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Toward Integrative Reading Science: The Direct and Indirect Effects Model of Reading

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Abstract

The authors propose an integrative theoretical model of reading called the direct and indirect effects model of reading (DIER) that builds on and extends several prominent theoretical models of reading. According to DIER, the following skills and knowledge are involved in reading comprehension: word reading, listening comprehension, text reading fluency, background knowledge (content knowledge and discourse knowledge), reading affect or socioemotions, higher order cognitions and regulation (e.g., inference, perspective taking, reasoning, and comprehension monitoring), vocabulary, grammatical (morphosyntactic and syntactic) knowledge, phonology, morphology, orthography, and domain–general cognitions (e.g., working memory and attentional control). Importantly, DIER also describes the nature of structural relations—component skills are hypothesized to have (a) hierarchical relations; (b) dynamic (or differential) relations as a function of text, activity (including assessment), and development; and (c) interactive relations. The authors then examined the hierarchical relations hypothesis by comparing a flat or direct relations model with hierarchical relations (or direct and indirect effects) models. Structural equation model results from 201 Korean-speaking first graders supported the hierarchical relations hypothesis and revealed multichanneled direct and indirect effects of component skills. These results are discussed in light of DIER, including instructional and assessment implications for reading development and reading difficulties.

Keywords

DIER, simple view of reading, reading fluency, reading comprehension, listening comprehension

Reading is ubiquitous and thus is a necessary skill in the modern information-driven society. Reading comprehension involves complex processes, requiring the orchestration of a number of skills and knowledge. Many theoretical models have been proposed and have provided rich and detailed descriptions about the complexity and multiplicity of the factors that contribute to reading comprehension; yet, the current literature is fragmented because many factors that influence reading comprehension have been studied in various fields and lines, and have not been unified into a single coherent model. To advance reading science, integration of accumulated rich body of knowledge, theories, and evidence is necessary. In this article, we present an integrative theoretical model of reading called the direct and indirect effects model of reading (DIER). DIER (Kim, 2017b) that focuses on the hierarchical nature of relations among component skills has been proposed. In the present study, we expand and formally present DIER as an integrative theoretical model by articulating component skills and their structural relations such as hierarchical relations; dynamic (or differential) relations as a function of text, activity (including assessment method), and development; and interactive relations. We then examined the hierarchical relations hypothesis, and associated direct and indirect effects of component skills, using data from beginning readers in Korean.

DIER

Component Skills That Contribute to Reading per DIER

According to DIER, the reading process draws on a complex array of language, cognition, knowledge, and skills, including word reading, listening comprehension, text reading fluency, background knowledge (content knowledge

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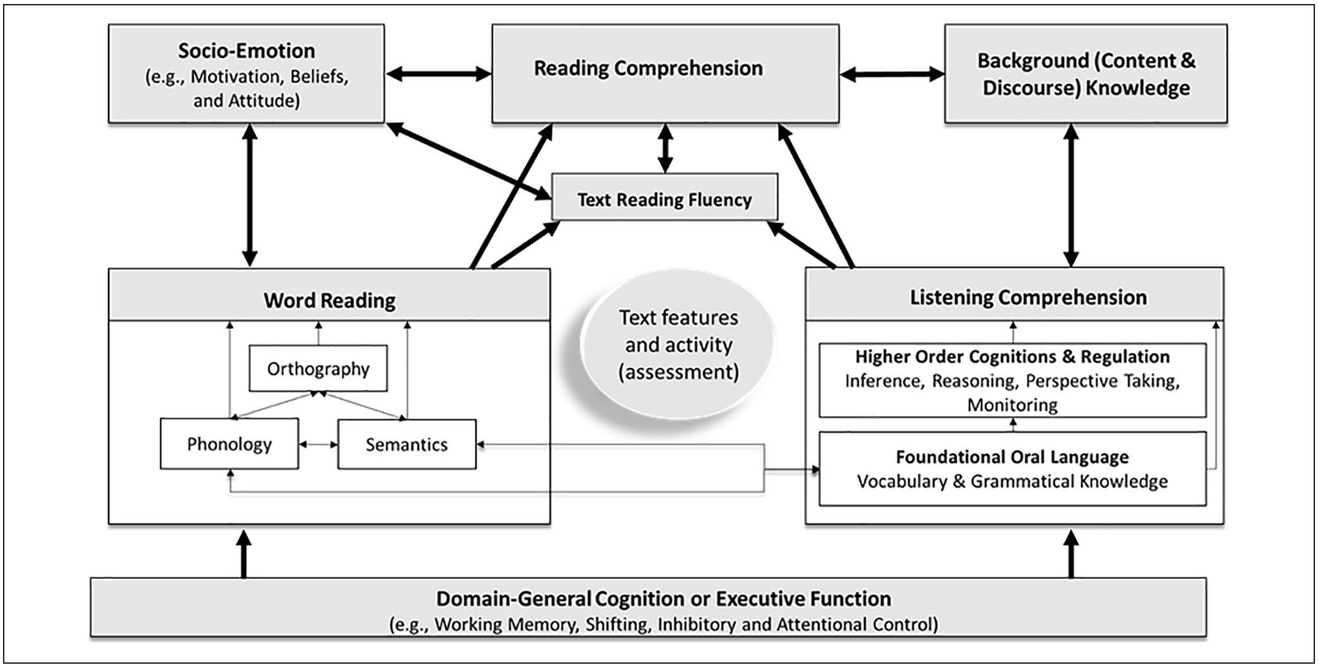

