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Developmental, Component-Based Model of Reading Fluency: An Investigation of Predictors of Word-Reading Fluency, Text-Reading Fluency, and Reading Comprehension

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Abstract

The primary goal was to expand our understanding of text reading fluency (efficiency or automaticity)—how its relation to other constructs (e.g., word reading fluency and reading comprehension) changes over time and how it is different from word reading fluency and reading comprehension. We examined (1) developmentally changing relations among word reading fluency, listening comprehension, text reading fluency, and reading comprehension; (2) the relation of reading comprehension to text reading fluency; (3) unique emergent literacy predictors (i.e., phonological awareness, orthographic awareness, morphological awareness, letter name knowledge, vocabulary) of text reading fluency vs. word reading fluency; and (4) unique language and cognitive predictors (e.g., vocabulary, grammatical knowledge, theory of mind) of text reading fluency vs. reading comprehension. These questions were addressed using longitudinal data (two timepoints; Mean age = 5;24 & 6;08) from Korean-speaking children ($N = 143$). Results showed that listening comprehension was related to text reading fluency at time 2, but not at time 1. At both times text reading fluency was related to reading comprehension, and reading comprehension was related to text reading fluency over and above word reading fluency and listening comprehension. Orthographic awareness was related to text reading fluency over and above other emergent literacy skills and word reading fluency. Vocabulary and grammatical knowledge were independently related to text reading fluency and reading comprehension whereas theory of mind was related to reading comprehension, but not text reading fluency. These results reveal developmental nature of relations and mechanism of text reading fluency in reading development.

Text reading fluency is typically defined as “the ability to read a text quickly, accurately, and with proper expression” (National Institute of Child Health and Human Development [NICHD], 2000, p. 3–5). In particular, previous studies which operationalized text reading fluency as text reading efficiency or automaticity excluding reading prosody have shown a strong relation of text reading fluency to reading comprehension (Daane et al., 2005; Fuchs, Fuchs, Hosp, Jenkins, 2001; Jenkins et al., 2003; Kim, Park, & Wagner, 2014; Kim, Wagner, & Lopez, 2012; Kuhn & Stahl, 2003; Riedel, 2007; Roehrig et al., 2008). Evidence from these studies suggests that text reading fluency explains additional variance in reading comprehension over and above word reading and language comprehension (Kim et al.,

2012, 2014; Klauda & Guthrie, 2008)—the two critical and necessary skills of reading comprehension according to the simple view of reading (Catts, Adlof, & Ellis Weismer, 2006; Hoover & Gough, 1990; Joshi, Tao, Aaron, & Quiroz, 2012; Kim, 2015; Mancilla-Martinez, Kieffer, Biancarosa, Christodoulou, & Snow, 2011; Savage, 2006; Vellutino, Tunmer, Jaccard, & Chen, 2007). Despite a large number of studies showing a strong relation of text reading fluency to reading comprehension for primary grade children, however, we have limited empirical evidence about the nature and role of text reading fluency (efficiency) in reading development. To address this gap, in the present study we examined how the relation of text reading fluency to reading comprehension changes over time, and how text reading fluency is a differentiated construct from word reading fluency and reading comprehension by examining unique, independent predictors of text reading fluency vs. word reading fluency, and text reading fluency vs. reading comprehension. These questions were addressed using longitudinal data (two timepoints) from Korean-speaking children. It is important to note that in the present study, we operationalize ‘reading fluency,’ as accuracy and rate at which the individual reads words at the lexical (i.e., reading words in isolation) and discourse levels (i.e., reading words in context). Therefore, ‘text’ reading fluency refers to reading words in connected texts such as passages, and ‘word’ reading fluency refers to reading words in isolation or in a list format. Reading prosody (or expression) is an important aspect of text reading fluency (Kuhn, Schwanenflugel, & Meisinger, 2010; Kuhn & Stahl, 2003), but it was beyond the scope of the present study. Although we acknowledge that automaticity or efficiency¹ are more accurate terms to describe accuracy and rate of reading words in or out of context, we use the term, fluency, given its wide use in the literature (e.g., Adlof, Catts, & Little, 2006; Baker, Stoolmiller, Good, & Baker, 2011; Fuchs et al., 2001; Jenkins et al., 2003; Kim et al., 2014; Wagner, Kim, & Foster, 2011; Nathan & Stanovich, 1991; Roehrig et al., 2008; Schwanenflugel et al., 2006; Silverman, Speece, Haring, & Ritchey, 2013; Wolf & Katzir-Cohen, 2001). Therefore, in the present study, word reading fluency refers to word reading efficiency or automaticity and text reading fluency refers to text reading efficiency or automaticity.

Text Reading Fluency and Reading Comprehension

Theoretical account about the role of text reading fluency in reading comprehension involves limited cognitive capacity (LaBerge & Samuels, 1974; Samuels, 2006). Reading words with accuracy and speed lifts cognitive constraints, allowing cognitive resources (e.g., working memory and attention) to be used for higher order meaning construction. That is, text reading fluency “unglues” the child from decoding (Chall, 1983). Recent studies have shown that text reading fluency, although highly related, is a separate construct from word reading fluency (Wagner et al., 2011, 2012, 2014; Kim & Wagner, in press; but see Schwanenflugel et al., 2006) and text reading fluency was predicted not only by word reading fluency, but also by oral language comprehension (listening comprehension hereafter), especially after children reached a certain level of word reading proficiency. These results are in line with Stanovich, Cunningham, and Feeman (1984)’s finding that

¹Note that automaticity and efficiency are not equivalent as the former refers to effortlessness whereas the latter refers to accuracy and speed (see Stanovich, 1980).

first-grade children read the same words more rapidly in context (i.e., coherent paragraph) than out of context (i.e., random, incoherent paragraph), and this difference was more pronounced at the end of school year than the beginning of the year.

Furthermore, the relation of text reading fluency to reading comprehension changed over time (Kim et al., 2012, 2014; Kim & Wagner, in press). In the beginning phase of reading development when decoding is the primary focus of development, word reading fluency and text reading fluency largely overlapped such that word reading fluency strongly influenced reading comprehension whereas text reading fluency did not make an independent contribution to reading comprehension. At a later phase, text reading fluency made an independent contribution to reading comprehension over and above word reading fluency and listening comprehension. For children learning to read in an opaque orthography, English, an independent contribution of text reading fluency was observed as early as in grade 2 (Kim et al., 2012) and also in grade 4 (Kim & Wagner, in press; Jenkins et al., 2003; Klauda & Guthrie, 2008). For children learning to read in a relatively transparent orthography, Korean, an independent contribution of text reading fluency was observed for younger children, kindergartners, in a cross-sectional study (Kim et al., 2014). The finding in Korean raises an important question about text reading fluency, namely, whether the developmental progression pattern observed in English (e.g., Wagner et al., 2011, 2012; Kim & Wagner, in press) is generalizable to languages with a transparent orthography. Theoretically, the pattern of developmental progression is expected to be similar across opaque and transparent orthographies—as children develop word reading skills, their cognitive resources can be allocated to meaning construction, and children’s ability to process meaning (i.e., listening comprehension) is expected to be related to text reading fluency. Although opaque and transparent orthographies differ in terms of duration of ‘word’ reading acquisition (Frost, Katz, & Benton, 1987; Seymour, Aro, & Erskine, 2003), the overall pattern of developmental relations of word reading fluency, listening comprehension, text reading fluency, and reading comprehension might be similar.

The hypothesis that text reading fluency involves meaning comprehension to some extent (Jenkins et al., 2003; Stanovich et al., 1984; Wolf & Katzir-Cohen, 2001) is supported by two lines of studies. First, studies suggest that reading comprehension makes an independent contribution to text reading fluency after accounting for word reading fluency (Jenkins et al., 2003), and word reading fluency and decoding fluency for children (Hudson, Torgesen, Lane, & Turner, 2012). These results have been taken to suggest that text reading fluency and reading comprehension have a bidirectional relation. The second line of studies has shown that ‘listening’ comprehension is related to text reading fluency after accounting for word reading fluency (Wagner et al., 2011, 2012, 2014; Kim & Wagner, in press). Together, these studies indicate that text comprehension (listening comprehension and reading comprehension) is indeed involved in text reading fluency. However, what is unclear is whether ‘reading’ vs. ‘listening’ comprehension matters in relation to text reading fluency after accounting for each other. Previous studies of reading comprehension to text reading fluency did not account for listening comprehension (Baker et al., 2011; Jenkins et al., 2003; Hudson et al., 2012), and those of listening comprehension to text reading fluency did not account for reading comprehension (Wagner et al., 2011, 2012, 2014; Kim & Wagner, in press). In the present study, we addressed this gap in the literature by investigating (1) the

relations of word reading fluency and listening comprehension to text reading fluency, and their relations to reading comprehension, and (2) the relation of reading comprehension to text reading fluency after accounting for word reading fluency and listening comprehension.

Emergent Literacy Skills Involved in Text Reading Fluency vs. Word Reading Fluency

One critical question in understanding text reading fluency as a construct is what differentiates text reading fluency from word reading fluency. That is, what makes accuracy and speed of reading words in connected text distinguished from accuracy and speed of reading context-free words? One way to examine this question is investigating how unique component emergent literacy skills differ for word reading fluency vs. text reading fluency. If text reading fluency is a distinctive construct from word reading fluency, various emergent literacy skills would be somewhat differentially related to word reading fluency vs. text reading fluency. According to the Ehri's model of word reading development (2002), text reading fluency is a direct outcome of word reading fluency, which, in turn, is the outcome of word reading accuracy. Given that the foundational skill for text reading fluency is word reading fluency (Hudson, Torgesen, Lane, & Turner, 2012), the influence of emergent literacy skills² (e.g., phonological awareness, orthographic awareness, morphological awareness, letter name knowledge, vocabulary, and rapid automatized naming) on word reading fluency vs. text reading fluency should be largely shared, particularly during the beginning phase of reading development. However, there might be unique emergent literacy skills that relate to text reading fluency over and above word reading fluency. In particular, orthographic awareness (knowledge of patterns of letters and word specific orthographic representation, Apel & Apel, 2011) might play a unique role in text reading fluency because readers, including developing readers, process words parafoveally (e.g., Plummer & Rayner, 2012; Rayner, Pollatsek, Ashby, & Clifton, 2012). Therefore, the ability to recognize multi-letter units beyond one-on-one mapping (i.e., orthographic awareness or forming orthographic codes) might facilitate word reading in connected texts (Nathan & Stanovich, 1991). In fact, Barker, Torgesen, and Wagner (1992) found that orthographic awareness was more strongly related to text reading fluency than to word reading fluency. To examine this hypothesis, the following emergent literacy skills were included in the present study as predictors of word reading fluency and text reading fluency: phonological awareness, orthographic awareness, morphological awareness, letter name knowledge, rapid automatized naming, and vocabulary. These emergent literacy skills were selected based on evidence about their relations to word reading in English and Korean (e.g., Adams, 1990; Cho & McBride-Chang, 2005; Cho, McBride-Chang, & Park, 2008; Compton, DeFries, & Olson, 2001; Kim, 2007, 2011; NICHD, 2000; Ouellette, 2006; Ricketts, Snowling, & Bishop, 2007; Schatschneider, Fletcher, Francis, Carlson, & Foorman, 2004; Wang, Ko, & Choi, 2009). These emergent literacy skills were assessed at time 1 while word reading fluency and text reading fluency were assessed at both earlier (time 1) and later timepoints (time 2). This allowed us to investigate how emergent literacy

²The term emergent literacy skills are used broadly in the present study to refer to sublexical skills such as phonological awareness, orthographic awareness, and letter naming, as well as vocabulary.

skills are similarly or differentially related to word reading fluency and text reading fluency at an earlier phase and a later phase of reading development.

