fluency	57.87	14.89	7	104	0.08	0.71
Rapid Automatized Naming	28.68	8.20	15	78	1.77	5.52
Morphological Awareness	19.30	6.68	1	36	−0.07	−0.48
Letter Word Identification	38.48	6.61	19	60	0.37	0.16
Letter Word Identification SS	112.47	12.89	75	142	−0.45	−0.01
WIAT Word Reading	23.02	10.20	2	55	0.40	−0.26
WIAT Word Reading SS	104.80	16.04	65	148	−0.09	−0.38
Sight Word Efficiency	43.66	14.32	4	73	−0.03	−0.63
Sight Word Efficiency SS	105.01	16.79	55	144	−0.46	−0.06
Oral Comp	16.18	3.74	5	26	0.14	−0.23
Oral Comp SS	112.26	13.40	73	148	−0.05	−0.24
OWLS Listening Comp	78.40	12.69	48	105	−0.28	−0.69
OWLS Listening Comp SS	105.39	13.82	62	133	−0.45	−0.31
WJ-III Passage Comp	21.56	3.90	6	31	−0.33	0.40
WJ-III Passage Comp SS	106.73	12.45	55	133	−0.79	−0.73
WIAT-III Reading Comp	22.51	7.95	1	36	−0.52	−0.40
WIAT-III Reading Comp SS	104.78	14.50	60	141	−0.08	0.26

Note. Unless otherwise noted, raw scores are reported. SWAN = Strengths and Weaknesses of ADHD Symptoms and Normal Behavior Scale; SS = Standard score; WIAT = Wechsler Individual Achievement Test Third Edition; Comp = Comprehension; OWLS = Oral and Written Language Scales; WJ-III: Woodcock Johnson Third Edition; WIAT-III = Wechsler Individual Achievement Test Third Edition.

Table 2

Correlations Between Variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Working Memory	--												
2. SWAN	.25	--											
3. Morphological awareness	.35	.39	--										
4. Elision	.30	.33	.54	--									
5. Orthographic Pattern	.23	.39	.44	.50	--								
6. Letter Naming Fluency	.10	.16	.27	.29	.28	--							
7. Rapid Automatized Naming	−.18	−.23	−.26	−.24	−.24	−.52	--						
8. WJ-III Letter Word ID	.27	.44	.56	.58	.63	.44	−.39	--					
9. WIAT-III Word Reading	.29	.46	.54	.57	.62	.41	−.37	.90	--				
10. Sight Word Efficiency	.26	.45	.50	.53	.58	.52	−.47	.83	.86	--			
11. Oral Comp	.35	.27	.63	.37	.29	.19	−.16	.38	.39	.36	--		
12. OWLS Listening Comp	.33	.34	.68	.38	.34	.18	−.17	.39	.39	.33	.57	--	
13. WJ-III Passage Comp	.33	.44	.57	.55	.52	.39	−.36	.77	.79	.76	.49	.49	--
14. WIAT-III Reading Comp	.39	.41	.61	.54	.49	.35	−.34	.69	.71	.69	.55	.55	.76

Note. All correlations are statistically significant ($p < .05$), except for the correlation equal to .10. SWAN = Strengths and Weaknesses of ADHD Symptoms and Normal Behavior Scale; N = Naming; WJ-III = Woodcock Johnson Third Edition; WIAT-III = Wechsler Individual Achievement Test Third Edition; Comp = Comprehension; OWLS = Oral and Written Language Scales.

Table 3

Model Fit Statistics

Model	χ^2 (df), p	CFI	RMSEA [90% CI]	SRMR
Figure 2a	25.66 (11), .007	.99	.06 [.03, .09]	.018
Figure 2b	34.45 (21), .03	.99	.04 [.01, .07]	.018
Figure 2c	55.43 (26), < .001	.99	.06 [.04, .08]	.021
Figure 2d	79.37 (41), < .001	.99	.05 [.03, .07]	.020
Figure 2e	99.56 (46), < .001	.99	.06 [.04, .07]	.021

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