Figure 1. Direct and indirect effects model of reading (DIER; Kim, 2020, printed with permission).
Note. The component skills are hypothesized to have hierarchical, dynamic (as a function of text, activity [assessment], and development), and interactive (or bidirectional) relations. Further interactive relations are hypothesized beyond what is illustrated here (see the text for more details). Grammatical knowledge includes morphosyntactic and syntactic knowledge. Semantics includes morphology and beyond.

and discourse knowledge [e.g., genre knowledge including text structure, register knowledge]), reading affect or socio-emotions (e.g., motivation, attitude, self-concept, self-efficacy, anxiety), higher order cognitions and regulation (e.g., inference, perspective taking, reasoning [see Note 1], monitoring, and setting goals), vocabulary, grammatical (morphosyntactic and syntactic) knowledge, phonology, morphology, orthography, and domain–general cognitions (e.g., working memory [see Baddeley, 2012] and attentional control [attentional control includes both cognitive or inhibitory control and behavioral control]; see Figure 1). These factors operate within the constraint of limited processing resources and develop interacting with environments, and larger ecological systems and factors (e.g., home environment, socioeconomic status, instruction, language factors—learning to read in an unfamiliar language; see the role of larger context in RAND Reading Study Group, 2002). DIER posits that these skills have hierarchical, dynamic, and interactive relations.

Hierarchical Relations Hypothesis of DIER

One key feature and hypothesis of DIER is multiple layers of *hierarchical relations* among component skills and consequent direct and indirect relations of component skills to reading comprehension (Kim, 2017b). In other words, not all the component skills make direct contributions to reading comprehension. Instead, proximal skills (see Note 2) have direct relations to reading comprehension, whereas distal skills support proximal skills and have *indirect* relations to reading comprehension via proximal skills. Proximal skills include word reading, listening comprehension, and text reading fluency. Word reading and listening comprehension are the two necessary skills for reading comprehension according to the simple view of reading (Hoover & Gough, 1990). Text reading fluency is built on word reading and listening comprehension and mediates their relations to reading comprehension (see Figure 1) as text reading fluency captures word reading as well as postlexical semantic processes (see Jenkins et al., 2003; Kim, 2015a). The proximal skills are hypothesized to completely mediate the relations of the other component skills (e.g., higher order cognitions and regulation, vocabulary, working memory) to reading comprehension, provided that reading comprehension and listening comprehension are measured equivalently—that is, texts used in reading comprehension and listening comprehension tasks are similar or equivalent in features and characteristics. If texts differ significantly in terms of language and cognitive demands, then distal skills may directly relate to reading comprehension over and above the proximal skills (see the dynamic relations hypothesis below for details).