Language and Cognitive Processes Involved in Text Reading Fluency vs. Reading Comprehension

Another question about text reading fluency as a construct involves what differentiates text reading fluency from reading comprehension. Semantic processes were hypothesized to be involved in text reading fluency (Jenkins et al., 2003; Perfetti, 1999), and evidence indeed suggests that text reading fluency is a function of not only word reading but also text comprehension (Hudson et al., 2012; Jenkins et al., 2003; Wagner et al., 2011, 2012, 2014; Nation & Snowling, 1998). Then, what comprehension processes are involved in text reading fluency vs. reading comprehension? According to Posner and Snyder (1975), two processes are involved in information processing: (1) automatic activation of semantically related memory is fast and does not use attentional capacity, and (2) slow-acting attention mechanism, on the other hand, responds to a preceding context and costs limited-capacity cognitive processor. Similarly, the verbal efficiency theory (Perfetti, 1999) hypothesizes that variation in automatic semantic activation, and conscious and/or unconscious prediction processes influence reading efficiency. Therefore, it is reasonable to hypothesize that automatic processes related to semantic network would be implicated in text reading fluency whereas higher order cognitive processes that might require slow-acting attention would be uniquely implicated in reading comprehension. In as much as vocabulary captures semantic activation and related processes, vocabulary is expected to be involved in text reading fluency. Grammatical knowledge may also be involved in text reading fluency because morpho-syntactic knowledge is essential to encoding meaning. In fact, in the verbal efficiency model, quality of lexical representation includes network of meanings such as vocabulary and morpho-syntactic processes (Perfetti, 2007; Perfetti & Stafura, 2014). In addition, individual differences in working memory are likely to influence text reading fluency to allow holding linguistic information temporarily (Perfetti, 1985).

Whereas some semantic activation and prediction processes might be involved in text reading fluency (Jenkins et al., 2003; see semantic activation in reading in priming studies such as Hohenstein, Laubrock, & Kliegl, 2010), reading comprehension is likely to rely on slow-acting attention mechanism such as higher order cognitive processes. Reading comprehension requires constructing the situation model (Kintsch, 1988) which involves a deep level of meaning processing such as evaluating initial propositions, making inferences across propositions, and integrating them with prior knowledge (Graesser, Singer, & Trabasso, 1994; Kintsch, 1988; Perfetti, Landi, & Oakhill, 2007). Therefore, higher order cognitive skills such as theory of mind, inference-making, and comprehension monitoring are candidate processes unique to text comprehension (Cain, 2007; Cain, Oakhill, & Bryant, 2004; Kim, 2015; Kim & Phillips, 2014; Oakhill, Cain, & Bryant, 2003; Tompkins, Guo, & Justice, 2012). Note that theory of mind, typically defined as one's representation of others' mental state (de Villiers, 2000; de Villiers & Pyers, 2002; Slade & Ruffman, 2005), has been studied extensively particularly in relation to syntactic aspects of oral language and autism spectrum (Baron-Cohen, Tager-Flusberg, & Cohen, 19994; de Villiers & Pyers, 2002;

Johnston, Miller, & Tallal, 2001; Slade & Ruffman, 2005). Theory of mind is included in the present study because it captures complex cognition such as making inferences about other's thoughts or emotions, which is an important aspect of text comprehension (Graesser et al., 1994). However, evidence about the role of theory of mind in text comprehension is mixed. Theory of mind was independently related to narrative story comprehension for English-speaking kindergartners after accounting for inhibitory control, vocabulary, and comprehension monitoring (Kim et al., 2014), and for Korean-speaking kindergartners after accounting for working memory, grammatical knowledge, vocabulary, and comprehension monitoring (Kim, 2015). In a study with English-only children and English learners in kindergarten, first grade, and second grade, theory of mind was related to comprehending fables after accounting for vocabulary and metacognitive language, all measured in English (Pelletier, 2006). In contrast, in a study with Chilean kindergartners, theory of mind was not related to comprehension of wordless picture book and story recall after accounting for working memory, vocabulary, inhibitory control, attention, inference, and comprehension monitoring (Strasser & del Rio, 2014). In addition to higher order cognitive skills, grammatical knowledge was hypothesized to be related to reading comprehension because grammatical knowledge, particularly the ability to repair grammatical errors, has been hypothesized to play a key role in integrating propositions and establishing coherence in text comprehension (Perfetti, 2007, Perfetti & Stafura, 2014). Indeed, evidence from English-speaking children has provided support for this hypothesis (Cain, 2007).

Present Study

To expand our understanding of text reading fluency, we had three guiding research questions in the present study. The first research question was developmental nature of the relations among word reading fluency, listening comprehension, text reading fluency, and reading comprehension. Based on previous studies, we hypothesized that word reading fluency would be strongly related to text reading fluency during an earlier phase of reading development, and listening comprehension would be related to text reading fluency at a later phase when children's word reading proficiency is more advanced. We further expected that word reading fluency would be independently related to reading comprehension at an earlier phase of reading development whereas text reading fluency would be independently related to reading comprehension at a later phase. Listening comprehension was hypothesized to be related to reading comprehension at both timepoints. We did not have a specific hypothesis about the relation of reading comprehension to text reading fluency over and above word reading fluency and listening comprehension.

The second research question was how various emergent literacy skills are related to word reading fluency vs. text reading fluency. In particular, we were interested in the relations of emergent literacy skills to text reading fluency after accounting for their contributions to word reading fluency. It was hypothesized that orthographic awareness would be uniquely related to text reading fluency after accounting for its relation to word reading fluency. The third research question was language and cognitive predictors of text reading fluency vs. reading comprehension. We hypothesized that foundational language and cognitive skills such as vocabulary, grammatical knowledge, and working memory would be related to text reading fluency whereas grammatical knowledge and higher level cognitive skills such as

theory of mind and comprehension monitoring would be independently associated with reading comprehension. Recent findings have shown that foundational and higher order skills are directly and indirectly related to text comprehension (Florit, Roch, & Levorato, 2013; Kim, 2015; Kim & Phillips, 2014), and therefore, in the present study, we examined direct and indirect relations of language and cognitive skills to text reading fluency vs. reading comprehension.

These three primary questions were addressed by using longitudinal data from kindergartners in South Korea. Although typically developing English-speaking kindergartners are not expected to have developed sufficient text reading fluency and reading comprehension to be measured reliably, many previous studies with Korean-speaking children have indicated that kindergartners in Korea have proficient word reading skills (Cho, 2009; Cho & McBride-Chang, 2005; Cho, McBride-Chang, & Park, 2008; Kim, 2007, 2011) and text reading fluency and reading comprehension (Kim, 2011, Kim et al., 2014). These are likely to be attributed to the educational context in South Korea in which early literacy instruction is typically provided in preschool (or kindergarten year 1) and kindergarten as well as various home-visit programs (Kim, 2011). An additional critical factor in literacy acquisition is grapheme-phoneme consistency. The Korean language has a relatively transparent orthography called Hangeul. Although its visual representation is α-syllabic (both syllables and phonemes are visually represented), Hangeul is an alphabetic system in which graphemes represent phonemes. Given a relatively rapid acquisition of word reading skills in languages with transparent orthographies (see Seymour et al., 2003), children in the present study were assessed in a relatively short time span between timepoints, approximately eight months apart, to adequately capture changing nature of relations.

Method

Participants

Data reported in the present study are from a larger study of reading development in Korean. The larger study consists of four timepoints of data collection from kindergarten year 1 (or prekindergarten) to kindergarten year 2. In the present study, we report data from two timepoints when measures relevant to the present study were administered. One hundred forty three children (63 girls) in South Korea were assessed in prekindergarten (or kindergarten year 1; mean age = 5.2 months, $SD = 3.34$), and again in kindergarten year 2 (mean age = 6.1 months, $SD = 3.36$ months). At time 1, children were assessed 7 months into the academic year, and at time 2, they were assessed 3 months into the next academic year. At time 2, 130 children remained in the study, which corresponds to approximately 9% attrition. However, children who left the study did not differ from those who remained in the study in all the measures at time 1 ($p > 0.24$). In addition, Little's test (Little, 1988) indicated missingness completely at random [MCAR, $\chi^2(16) = 17.80, p = 0.34$]. Gender imbalance reflected enrollment status in the institute.

The sample children were from a single private institute. Kindergarten attendance in Korea is virtually the norm, albeit not mandatory (Kim, 2011). Kindergarten education is offered in public and private institutes, and kindergarten tuition is partially subsidized by the

government. Data on socioeconomic status were not available from individual children, but according to the school personnel and the neighborhood, the sample children were from middle class families. Korea is highly homogenous in terms of ethnic composition and all the children in the present study were monolingual Korean speakers without any hearing, vision, or language impairments.

Measures

Because we wanted to examine developmental patterns of the relations among word reading fluency, text reading fluency, reading comprehension, and listening comprehension, these constructs were assessed at times 1 and 2. However, emergent literacy skills, and language and cognitive skills were assessed only times 1 and 2, respectively, due to time and resource constraints. That is, children's emergent literacy skills such as phonological awareness, letter name knowledge, orthographic awareness, morphological awareness, rapid automatized naming, and vocabulary were assessed only at time 1, and language and cognitive skills (i.e., vocabulary, grammatical knowledge, working memory, theory of mind, and comprehension monitoring) were assessed only at time 2. Administration times for emergent literacy skills, and language and cognitive skills were determined considering developmental progression—emergent literacy skills were expected to be critical for fundamental reading skills (e.g., word reading) at an earlier timepoint, and language and cognitive skills were hypothesized to be important to more advanced reading skills such as text reading fluency and reading comprehension.

No standardized and normed assessments were available in Korean at the time of the study and thus, measures were developed and/or adapted from previous studies with Korean-speaking children and English-speaking children. Unless otherwise noted, all the items in the tasks were scored dichotomously. All the tasks had high reliability estimates (see Table 1) with an exception of the listening comprehension task 1 at time 2, which had a relatively low estimate (0.64). However, its impact is minimized due to the use of a latent variable approach in the present study.

Skills Assessed at Times 1 and 2

Reading comprehension—Three tasks from previous studies were employed (Kim, 2011; Kim et al., 2014). In the first two tasks, the child was asked to read short passages and to answer comprehension questions about characters, events, problems, and resolutions. At time 1, two passages were 100 words and 97 words long (294 syllables and 314 syllables) with five and six comprehension questions, respectively. At time 2, two passages had 112 and 158 (313 syllables and 507 syllables) with six and seven comprehension questions, respectively. The last task, which was administered at both times was an oral cloze task, had been adapted from the Passage Comprehension subtest of Woodcock Johnson-III (Woodcock, McGrew, & Mather, 2001). In this task, the child was asked to read sentences and short passages, and to provide missing words. There were 3 practice items and 21 test items.

Text reading fluency—Three previously unseen passages were used (Kim, 2011, Kim et al., 2014). The child was asked to read each passage quickly and accurately. The three

passages ranged from 279 to 362 syllables. Korean is an agglutinative language and therefore, texts used in the present study included many inflected words. The texts ranged from 1 to 6 syllable words³ with 2 to 16 graphemes. Children's performances were measured by the number of accurately read syllables in 40 second. Syllables omitted, substituted, and hesitations of more than 3 seconds were scored as errors. Test-retest correlations were reported to be greater than 0.91. Number of syllables, not words, is reported in the present study because the concept of word and related spacing in Korean is different from that in English (Lee & Ramsey, 2000). Instead, syllables count is used as the metric of text volume in Korea (Kim et al., 2014).

Word reading fluency—To assess children's word reading fluency, children were shown words in a context-free list format and were asked to read aloud words quickly and accurately in three tasks. A total of 60 items in each task, ranging from 175 to 195 in syllables, were randomly selected from the three passages for the text reading fluency tasks. Therefore, the same words were used in the word reading fluency tasks and text reading fluency tasks. The number of accurately read items in 40 seconds was the child's score. Note that in the text reading fluency, number of correctly read syllables is reported whereas in the word reading fluency task, number of correctly read items is reported. This is because in the word reading fluency task, items correspond to spacing in the text reading fluency texts. For instance, 아빠 한테 (dad + a proposition 'to') was presented together as an item in the word reading fluency task because they are not separated by space in connected texts although nouns and prepositions are separated by space and considered as two separate words in English (see Lee & Ramsey, 2000, for more information about the concept of words and spacing in Korean). There were 4 practice items that were not from the text reading fluency passages, and there were 60 test items.

Listening comprehension—Two tasks were used from a previous study (Kim et al., 2014). These were originally adapted from the Listening Comprehension Scale of the Oral and Written Language Scales (OWLS; Carrow-Woolfolk, 1995) and Paragraph Comprehension subtest of Comprehensive Assessment of Spoken Language (CASL; Carrow-Woolfolk, 1999). In the first task, children were asked to point to the picture that best described the heard sentences out of 4 options (i.e., 4 pictures). There were 34 test items with 2 practice items. In the second task, children were asked to identify a picture out of 4 pictures that best described the answer to the question based on the short stories they heard. There were 19 test items with 1 practice item.

Emergent Literacy Skills Assessed at Time 1

The emergent literacy skills in the present study have been used in previous studies and greater details are found in those studies (e.g., nature of orthographic awareness task items; Kim, 2010, 2011).

³In an agglutinative language like Korean, words are formed by joining morphemes together. For instance, a 6 syllable word used in the text reading fluency task, 부탁드려야겠다, is composed of several morphemes (a main verb, a future tense, and an auxiliary verb denoting one's intention). Different morphemes or inflections are not separated by spaces in Korean. Many root words in Korean are two- and three syllables long (Kim, 2007).

Letter naming fluency—Korean alphabet letters (a total of 40) were presented in random order in a row of 8 in 13 rows, and the child was asked to name the letter as accurately and fast as possible. The number of correctly identified letters for 40 seconds was the score. Self-corrected names were given credit.

Phonological awareness—A deletion task was used, in which the child was asked to delete syllables and phonemes (Kim, 2011). For instance, for the syllable deletion, the child was asked to say /fige/, and was asked to delete /fi/ from /fige/ (clock or watch) and the correct answer is /ge/ (dog or crab). In the phoneme deletion, the child was asked to say /mul/ (water), and say the word without /l/, which is /mu/ (radish). There were 5 practice items (3 syllable items; 2 phoneme items) and 27 test items (15 syllable items; 12 phoneme items). As seen in Table 1, it appears that on average, children were able to perform accurately at the syllable level ($M = 13.14$) but with large variation around the mean ($SD = 6.91$).

Morphological awareness—A compound construction task was used because in Korean compound construction is an important morphological features (Cho, McBride-Chang, & Park, 2008; Kim, 2011). In the first nine items, the child was presented with scenarios in two or three sentences and was asked to create a compound noun. An example item is as follows: “When a refrigerator keeps kimchi (a Korean dish) in it, we call it kimchi refrigerator. If a refrigerator keeps a flower in it, what we would we call it?” The correct answer is a flower refrigerator. The second nine items were presented without scenarios. There were two practice items and 18 test items.

Orthographic awareness—Orthographic choice task was used (Kim, 2010, 2011). In this task, the child’s sensitivity to several orthographic constraints in the Korean writing system was assessed. For instance, in Korean a vertical vowel letter is only permitted on the right of the preceding consonant, not on the left. Therefore, ㅏ ㅑ is illegal whereas ㅘ is legal. There were four practice items and 30 test items.

Rapid automatized naming—A digit task was used (Kim, 2011). In this task, five different digits were repeated randomly 10 times in five rows. The child was asked to name all the stimuli as fast as possible. As expected, there were few errors in accuracy, and thus, latency score was used.

Expressive vocabulary—In this task, the child was asked to provide names of items (e.g., airplane), synonyms (another word for ‘angry’), and superordinate terms (e.g., furniture) (Kim, 2011). Items were presented with corresponding illustrations. There were three practice items and 33 test items.

Language and Cognitive skills Assessed at Time 2

Working memory—The listening span task from previous studies (Cain et al., 2004; Florit, Roch, Altoè, & Levorato, 2009; Kim & Phillips., 2014;) was adapted to Korean. In this task, the child was asked to identify whether the sentence they heard is correct or not (Yes/No response). After hearing all the sentences (e.g., 2 sentences), the child was asked to

identify the first words in the sentences they heard. The sentences were statements involving common knowledge (e.g., Birds fly in the sky). Note that listening span tasks in English and European languages require children to identify the last word in each sentence (e.g., Cain et al., 2004; Florit et al., 2009). However, this was modified in Korean as identifying the first word in each sentence because of the SOV sentence structure in Korean. Verbs and adjectives in Korean are always inflected, and tend to have the same or similar final inflections in a given context. Therefore, sentence final words (i.e., verbs with highly similar inflections) were deemed inappropriate for the task. First words in the task were all nouns. There were four practice items and 15 experimental items with increasing difficulty (i.e., listening to two sentences vs. three sentences). Children's yes/no responses regarding the veracity of the statement were not scored, but their responses on the first words in correct order were given a score of 2 per item, and responses including the first words in incorrect order was given 1 point. Therefore, a total possible maximum score was 30.

Receptive vocabulary—A receptive vocabulary task was adapted from the Peabody Picture Vocabulary Test-4th Edition (Dunn & Dunn, 2007). In this task, the child hears a word and is asked to identify a corresponding picture out of four options. The task included 51 items with increasing difficulty that had accompanying color illustrations. Task administration stopped after 6 consecutive incorrect responses.

Grammatical knowledge—The child was asked to detect and correct grammatical errors, and complete unfinished sentences. In the error detection and correction part, the child was asked to identify whether the sentence they heard is correct or incorrect, and if incorrect, the child was asked to correct the sentence. In the three practice items, the child was provided explanations. For instance, a sentence “나는 가게가 갑니다.” (I go to a store.) had an incorrect postposition (the underlined part). The child was told that 가 /ka/ (postposition) is incorrect but 에 /e/ is correct. Twelve experimental items (9 incorrect sentences) involved grammatical markers, tense, and postpositions. In the sentence completion items (5 test items and 1 practice item), and was asked to complete the sentence based on the preceding sentence they heard. For example, the child heard, “Minsoo, did you do homework? No, later homework...” The correct response is “(I) will do.” Note that verbs come at the end of the sentence in Korean. Altogether, there were a total of 17 experimental items in the grammatical knowledge task, but a total possible maximum score was 26 because 1 point was given per correct response for 12 grammatical error identification items; 1 point for correcting 9 incorrect sentences; and 1 point for each of the 5 sentence completion items.

Theory of mind—First and second-order false belief scenarios were employed. There were four first-order scenarios, involving locations of a cake, drawing, a birthday gift, and content of a snack box adapted from a previous study (Gwon & Lee, 2012). The first three involved change of location stories, and the last one was an appearance-reality task (or unexpected identity) using a snack box that is highly familiar to children in Korea. One second-order false belief scenario involved different types of bread sold in a bakery, which was adapted from a previous study with English-speaking children (Kim & Phillips, 2014). The second-order task examined the child's ability to infer a story character's mistaken belief about another character's knowledge. In all the tasks (except for the snack box task),

the tester presented a series of illustrations to the child and explained the context. Then, the tester asked the child a series of questions involving characters' beliefs such as "Where do you think Jungwoo will look for his cake?," and "Minsoo thinks that they sell only sweet potato bread at the bakery. Why does he think that?" (see e.g., Bartsch, & Wellman, 1989; Caillies, Hody, & Calmus, 2012; Caillies & Sourn-Bissaoui, 2008 for a similar approach). There were a total of 18 items: three questions in each of the four first-order tasks, and six questions in the second-order task.

Comprehension monitoring—An inconsistency detection task was adapted from Baker (1984) and Cain et al. (2004). A similar adapted task has been used with English-speaking kindergartners (Kim & Phillips, 2014). In the task, the child was asked to identify whether the story made sense or not, and if the story did not make sense, the child was asked to provide a brief explanation. An example of an inconsistent item is as follows: "Minhee's favorite color is blue. She wears blue every day. Minhee has blue pants, and even blue shoes. Minhee likes to have everything purple!" An example of a consistent and coherent story is as follows: "Joonsoo is five years old. He only likes chocolate milk. He pours cool milk into a cup every evening. Joonsoo's favorite milk is chocolate milk." There were 4 practice items and 15 experimental items. Feedback and explanations (e.g., meaning of "not making sense") were provided in the practice items. Consistent (7 items) and inconsistent stories (8 items) were randomly spread across items. For the eight inconsistent stories, the accuracy of children's explanation was also dichotomously scored, and thus, a total possible score was 23 (15 + 8).

Procedures

Rigorously trained research assistants assessed children individually in a quiet room in the school. Assessments were counterbalanced within session to reduce fatigue effects. Research assistants had extensive experiences with children, including language and literacy assessments. Assessment battery was typically administered in four sessions with each session 25 to 30 minute long.

Data Analysis Strategy

Confirmatory factor analysis (CFA) and structural equation modeling using MPLUS 7.1 (Muthén & Muthén, 2013) were primary data analytic strategies. Latent variables were created for the following constructs for which multiple measures were used: word reading fluency, text reading fluency, listening comprehension, and reading comprehension. Latent variable approach is preferred because latent variables capture common variables among observed variables (also called indicators), and thus minimize the influence of measurement error (Bollen, 1989; Kline, 2005). However, children's emergent literacy skills, and language and cognitive skills were assessed by single measures for each construct due to time and resource constraints. The research questions were addressed by fitting structural equation models. Model fits were evaluated by using the following multiple indices: Chi-square statistics, comparative fit index (CFI), the Tucker-Lewis index (TLI), Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), root mean square error of approximation (RMSEA), and standardized root mean square residuals (SRMR). Typically, RMSEA values below 0.08, CFI and TLI values equal to or greater than 0.95, and SRMR

equal to or less than 0.05 indicate an excellent model fit (Hu & Bentler, 1999), and TLI and CFI values greater than 0.90 are considered to be acceptable (Kline, 2005). Note that given multiple hypothesis testing, we applied Benjamini-Horchberg correction for statistical significance testing (Benjamini-Horchberg, 1995). Therefore, only statistically significant paths after the Benjamini-Horchberg corrections are reported but p-values associated with statistically significant paths are from the uncorrected outputs.