Word reading and listening comprehension are supported by component skills of their own. Word reading, a lexical-level reading skill, is supported by knowledge and awareness of phonology, orthography, and semantics (e.g., morphology; see the bottom left of Figure 1; Adams, 1990; Bishop & Snowling, 2004; National Early Literacy Panel, 2008; National Institute of Child Health and Human Development [NICHD], 2000; National Research Council, 1998). Listening comprehension, a discourse-level oral language skill, is supported by higher order cognitions and regulation, such as inference, perspective taking, reasoning, and comprehension monitoring, which, in turn, are supported by foundational oral language skills such as vocabulary and grammatical knowledge (Kim, 2016). At the foundation of listening comprehension and word reading are domain–general cognitions or an executive function such as working memory, shifting, and inhibitory and attentional control. In other words, domain–general cognitions support reading comprehension (Daneman & Carpenter, 1980; Peng et al., 2018) via its component skills, such as listening comprehension (Daneman & Merikle, 1996; Florit et al., 2009; Kendeou et al., 2008; Kim, 2016), foundational oral language skills (Gathercole et al., 1992; Kim & Phillips, 2014; Verhagen & Leseman, 2016), higher order cognitions and regulation (e.g., Kim, 2015b; Mutter et al., 2006), word reading, and component skills of word reading (e.g., phonological awareness, morphological awareness; Biname & Poncelet, 2015; Chung & McBride-Chang, 2011; Deacon et al., 2009; Kim et al., 2018; Kim & Petscher, 2016; Swanson & Ashbaker, 2000).

Hierarchical relations of language and cognitive skills to listening comprehension (see bottom right of Figure 1) are based on the mapping of mental representations for discourse comprehension with language skills and cognitive skills (Kim, 2016). Successful discourse comprehension occurs when one constructs an accurate mental representation known as the situation model (Kintsch, 1988). The situation model is built on a lower level mental representation, textbase (initial elementary text-based propositions), which, in turn, is built on a surface code (the representation of words and phrases used in the text). These various mental representations differ in the processes involved, and thus, their demands on language and cognitive skills differ (Kim, 2016). The surface code requires domain–general cognitions (e.g., working memory, attention) to simultaneously hold and process a series of incoming linguistic information. Foundational oral language skills (vocabulary and grammatical knowledge) are needed to establish the textbase representation for parsing and semantic analysis. Higher order cognitions and regulation (e.g., comprehension monitoring, inference, reasoning, perspective taking) are needed to establish local and global coherence in the situation model because many initial, local propositions in the textbase representation are inaccurate and incomplete (Kintsch, 1988; Kintsch & Rawson, 2005).

Hierarchical relations elucidate mechanisms and pathways by which component skills are related to one another and to reading comprehension. Specification of structural relations is particularly important for reading comprehension as it involves a complex array of skills, which are related to one another. A corollary of the hierarchical relations hypothesis is multichanneled cascading effects of lower order skills on higher order skills. Working memory, for example, is important both to reading comprehension and to component skills of reading comprehension (see, for example, Peng et al., 2018, for a meta-analysis) such as listening comprehension (Daneman & Merikle, 1996; Kim, 2015b; Kim & Phillips, 2014), theory of mind (Borst et al., 2010), vocabulary (Gathercole et al., 1992; Kim, 2017a), grammatical knowledge (Kim, 2015b; Verhagen & Leseman, 2016), word reading (Kim et al., 2018; Swanson & Ashbaker, 2000), and phonological awareness (Biname & Poncelet, 2015; Deacon et al., 2009; Kim & Petscher, 2016; Yang et al., 2019). By integrating findings from several lines of work, DIER captures the multiple pathways by which working memory contributes to reading comprehension (working memory → vocabulary and grammatical knowledge → higher order cognitions and regulation → listening comprehension → text reading fluency → reading comprehension; working memory → phonological, semantic, and orthographic awareness → word reading → text reading fluency → reading comprehension). Doing so also helps explain previous conflicting findings. Again, using the example of working memory, despite the well-established role of working memory in reading comprehension (e.g., Peng et al., 2018), the relation of working memory to reading comprehension was contested (Freed et al., 2017) because it was not independently related to reading comprehension in some studies (e.g., Freed et al., 2017; Tighe & Schatschneider, 2016; Van Dyke et al., 2014). According to DIER, inconsistency in previous studies is explained by the differences in skills accounted for across studies (e.g., if higher order skills are accounted for in the statistical model, working memory is not likely to have a direct relation). Another example is morphological awareness as it makes a contribution to reading comprehension via multiple pathways (e.g., via word reading → text reading fluency → reading comprehension; via vocabulary and grammatical knowledge → higher order cognitions and regulation → listening comprehension → text reading fluency → reading comprehension). Growing evidence indicates that not all component skills make direct contributions, but instead make direct and/or indirect contributions to reading comprehension (Ahmed et al., 2016; Cromley & Azevedo, 2007; Kieffer et al., 2013; Kim, 2015b; Kim, Guo, et al., 2020; Vellutino et al., 2007).