Results

Descriptive statistics are presented in Table 1. On average, at time 1 children were able to read 10 to 12 words in 40 seconds in context-free format, and approximately 48 to 51 syllables per 40 seconds in connected text. Forty eight syllables were equivalent to approximately 38 words in 60 seconds using the English convention of words. At time 2, this increased to an average performance of 20 to 21 words in context-free format and 83 to 87 syllables in connected text. The latter performance is similar to what was reported in a previous study with kindergarten children from similar backgrounds (Kim et al., 2014), and was equivalent to approximately 63 words in 60 seconds following English convention of words. Children's average performances at time 2 on the reading comprehension and listening comprehension tasks were also similar to a previous study with kindergartners (Kim et al., 2014). Note, however, that at time 1, the word reading fluency task 2 and rapid automatized naming had somewhat large skewness values. The skewness value for the rapid automatized naming was driven by a few slow namers which stretched the tail on the right (see Appendix A for the plot). Positive skew of the word reading task also indicates some floor effect, which is a limitation of the study. Because transformations of these measures did not make substantial changes in distribution patterns, and the skewness values were on the borderline, raw scores were used in the analysis. Note that when analysis was conducted excluding outliers in the rapid automatized naming task, results were essentially the same, and thus, results from the entire sample are reported in the paper.

Tables 2 and 3 show correlations among measures at time 1 and time 2, respectively. Correlations between time 1 and time 2 measures are not presented due to space constraint, but available upon request. All the relations are in expected directions. Emergent literacy skills were weakly to moderately related to each other ($-0.28 \leq r_s \leq 0.56$, Table 2), and moderately to relatively strong related to literacy skills ($0.41 \leq r_s \leq 0.68$, Table 2). Literacy skills were all fairly strongly to strongly related to each other ($0.59 \leq r_s \leq 0.96$, Tables 2 and 3). Language and cognitive skills were weakly to fairly strongly related to reading comprehension ($0.17 \leq r_s \leq 0.59$, Table 3). Language and cognitive skills were also weakly to relative strongly related to listening comprehension skills ($0.17 \leq r_s \leq 0.65$, Table 3), which is similar to previous studies with children speaking English, Finnish, and Italian (Florit et al., 2009; Kim & Phillips, 2014; Lepola, Lynch, Laakkonen, Silvén, & Niemi, 2012).

Research Question 1: Developmental Relations among Word Reading Fluency, Listening Comprehension, Text Reading Fluency, and Reading Comprehension

Prior to addressing the research question, confirmatory factor analysis was conducted to examine whether word reading fluency and text reading fluency tasks are best described as a single construct or two dissociable constructs. When the tasks were considered to capture a single construct, the model fit was poor: $\chi^2(53) = 415.82, p < 0.001$; CFI = 0.91; TLI = 0.88; RMSEA = 0.22 (90% CI 0.20 – 0.24); SRMR = 0.02. In contrast, model fit for two separate constructs was excellent: $\chi^2(48) = 71.77, p = 0.02$; CFI = 0.99; TLI = 0.99; RMSEA = 0.06 (90% CI 0.03 – 0.09); SRMR = 0.007. Chi-square difference test indicated that the two factor model was superior: $\chi^2(df = 5) = 344.05, p < 0.001$. After establishing that word reading fluency and text reading fluency are best described as dissociable constructs, we examined measurement invariance at two timepoints for the model in Figure 1 following procedures in Brown (2006). First, a baseline of non-invariance model was specified by allowing the loadings to vary completely. This model yielded good fit to the data: $\chi^2(191) = 324.09, p < 0.001$; CFI = 0.97; TLI = 0.97; RMSEA = 0.07 (90% CI 0.057–.083); SRMR = 0.03. When a full invariance model was fit, it was poorer than the non-invariance model: $\chi^2(df = 11) = 248.36, p < 0.001$. After inspecting loadings in the models, a partial invariance model was fitted in the final model by allowing loading constraints of the following variables: reading comprehension task 2 and listening comprehension task 1. Loadings of indicators to latent variables are presented in Figure 1.

To address the first research question, word reading fluency and listening comprehension were hypothesized to have direct paths to text reading fluency as well as reading comprehension. Text reading fluency was hypothesized to have a direct path to reading comprehension (see Figure 1). The structural equation model which examined the relations of word reading fluency, listening comprehension, and text reading fluency to reading comprehension fit the data well: $\chi^2(198) = 350.98, p < 0.001$; CFI = 0.97; TLI = 0.97; AIC = 17197.567; BIC = 17425.166; RMSEA = 0.074 (90% CI 0.061–.086); SRMR = 0.034. Standardized coefficients are shown in Figure 1. At both times 1 and 2, word reading fluency was strongly related to text reading fluency ($\gamma_s = 0.91$ and 0.89 for times 1 and 2, respectively, $p < 0.001$) after accounting for listening comprehension. Listening comprehension was weakly related to text reading fluency and was not statistically significant at time 1 ($\gamma = 0.08, p = 0.05$) but it was related to text reading fluency at time 2 ($\gamma = 0.14, p < 0.001$) after accounting for word reading fluency. Word reading fluency was somewhat weakly related to reading comprehension at time 1 ($\gamma = 0.30, p = 0.01$), but not at time 2 ($\gamma = -0.07, p = 0.73$) after accounting for text reading fluency and listening comprehension. Listening comprehension was consistently but somewhat weakly related to reading comprehension at time 1 ($\gamma = 0.26, p < 0.001$) and moderately at time 2 ($\gamma = 0.36, p < 0.001$) after accounting for word reading fluency and text reading fluency. Text reading fluency was moderately related to reading comprehension at time 1 ($\beta = 0.50, p < 0.001$) and fairly strongly at time 2 ($\beta = 0.73, p < 0.001$). Total amounts of variance explained were 0.90 in text reading fluency and 0.92 in reading comprehension at time 1, and 0.94 in text reading fluency and 0.87 in reading comprehension at time 2.

The relation of reading comprehension to text reading fluency was also examined using a structural equation model (Figure 2). The model fit the data well: $\chi^2(198) = 345.36, p < 0.001$; CFI = 0.97; TLI = 0.97; AIC = 17191.948; BIC = 17419.547; RMSEA = 0.072 (90% CI 0.060–.085); SRMR = 0.033. Model fits between Figure 1 and Figure 2 can be compared using BIC differences because these models are not nested. BIC difference of 5.62 is considered meaningful, albeit weak evidence (Kass & Raftery, 1995; Raftery, 1995), such that the model in Figure 2 fit the data better than the model in Figure 1. However, caution needs to be taken because BIC is not large, and model fit comparison based on BIC values is highly unstable (Preacher & Merkle, 2012). As shown in Figure 2, reading comprehension was independently related to text reading fluency at time 1 ($\beta = 0.49, p < 0.001$) and at time 2 ($\beta = 0.29, p < 0.001$) after accounting for word reading fluency and listening comprehension. In contrast, listening comprehension was not independently related to text reading fluency at time 1 ($\gamma = 0.07, p = 0.22$) and at time 2 ($\gamma = 0.00, p = 1.00$) after accounting for word reading fluency and reading comprehension. A total of 93, 95, 89, and 86% of variance was explained, respectively, in text reading fluency at time 1, text reading fluency at time 2, reading comprehension at time 1, and reading comprehension at time 2.

Research Question 2: Relations of Emergent Skills to Word Reading Fluency and Text Reading Fluency

To examine whether emergent literacy skills are related to text reading fluency over and above word reading fluency (research question 2), we compared with two alternative sets of models. In one set of models, word reading fluency was hypothesized to completely mediate the relation between emergent literacy skills to text reading fluency (full mediation model) such that emergent literacy skills are not related to text reading fluency once word reading fluency is accounted for. In the other set of models, word reading fluency was hypothesized to partially mediate the relation between emergent literacy skills to text reading fluency (partial mediation model)—some emergent literacy skills are related to text reading fluency after accounting for word reading fluency. The unique relations of emergent literacy skills to text reading fluency can be examined only if the partial mediation model fits the data better. Therefore, these alternative models were fitted to the data at time 1 as well as time 2. Results showed that partial mediation models are superior to full mediation models for text reading fluency at both times: $\chi^2 = 30.94, df = 7, p < 0.001$ for the text reading fluency model at time 1; $\chi^2 = 24.76, df = 7, p < 0.001$ for the text reading fluency model at time 2. These results indicate that emergent literacy skills are related to word reading fluency as well as to text reading fluency, permitting an examination of unique emergent literacy skills related to word reading fluency vs. text reading fluency. See loadings of indicators to latent variables in Figure 3.

The structural equation model at time 1 (partial mediation model) fit data very well: $\chi^2(32) = 48.73, p = 0.03$; CFI = 0.99; TLI = 0.99; AIC = 11154.39; BIC = 11325.83; RMSEA = 0.061 (90% CI 0.02–.093); SRMR = 0.008. Standardized results for time 1 are shown in Figure 3a, letter naming fluency, rapid automatized naming, and vocabulary were independently related to word reading fluency with weak to moderate magnitudes of strengths ($-0.15 \leq \gamma \leq 0.39; p \leq 0.017$). For the text reading fluency outcome, orthographic awareness was weakly but positively related to text reading fluency ($\gamma = 0.09, p = 0.009$)

after accounting for word reading fluency. Letter naming fluency had a negative suppression effect ($\gamma = -0.16, p < 0.001$; Tzengov and Henik, 1991)—it was positively related to text reading fluency in bivariate correlations (see Table 2) but negatively related to the outcome after accounting for other predictors in the model. Approximately 62% and 92% of total variance were explained in the word reading fluency and text reading fluency, respectively.

Figure 3b shows results for the word reading and text reading outcomes at time 2. Model fit was excellent: $\chi^2(32) = 38.92, p = 0.17$; CFI = 1.00; TLI = 0.99; AIC = 10895.06; BIC = 11066.50; RMSEA = 0.039 (90% CI 0.00–.077); SRMR = 0.009. For the word reading fluency outcome, all but morphological awareness ($p = 0.83$) and vocabulary ($p = 0.07$) were independently related to word reading fluency. For the text reading fluency outcome, phonological awareness ($\gamma = 0.09, p = 0.01$) and vocabulary ($\gamma = 0.10, p = 0.002$) were independently related to text reading fluency after accounting for word reading fluency. Approximately 64% and 95% of total variance were explained in the word reading fluency and text reading fluency, respectively.

Research Question 3: Relations of Language and Cognitive Skills to Text Reading Fluency and Reading Comprehension

To address the third research question, text reading fluency and reading comprehension were hypothesized to be directly predicted by higher order cognitive skills (theory of mind and comprehension monitoring). In addition, the foundational language and cognitive skills (vocabulary, grammatical knowledge, and working memory) were hypothesized to be related to text reading fluency and reading comprehension directly, and indirectly via higher order skills (see Figure 4). It was hypothesized and evidence supports that higher order cognitive skills are built on foundational language and cognitive skills (Davis & Pratt, 1995; Kim, 2015; Oakhill, Cain, & Bryant, 2003; Yuill, Oakhill, & Parkin, 1989). Because our primary question was how language and cognitive skills are uniquely related to text reading fluency vs. reading comprehension, text reading fluency and reading comprehension were allowed to covary without any directional paths between text reading fluency and reading comprehension (i.e., text reading fluency predicting reading comprehension or vice versa).