Dynamic Relations Hypothesis of DIER

Another central tenet of DIER is *dynamic relations*—the roles of component skills in comprehension are not fixed or static. Instead, they are expected to vary as a function of text characteristics, activity (e.g., assessment method), and development of component skills. *Text characteristics* would influence the extent to which specific component skills contribute to comprehension (including both oral texts [listening comprehension] and written texts [reading comprehension]) as texts vary in their language and cognitive features and demands. If texts include a number of sophisticated vocabulary words, the relative contribution of vocabulary to comprehension will increase. Working memory demand would vary depending on whether relevant information is provided adjacent to or distant from focal locations in the text (Cain, Lemmon, & Oakhill, 2004; Yuill et al., 1989). Similarly, some texts require a greater extent of inference, perspective taking, and topic knowledge, or lack cohesion compared with others (e.g., Wolfe, 2005). These features tend to covary by genre (e.g., narrative vs. expository; Derewianka, 1990; Stein & Trabasso, 1981). Dynamic relations as a function of text features explain interindividual and intraindividual variation in comprehension as text features interact with individual characteristics (e.g., working memory, vocabulary knowledge, inference skill; see Collins et al., 2020; Francis et al., 2018; McNamara et al., 1996; Ozuru et al., 2009). Accounting for text factors in a theoretical model of reading is in line with research on the measurement of comprehension that argues for the use of multiple tasks to measure comprehension (e.g., Francis, Fletcher, et al., 2005) as well as a recent call for recognizing text characteristics in a theoretical model of reading comprehension (Francis et al., 2018). Note here again that comprehension includes both oral texts and written texts, and, therefore, the roles of text features and the measurement issue apply to oral texts as well (listening comprehension; Kim & Petscher, 2020).

Dynamic relations as a function of text features also apply to the relations of phonological, orthographic, and morphological awareness to word reading skill within *and* across languages. Words in written texts vary in orthographic features and transparency. Although phonology, orthography, and semantics (e.g., morphology) are involved in word reading skills (Adams, 1990; Carlisle & Katz, 2006; Perfetti, 2007; Seidenberg, 2005), words vary in the demands of phonological, orthographic, and semantic processing. For example, words such as *bat* can be decoded using the knowledge of grapheme–phoneme correspondences, whereas decoding *react* would be facilitated by the knowledge of morphological structure (re-act) in addition to the knowledge of grapheme–phoneme correspondences. Studies indeed have shown that word features (e.g., morphological composition) interact with individual characteristics such as children's phonological, orthographic, and morphological awareness (Goodwin et al., 2014; Kearns, 2015; Kim et al., 2016). The relative weight of phonological, orthographic, and semantic processing would also apply to orthographic depth of writing systems as well as other linguistic features of focal language (see linguistic grain size theory, Ziegler & Goswami, 2005; also see Perfetti & Dunlap, 2008). For instance, in languages with transparent orthography, phonological awareness and knowledge of phoneme–grapheme correspondences would largely explain one's word reading skill, whereas in languages with deep orthography or those that employ morphophonemic principle (English, Korean; Cho et al., 2008) and/or morphosyllabic writing systems (e.g., Chinese; McBride-Chang et al., 2005), morphology would also play an important role in word reading. Although the component skills and their overall structural relations specified in DIER are not expected to differ across languages, the relative extent (or weights) of contributions of component skills is posited to vary due to characteristics of language and writing systems. This principle also extends to word reading difficulties such that the extent to which phonological, orthographic, and semantic awareness contributes to word reading difficulties would depend on writing systems and orthographies (e.g., Share, 2008).

The dynamic relations are also hypothesized as a function of *activity*. Reading is embedded in various activities (tasks and goals; RAND Reading Study Group, 2002), and therefore, sources of variation in one's reading performance include activity and associated goals (e.g., van den Broek et al., 2001). Another activity factor that influences one's performance is assessment method. Reading assessments, reading comprehension in particular, vary largely in multiple aspects (e.g., open-ended, multiple choice, cloze, or retell or free recall format; oral vs. silent reading mode). If different assessment methods add different constraints and/or vary in the extent to which they draw on different processes and skills (see Note 3), then one's performance on reading and the relations of language and cognitive skills to reading performance would differ (e.g., Cutting & Scarborough, 2006; Francis et al., 2005; Keenan et al., 2008; Reardon et al., 2018). Assessment methods also influence measurement of language skills, specifically listening comprehension (Kim & Petscher, 2020). Activity and assessment methods would interact with individual characteristics and text factors (e.g., Collins et al., 2019; Kim & Petscher, 2020).

It is important to note here that the recognition of dynamic nature as a function of text characteristics and activity does not imply that comprehension cannot be assessed as a skill or ability nor does it minimize the importance of child factors (component skills and knowledge). Measuring one's comprehension skill is certainly possible (measuring using multiple texts and assessment formats) and has a considerable value to describe general comprehension skill and track its development (Francis et al., 2018). Moreover, studies have shown that a substantial amount of variance in one's reading performance is due to individual or child characteristics, text features, and assessment methods (e.g., Collins et al., 2019; Francis et al., 2018). What is proposed in DIER is an explicit recognition and explanation of the role of text features and activity (assessment method) and their interaction with individual characteristics in one's performance on comprehension tasks in a theoretical model of reading.

The dynamic relations hypothesis as a function of *development* states that the roles of component skills change with development. For example, language and higher order cognitions and regulation would play greater roles in reading comprehension at a more advanced phase of reading development, whereas word reading and its component skills would play larger roles at the beginning phase of reading development. This hypothesis largely stems from the changing role of word reading in reading development (as word reading places a larger constraint on reading comprehension at the beginning phase of reading development than at an advanced phase) as well as the nature of texts (i.e., the increased complexity and density of ideas and language in upper grades; Bailey, 2007; Scarcella, 2003; Schleppegrell, 2001; Snow & Uccelli, 2009). This hypothesis is in line with evidence that word reading is strongly related to reading comprehension in primary grades, whereas listening comprehension is strongly related to reading comprehension in later phases (e.g., Adlof et al., 2006; Francis et al., 2005; Kershaw & Schatschneider, 2012; Kim & Wagner, 2015).

The dynamic roles of word reading and listening comprehension as a function of development also have consequences for the mediating role of text reading fluency (Kim, 2015a). In the beginning phase of reading development, word reading acts as a bottle neck to a large extent so that the role of text reading fluency in reading comprehension largely overlaps with that of word reading, and text reading fluency does not mediate the relation of word reading to reading comprehension (Kim et al., 2011). As reading develops, the constraining role of word reading decreases, which, in turn, increases the mediating role of text reading fluency (see Kim et al., 2014; Kim & Wagner, 2015). The mediating role of text reading fluency also varies for word reading versus listening comprehension such that with development, text reading fluency completely mediates the relation of word reading to reading comprehension once children reach a certain level of reading development, whereas text reading fluency does not completely mediate the relation of listening comprehension to reading comprehension at any developmental phase (Kim & Wagner, 2015; see Kim, 2015a, for a theoretical explanation). The timing of these developmental changes in mediating roles varies by orthographic depth because of differences in the rate of word reading acquisition such that changes are observed in a shorter time span in transparent orthographies than in opaque orthographies (Kim, 2015a).