The model had an excellent fit to the data: $\chi^2(28) = 40.26, p = 0.06$; CFI = 0.99; TLI = 0.98; AIC = 8556.70; BIC = 8697.21; RMSEA = 0.058 (90% CI 0.00–.096); SRMR = 0.023. As shown in Figure 4, for the text reading fluency outcome, vocabulary ($\gamma = 0.30, p < 0.001$) and grammatical knowledge ($\gamma = 0.36, p < 0.001$), were independently related whereas working memory ($\gamma = 0.12, p = 0.14$), theory of mind ($\beta = 0.10, p = 0.23$), and comprehension monitoring ($\beta = 0.02, p = 0.87$) were not. For reading comprehension, vocabulary ($\gamma = 0.18, p = 0.02$), grammatical knowledge ($\gamma = 0.42, p < 0.001$), and theory of mind ($\beta = 0.20, p = 0.02$) were related whereas working memory ($\gamma = 0.10, p = 0.20$) and comprehension monitoring ($\beta = 0.12, p = 0.19$) were not. Theory of mind was predicted by all the three foundational language and cognitive skills ($0.20 \leq \gamma \leq 0.26, ps < 0.025$). Comprehension monitoring was predicted by grammatical knowledge ($\gamma = 0.37, p < 0.001$) and working memory ($\gamma = 0.39, p < 0.001$), but not vocabulary ($\gamma = 0.07, p = 0.37$). Approximately 42% of total variance was explained in text reading fluency and 55% in reading comprehension.

Discussion

The primary aim of the present study was to enhance our understanding about text reading fluency, defined as accuracy and rate of reading connected texts, and its role in reading development. This goal was addressed in several ways by examining (1) developmental progression of the relations of word reading fluency, listening comprehension, and text reading fluency to reading comprehension; (2) the relation of reading comprehension to text reading fluency; (3) emergent literacy predictors of text reading fluency vs. word reading fluency; and (4) language and cognitive predictors of text reading fluency vs. reading comprehension.

One critical premise prior to examining these questions is that word reading fluency and text reading fluency are two dissociable constructs. This was supported in the present study. In conjunction with previous studies with English-speaking children (Wagner et al., 2011, 2012; Kim & Wagner, in press) and Korean-speaking children (Kim et al., 2014), the present finding indicates that word reading fluency and text reading fluency are separable skills. Then, what explains the difference between word reading fluency and text reading fluency? According to theoretical accounts, text reading fluency captures factors that originate from context, that is, post-lexical meaning processes are involved in text reading fluency (Jenkins et al., 2003; LaBerge & Samuels, 1974; Samuels, 2006). Consistent with this hypothesis, we found that listening comprehension was related to text reading fluency, particularly after children developed a certain level of reading proficiency. Furthermore, reading comprehension was related to text reading fluency over and above word reading fluency and listening comprehension at both times 1 and 2. The present findings, in conjunction with previous studies, suggest that text comprehension is implicated in text reading fluency (Baker et al., 2011; Hudson et al., 2012; Jenkins et al., 2003; Wagner et al., 2011, 2012, 2014), and text reading fluency and reading comprehension may have a reciprocal relation (Baker et al., 2011; Hudson et al., 2012; Jenkins et al., 2003). Text reading fluency has been described as a “bridge” between word reading and reading comprehension (Kuhn et al., 2010; Pikulski & Chard, 2005; Rasinski, 2004). The present findings suggest that the bridging or mediating role of text reading fluency is due to the fact that text reading fluency captures some comprehension processes (see below for further discussion) as well as word reading fluency. Furthermore, the bridge appears to be a two-way street such that text reading fluency predicts reading comprehension, and reading comprehension predicts text reading fluency. Interestingly, after accounting for reading comprehension, listening comprehension was not independently related to text reading fluency, suggesting that although individual differences in listening comprehension do influence text reading fluency, its influence is largely indirect via reading comprehension at least at this point of reading development. On the other hand, reading comprehension was independently related to text reading fluency. This might be because when children are still developing reading skills, semantic access is constrained by decoding processes (converting orthography to phonology e.g., see Perfetti & Stafura, 2014) to a greater extent than when reading skills are more advanced. Because reading comprehension and text reading fluency both involve decoding processes whereas listening comprehension does not, this might explain the unique, independent relation of reading comprehension to text reading fluency.

In contrast, at a more advanced phase of reading development, differences in meaning access in listening and reading are likely to decrease. This speculation is supported by the trend of a stronger magnitude of the relation between reading comprehension and text reading fluency at time 1 ($\beta = 0.49$) than at time 2 ($\beta = 0.29$). Furthermore, the relation of listening comprehension and reading comprehension becomes stronger as children develop their reading skills (Adlof et al., 2006; Gernsbacher, Varner, & Faust, 1990; Kim & Wagner, in press). In fact, extremely strong relations (greater than 0.90) have been observed for children in grade 8 (Adlof et al., 2006) and college students (Gernsbacher et al., 1990).

It is striking that the pattern of relations found in Figure 1 is highly similar to findings from a longitudinal study with English-speaking children—the independent contribution of listening comprehension to text reading fluency after accounting for word reading fluency was found at a later phase of reading development (advanced first graders and typically developing second graders), but not at an early phase (average first graders) (Wagner et al., 2011, 2012). A highly similar pattern found for English-speaking children and Korean-speaking children suggests that this developmental progression of relations might be similar in languages with varying depth of orthography. However, cautions need to be taken due to age differences between previous studies with English-speaking children and the present study. English-speaking children in previous studies were older (i.e., first and second grade), and therefore, are likely to be more advanced in language and cognitive skills. As noted earlier, age differences in previous studies with English-speaking children and Korean-speaking children are primarily due to differences in educational context and transparency of orthography. English-speaking children are not typically expected to have developed sufficient reading in connected texts until first grade whereas children in Korea are expected to have developed sufficient foundational reading skills prior to first grade. Therefore, studying first and second graders in Korea would entail missing an important window of time when foundational word reading, text reading fluency, and reading comprehension skills are acquired. Furthermore, evidence indicates that orthographic depth, not age, is likely to be the main factor contributing to differences in word reading acquisition in various languages (Seymour et al., 2003; also see Ellis et al., 2004). Taken these findings together, it appears that despite potential differences in the level of language and cognitive skills between English-speaking children and Korean-speaking children in these studies, overall covariance (or correlational) patterns in the relations among listening comprehension, word reading fluency, and text reading fluency are similar in English and Korean.

When it comes to the relations of word reading fluency, text reading fluency, and listening comprehension to reading comprehension, at an earlier phase of reading development, both word reading fluency and text reading fluency were independently related to reading comprehension after accounting for listening comprehension. At a later phase, only text reading fluency, not word reading fluency, was independently related to reading comprehension. A very similar developmental progression was found for children learning to read in English (Jenkins et al., 2003; Kim et al., 2012). These findings suggest that text reading fluency, although highly related to word reading fluency, makes an independent contribution over and above word reading fluency and listening comprehension. Therefore, the relation of text reading fluency to reading comprehension is not static, but changes over time, and the pattern of changing relations is similar in languages with varying orthographic

depths. However, again studies with English-speaking children were conducted with older children. Therefore, replications are needed with children learning to read in languages with transparent orthographies where word reading acquisition occurs at a later age than Korean-speaking children due to later introduction of literacy instruction (e.g., German, see Seymour et al., 2003).

Another way to expand our understanding about text reading fluency is to investigate what differentiates text reading fluency from word reading fluency and from reading comprehension. For the former, we investigated the relations of emergent literacy skills to word reading fluency vs. text reading fluency at two developmental timepoints. At an earlier timepoint, letter naming fluency, rapid automatized naming, and vocabulary were uniquely related to word reading fluency. For the text reading fluency, orthographic awareness made an independent contribution after accounting for its contribution to word reading fluency and the contribution of word reading fluency to text reading fluency (see Figure 3a). This is convergent with a finding with English-speaking children by Barker, Torgesen and Wagner (1992), and suggests that children's ability to process words in chunks is particularly facilitative in connected text reading. At a more advanced phase, vocabulary and phonological awareness made independent contributions to text reading fluency (Figure 3b). The finding that vocabulary was uniquely related to text reading fluency at a later phase (time 2) is line with the fact that children were able to utilize comprehension processes in text reading fluency at that point of reading development (Wagner et al., 2011, 2012, 2014).

To tease out comprehension processes involved in text reading fluency and reading comprehension, we examined how language and cognitive skills are related to text reading fluency vs. reading comprehension. Based on the two-process theoretical account of information processing (Perfetti, 1985; Posner & Snyder, 1975), we hypothesized that automatic processes related to semantic network such as vocabulary and grammatical knowledge would be related to text reading fluency whereas slow-acting attention-requiring, higher order processes such as theory of mind and comprehension monitoring would be related to reading comprehension. Grammatical knowledge was also hypothesized to uniquely relate to reading comprehension (Cain, 2007; Perfetti & Stafura, 2014). Results in the present study largely support these hypotheses. Vocabulary and grammatical knowledge were independently related to text reading fluency and reading comprehension whereas theory of mind was independently related to reading comprehension. The contributions of vocabulary and grammatical knowledge to text reading fluency suggest that automatic lexical access and semantic encoding are indeed involved in fast reading of words in connected text (i.e., text reading fluency). The roles of vocabulary and grammatical knowledge in reading comprehension are in line with previous studies (Cain et al., 2004; Cain, 2007; O'Connor, Swanson, & Geraghty, 2010; Quinn, Wagner, Petscher, & Lopez, 2015; Tunmer & Chapman, 2012) and with the hypothesis that lexical quality including morpho-syntactic processes is involved in construction and integration of propositions (Perfetti, 2007; Perfetti & Stafura, 2014).

When it comes to the relation of higher order cognitive processes (comprehension monitoring and theory of mind) to reading comprehension, our hypothesis was partially supported in that theory of mind was independently related to reading comprehension, but

comprehension monitoring was not. Integration processes needed for the situation model requires reasoning and inference making, which is resource (attention) demanding, and thus would not be used in text reading fluency, but in reading comprehension. These results are in line with previous studies which have shown the role of theory of mind in text comprehension (e.g., Kim, 2015; Kim & Phillips, 2014; Pelletier, 2006; but see Strasser & del Rio, 2014). In contrast to theory of mind, comprehension monitoring was not independently related to reading comprehension controlling for the other variables in the model. These results are divergent from previous studies (e.g., Cain et al., 2004). However, these results cannot be directly compared with previous studies. In particular, language and cognitive predictors taken into consideration in statistical models are different. For instance, in Cain and her colleagues study (2004), comprehension monitoring was independently related to reading comprehension after accounting for word reading, vocabulary and verbal IQ. In comparison, in the present study, three foundational language and cognitive skills (vocabulary, grammatical knowledge, and working memory), and a high order skill (theory of mind) were accounted for in the model. Future replications are warranted to illuminate the precise role of comprehension monitoring in reading comprehension in the context of other higher order skills.

Limitations, Future Directions, and Conclusion

Several weaknesses are worth noting. First, there were slight floor effects in reading tasks at time 1, which would have limited variance in these variables to some extent. In addition, the sample size, particularly at time 2, was relatively small ($N = 130$). Post-hoc power analysis revealed that to detect a small effect size of 0.10 for the given design of the present study, a minimum sample size is 138. Third, due to time and resource constraints, emergent literacy skills, and language and cognitive skills were assessed with single measures, and therefore latent variables were not used for these constructs. In addition, due to lack of standardized and normed measures in the target skills of the present study, measures used in the study were experimental, although many were used in previous studies. This limits external validity of the findings.

The correlational nature of the present study limits inferences related to practical implications. However, in conjunction with previous studies, the present findings suggest that instructional attention to listening comprehension would benefit not only reading comprehension, but also text reading fluency. That is, the independent relation of listening comprehension to text reading fluency suggests that listening comprehension makes a contribution to the accuracy and rate of connected text reading over and above word reading fluency. Several approaches have been shown to be effective in improving oral language, including effective read-alouds (e.g., bookreading) and vocabulary instruction (Coyne et al., 2010; Silverman, 2007; Whitehurst et al., 1994). In addition, converging with previous studies, attention to emergent literacy skills would facilitate children's word reading fluency. In particular, however, instruction on orthographic awareness—letter patterns and multi-letter units (e.g., graphemes and phonograms)—should be considered as part of text reading fluency instruction, particularly during an earlier phase of reading development.

Despite these limitations, we believe that the findings of the present study revealed and supported several important theoretical hypotheses about text reading fluency—how it is differentially related to reading comprehension over time, how it is different from word reading fluency as well as reading comprehension in terms of component skills. Overall these results suggest text reading fluency (efficiency or automaticity) is an important construct in reading development.

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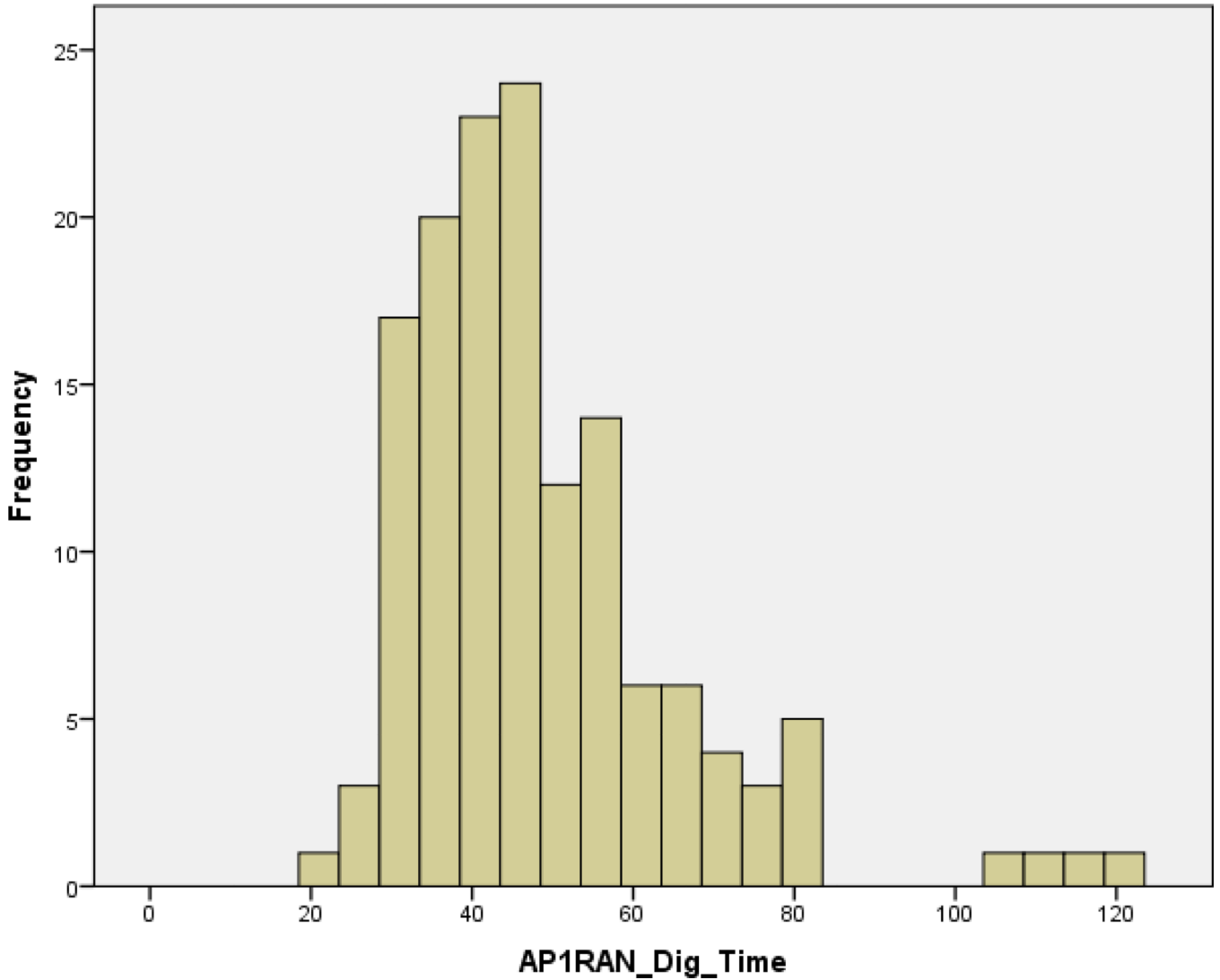
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Appendix A: Distribution of Rapid Automated Naming Task



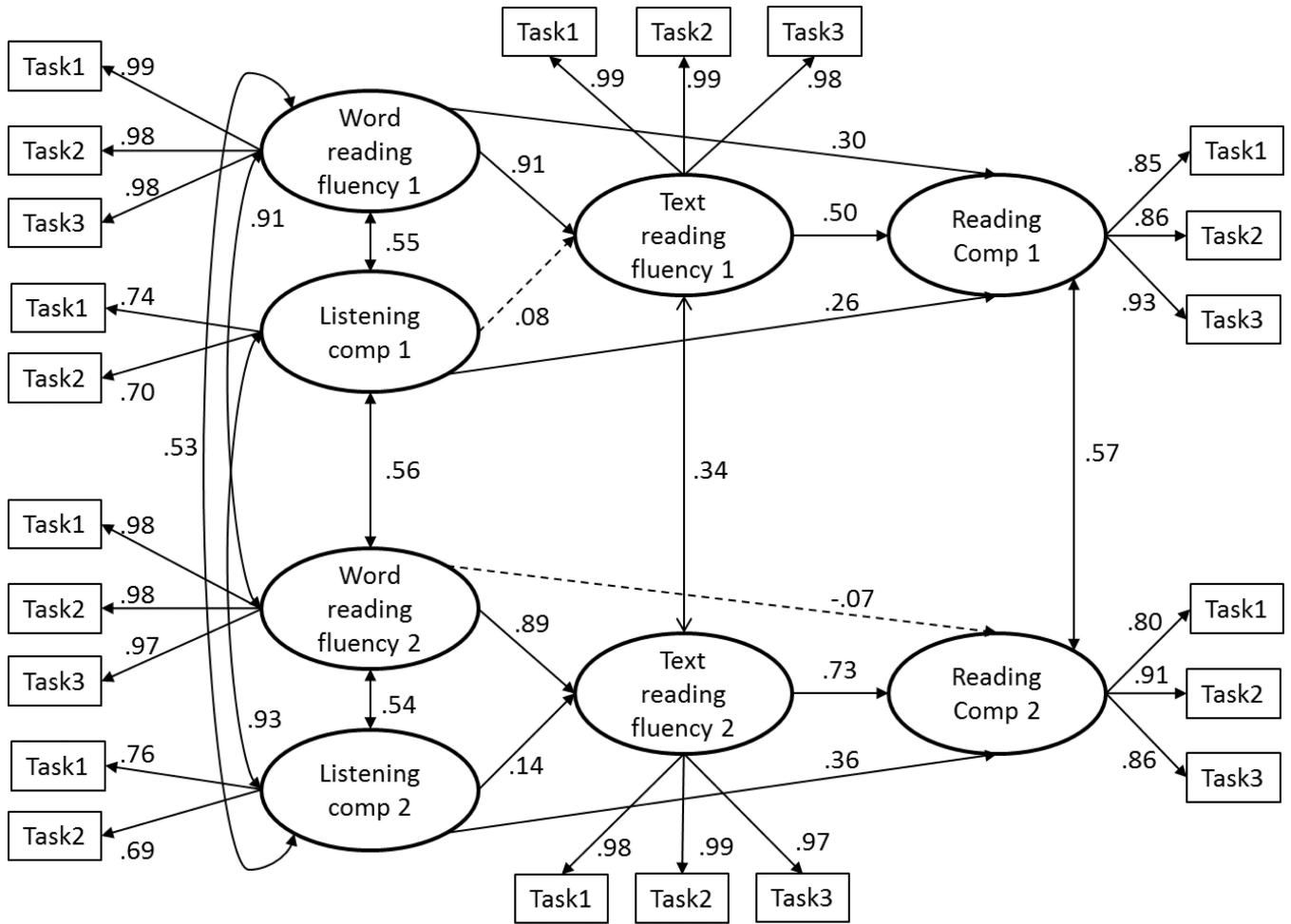


FIGURE 1. Standardized structural regression weights in which word reading fluency and listening comprehension predict text reading fluency, and word reading, listening comprehension, and text reading fluency predict reading comprehension at time 1 and time 2. Solid lines represent statistically significant relations and dotted lines statistically nonsignificant relations.

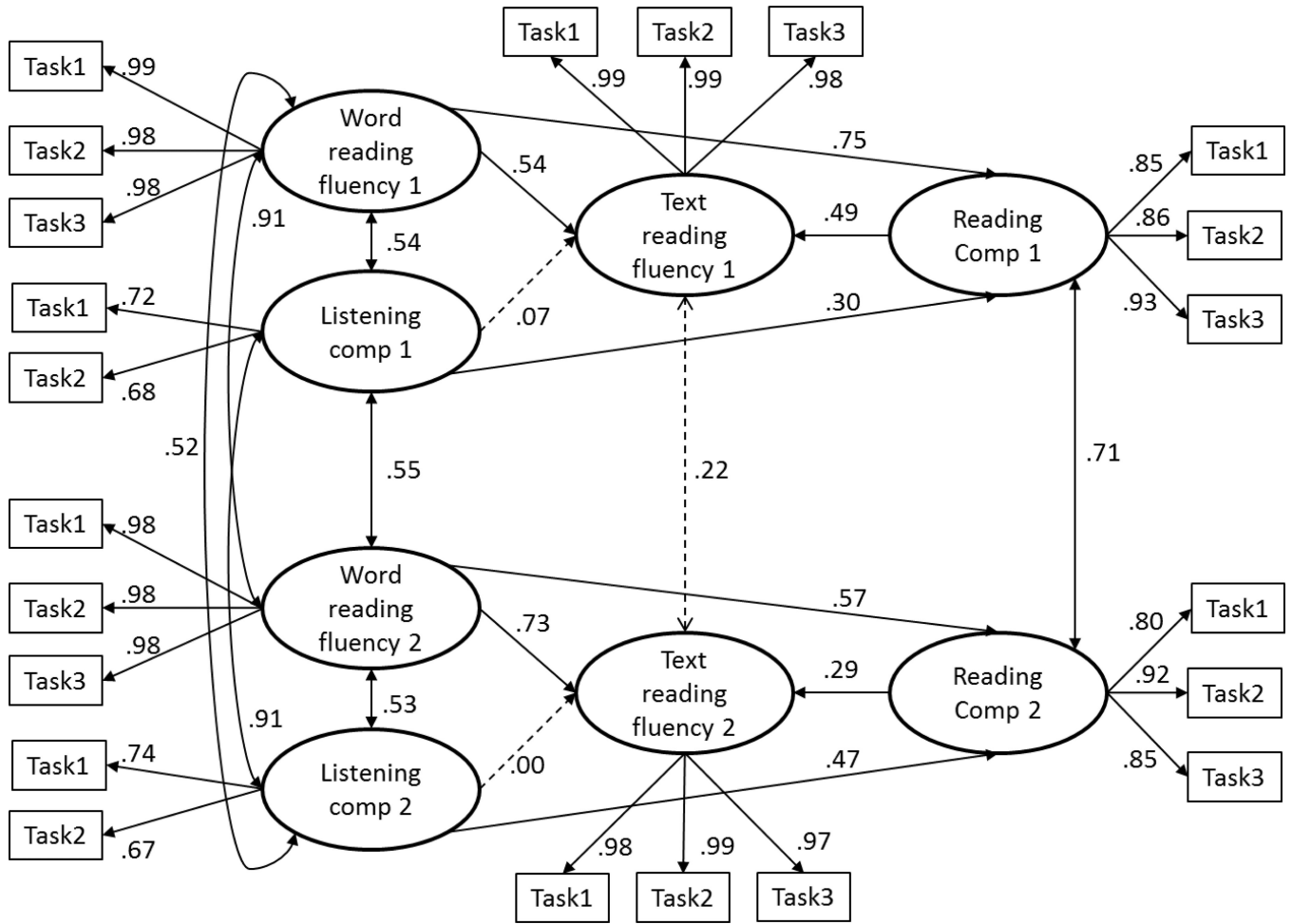
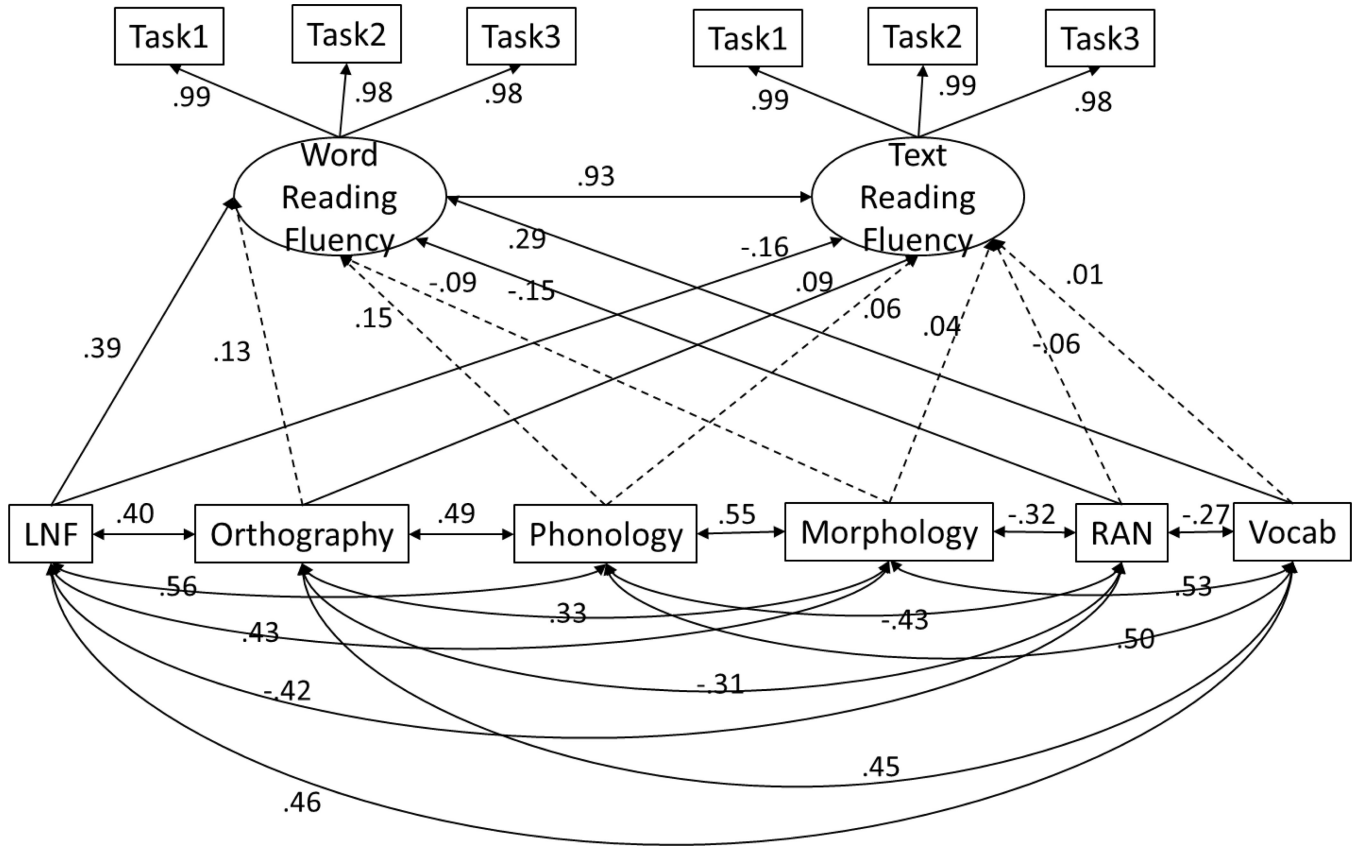


FIGURE 2. Standardized structural regression weights in which word reading fluency and listening comprehension predict text reading fluency, and word reading, listening comprehension, and reading comprehension predict text reading fluency at time 1 and time 2. Solid lines represent statistically significant relations and dotted lines statistically nonsignificant relations.



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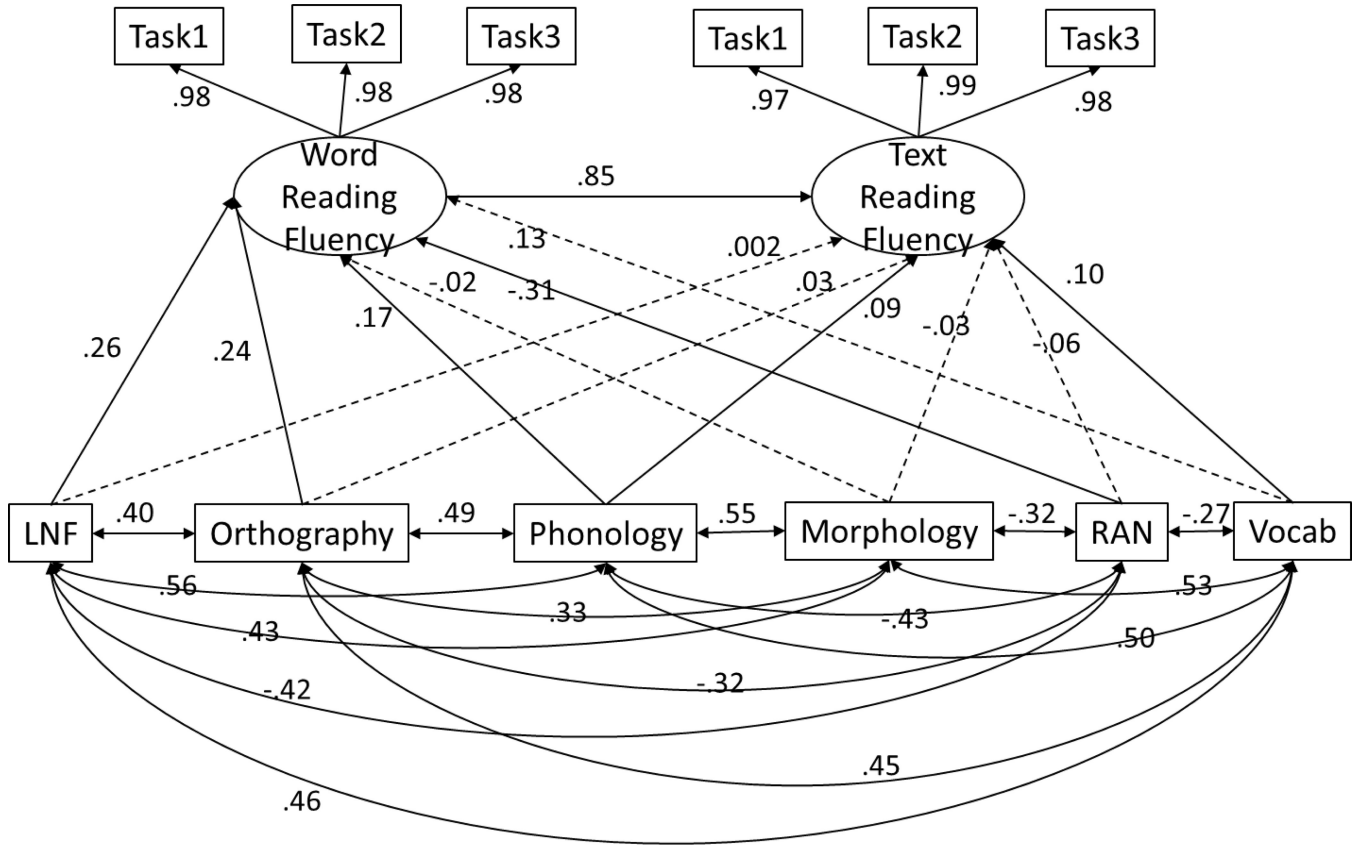


FIGURE 3.
 a Standardized structural regression weights for word reading fluency and text reading fluency at time 1 predicted by letter naming fluency (LNF), orthographic awareness (Orthography), phonological awareness (Phonology), morphological awareness (Morphology), rapid automatized naming (RAN), and vocabulary (Vocab). Solid lines represent statistically significant relations and dotted lines statistically non-significant relations.
 b Standardized structural regression weights for word reading fluency and text reading fluency at time 2 predicted by letter naming fluency (LNF), orthographic awareness (Orthography), phonological awareness (Phonology), morphological awareness (Morphology), rapid automatized naming (RAN), and vocabulary (Vocab). Solid lines represent statistically significant relations and dotted lines statistically non-significant relations.

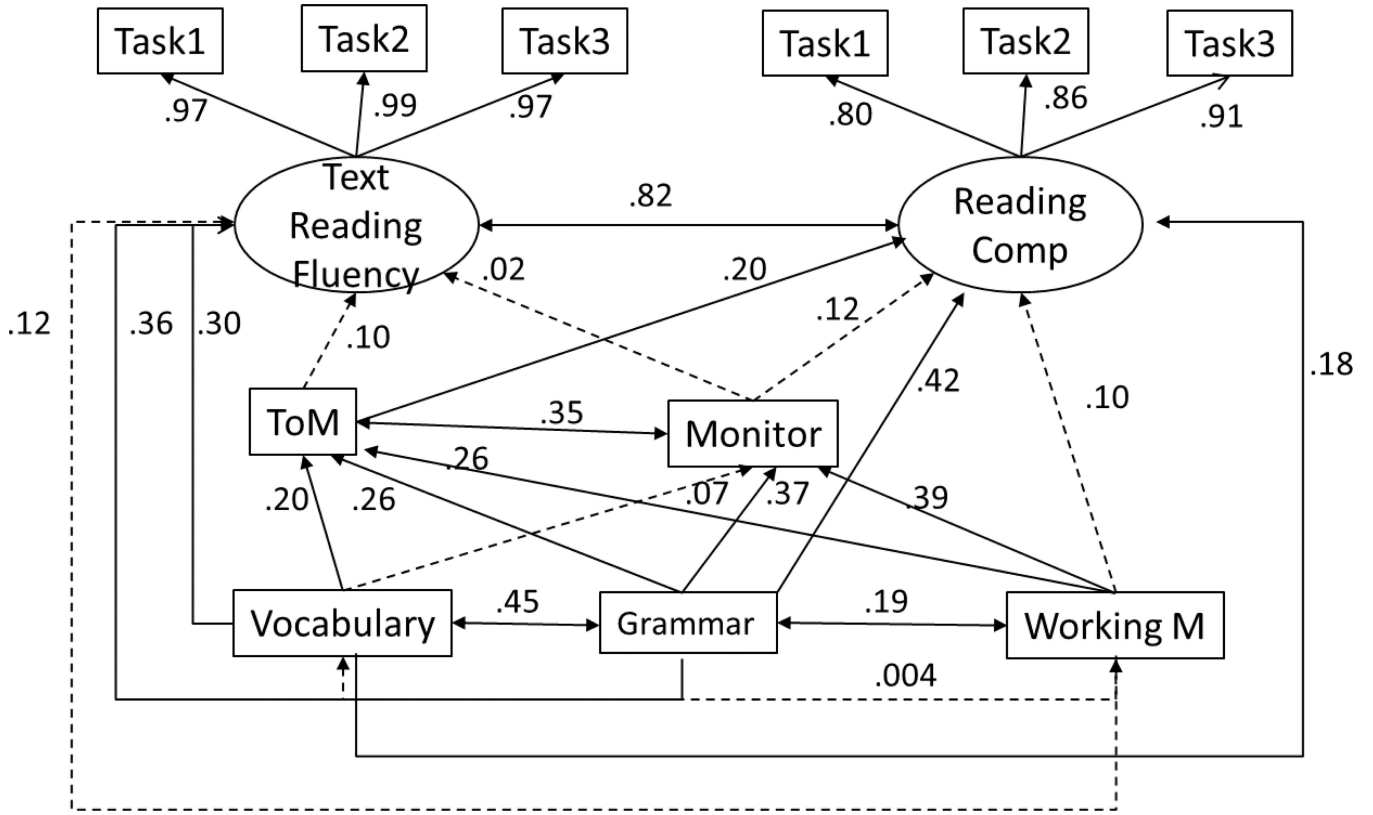


FIGURE 4. Standardized structural regression weights in a model in which reading comprehension and text reading fluency are predicted by theory of mind (ToM), comprehension monitoring (Monitor), vocabulary, grammatical knowledge (Grammar), and working memory (Working M). Solid lines represent statistically significant relations and dotted lines statistically nonsignificant relations.

TABLE 1

Descriptive Statistics

Variables	α	Mean	SD	Min-Max	Skewness	Kurtosis
<i>Time 1</i>						
Text reading fluency 1	+	48.22	46.78	0 – 211	1.09	.75
Text reading fluency 2	+	47.43	45.35	0 – 210	1.07	.66
Text reading fluency 3	+	51.15	48.40	0 – 195	1.03	.45
Word reading fluency 1	+	11.92	12.87	0 – 46	1.07	.20
Word reading fluency 2	+	10.42	12.77	0 – 51	1.46	1.44
Word reading fluency 3	+	10.89	12.44	0 – 46	1.30	.72
Reading Comprehension 1	.84	1.69	1.84	0 – 5	.56	-1.18
Reading Comprehension 2	.93	3.00	2.56	0 – 6	-1.12	-1.76
Reading Comprehension 3	.93	5.49	5.19	0 – 20	.80	-.29
Listening comprehension 1	.80	15.97	3.96	4 – 25	-.23	-.05
Listening comprehension 2	.77	11.76	3.43	3 – 19	-.39	-.35
Letter naming fluency	.93*	8.13	7.41	0 – 36	.94	.94
Orthographic awareness	.81	21.31	4.80	11 – 30	-.39	-.94
Phonological awareness	.91	13.14	6.91	0 – 27	-.12	-.48
Morphological awareness	.87	8.86	4.34	0 – 18	-.36	-.72
Rapid automatized naming	.86**	48.94	17.16	21 – 120	1.66	3.71
Expressive vocabulary	.77	19.71	4.29	11 – 30	.04	-.82
<i>Time 2</i>						
Text reading fluency 1	+	84.67	46.88	0 – 198	.25	-.56
Text reading fluency 2	+	83.09	46.77	0 – 214	.50	-.16
Text reading fluency 3	+	87.37	49.97	0 – 195	.48	-.40
Word reading fluency 1	+	21.45	13.63	0 – 54	.37	-.54
Word reading fluency 2	+	20.29	14.03	0 – 59	.63	-.14
Word reading fluency 3	+	21.08	14.68	0 – 58	.54	-.51
Reading Comprehension 1	.79	2.38	1.99	0 – 6	.19	-1.32

Variables	α	Mean	SD	Min-Max	Skewness	Kurtosis
Reading Comprehension 2	.81	2.25	2.11	0 – 7	.52	-.97
Reading Comprehension 3	.93	9.65	5.62	0 – 20	-.06	-1.03
Listening comprehension 1	.64	20.65	3.81	9 – 31	-.33	.38
Listening comprehension 2	.76	14.67	3.20	6 – 19	-.57	-.45
Theory of mind	.72	10.02	3.09	2 – 17	.05	-.56
Comprehension monitoring	.72	17.28	3.86	7 – 23	-.60	-.26
Receptive vocabulary	.79	40.38	4.85	27 – 48	-.64	-.19
Grammatical knowledge	.88	18.17	5.53	6 – 26	-.57	-.82
Working memory	.79	13.05	6.18	0 – 26	-.45	-.05

Note: Min = Minimum Max = Maximum

+see Table 2 for alternate form reliability

*test-retest reliability (approximately 7 days apart, n = 50) **

TABLE 2

Correlations among measures in Time 1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. TRF1	1.00															
2. TRF2	0.98	1.00														
3. TRF3	0.97	0.97	1.00													
4. WRF1	0.92	0.93	0.92	1.00												
5. WRF2	0.90	0.92	0.91	0.97	1.00											
6. WRF3	0.92	0.92	0.92	0.97	0.96	1.00										
7. RC1	0.76	0.76	0.77	0.76	0.74	0.77	1.00									
8. RC2	0.78	0.78	0.78	0.76	0.70	0.72	0.80	1.00								
9. RC3	0.87	0.88	0.87	0.86	0.85	0.84	0.78	0.80	1.00							
10. LC1	0.40	0.41	0.40	0.38	0.36	0.37	0.43	0.37	0.48	1.00						
11. LC2	0.41	0.42	0.40	0.42	0.40	0.40	0.52	0.43	0.48	0.52	1.00					
12. LNF	0.59	0.58	0.58	0.68	0.65	0.68	0.60	0.66	0.65	0.29	0.37	1.00				
13. OA	0.54	0.54	0.55	0.50	0.48	0.49	0.51	0.59	0.60	0.32	0.26	0.41	1.00			
14. PA	0.59	0.61	0.60	0.59	0.57	0.57	0.62	0.66	0.62	0.35	0.42	0.56	0.50	1.00		
15. MA	0.42	0.43	0.41	0.41	0.35	0.41	0.49	0.47	0.48	0.45	0.47	0.43	0.33	0.55	1.00	
16. RAN	-0.49	-0.48	-0.50	-0.47	-0.44	-0.44	-0.41	-0.54	-0.48	-0.24	-0.25	-0.42	-0.33	-0.43	-0.32	1.00
17. Vocab	0.56	0.59	0.58	0.59	0.56	0.58	0.61	0.54	0.66	0.59	0.55	0.46	0.46	0.51	0.53	-0.28

All coefficients are statistically significant at .001 level.

Note: TRF = Text Reading Fluency; WRF = Word Reading Fluency; RC = Reading Comprehension; LC = Listening comprehension; LNF = Letter naming fluency; OA = Orthographic awareness; PA = Phonological awareness; MA = Morphological awareness; RAN = Rapid automatized naming; Vocab = Expressive vocabulary Numbers following each variable represent tasks.

TABLE 3

Correlations among measures in Time 2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. TRF1	1.00														
2. TRF2	0.96	1.00													
3. TRF3	0.95	0.96	1.00												
4. WRF1	0.93	0.93	0.93	1.00											
5. WRF2	0.91	0.92	0.92	0.95	1.00										
6. WRF3	0.92	0.92	0.93	0.95	0.96	1.00									
7. RC1	0.66	0.68	0.65	0.62	0.61	0.59	1.00								
8. RC2	0.74	0.74	0.71	0.70	0.67	0.67	0.75	1.00							
9. RC3	0.84	0.84	0.83	0.82	0.78	0.78	0.70	0.76	1.00						
10. LC1	0.44	0.46	0.47	0.43	0.39	0.41	0.45	0.52	0.55	1.00					
11. LC2	0.45	0.45	0.45	0.40	0.39	0.40	0.45	0.49	0.51	0.60	1.00				
12. TOM	0.39	0.40	0.40	0.32	0.33	0.32	0.47	0.50	0.41	0.45	0.57	1.00			
13. Monitor	0.44	0.44	0.42	0.40	0.41	0.41	0.41	0.46	0.47	0.45	0.65	0.51	1.00		
14. Vocab	0.51	0.51	0.50	0.46	0.44	0.44	0.44	0.48	0.50	0.58	0.58	0.41	0.44	1.00	
15. Grammar	0.56	0.55	0.54	0.53	0.49	0.50	0.58	0.57	0.59	0.45	0.61	0.42	0.53	0.47	1.00
16. Working M	0.28	0.29	0.29	0.24	0.23	0.24	0.17+	0.22	0.28	0.17+	0.28	0.26	0.35	0.19	0.24

All coefficients are statistically significant at .05 except +.

Note: TRF = Text Reading Fluency; WRF = Word Reading Fluency; RC = Reading Comprehension; LC = Listening comprehension; ToM = Theory of Mind; Monitor = Comprehension Monitoring; Vocab = Receptive Vocabulary; Grammar = Grammatical knowledge; Working M = Working Memory

Numbers following each variable represent tasks.