Interactive Relations Hypothesis of DIER

The third hypothesis of DIER is *interactive relations*—component skills are expected to develop interacting with each other and environments (e.g., Ford & Lerner, 1992). Studies have shown that motivation and affect (e.g., reading motivation, attitudes, self-concept, efficacy, anxiety) predict reading achievement (e.g., L. Baker & Wigfield, 1999; Katzir et al., 2009; Wigfield & Guthrie, 1997) and that reading skills predict motivation and affect (Chapman & Tunmer, 2003; Katzir et al., 2018). Indeed, longitudinal studies have shown bidirectional relations of motivation and affect with reading development (Lepola et al., 2000). Text reading fluency and reading comprehension (D. L. Baker et al., 2011; Jenkins et al., 2003; Kim, 2015a), foundational oral language skills (vocabulary and grammatical knowledge) and morphological awareness (Kieffer & Lesaux, 2012; McBride-Chang et al., 2008), and foundational oral language skills and inference (e.g., Currie & Cain, 2015; Kim, 2015b, 2016, 2017a; Lepola et al., 2012) are also posited to have bidirectional relations. In addition, reading skills are expected to have interactive relations with other component skills via reading experience or exposure. Children with higher reading skills are likely to read more, and exposure to texts will facilitate acquisition of background knowledge (Sparks et al., 2014; Stanovich, 1998), reading skills (word reading and text reading fluency), and language and cognitive skills (e.g., vocabulary, Quinn et al., 2020; theory of mind, Tsunemi et al., 2014; and inhibitory control, Fuhs et al., 2014).

DIER as an Integrative Model

DIER builds on, integrates, and extends several lines of work, including the simple view of reading (Hoover & Gough, 1990), the multicomponent view of reading (Cain, 2009), the componential model of reading (Joshi & Aaron, 2012), discourse comprehension (Graesser et al., 1994; Kintsch, 1988; Zwaan & Radvansky, 1998), listening comprehension (e.g., Florit et al., 2009; Kendeou et al., 2008; Kim, 2016; Kim & Phillips, 2014), the automaticity theory (LaBerge & Samuels, 1974), text reading fluency (e.g., Fuchs et al., 2001; Wolf & Katzir-Cohen, 2001), the direct and inferential mediation model (Cromley & Azevedo, 2007), measurement of comprehension (e.g., Cutting & Scarborough, 2006; Francis, Fletcher, Catts, & Tomblin, 2005; Keenan et al., 2008), the reading systems framework (Perfetti & Stafura, 2014), the triangle model (Adams, 1990), and the linguistic grain size theory (Ziegler & Goswami, 2005). For example, the simple view states that reading comprehension relies on word reading and listening comprehension (Hoover & Gough, 1990). According to the multicomponent view (Cain, 2009), reading comprehension draws on multiple factors such as working memory, attention, vocabulary, syntactic knowledge, inference, and comprehension monitoring (e.g., Barnes et al., 1996; Brimo et al., 2017; Cain, 2007; Cain, Oakhill, & Bryant, 2004; Chung et al., 2014; Conners, 2009; Elleman et al., 2009; NICHD, 2000; Perfetti et al., 2005; van den Broek & Kremer, 2000). Recent work revealed that listening comprehension also draws on a highly similar set of component skills as those included in the multicomponent view (e.g., Daneman & Merikle, 1996; Florit et al., 2009; Kendeou et al., 2008; Kim, 2015b, 2016; Kim & Phillips, 2014; Tompkins et al., 2013). In fact, this overlap is not surprising, in that discourse comprehension includes comprehension of oral texts (listening comprehension) and written texts (reading comprehension), and therefore, processes and component skills are expected to be highly similar. The only processes unique in comprehension of *written* texts (reading comprehension) are those involved in decoding or word reading. This is essentially the point of the simple view of reading (Gough & Tunmer, 1986). However, the simple view of reading lacked many details needed for a theoretical model—for example, component skills of listening comprehension remained a black box; processes and structural relations were not specified. DIER critically extends the simple view of reading and other efforts (a) by specifying processes and component skills beyond decoding and listening comprehension (e.g., text reading fluency, higher order cognitions, background knowledge, reading affect, and domain–general cognitions), (b) by including text and activity factors (beyond individual characteristics on which the vast majority of previous models and frameworks focused), and (c) by articulating structural relations (hierarchical, dynamic, and interactive relations).

DIER consolidates extant theoretical models and literature from several lines of work into a unifying model. Existing theoretical models provided necessary, detailed, and rich information. However, the majority of them focus on a specific aspect (e.g., word reading, automaticity) and have been examined in parallel, and without integration efforts, they present an incomplete and isolated, if not confusing, picture. For example, the triangle model (Adams, 1990) focuses on skills and processes involved in word reading, the lexical-level reading skill. To understand the roles of component skills of word reading (e.g., phonological awareness, morphological awareness) in reading comprehension, the discourse-level reading skill, the triangle model needs to be situated within and be integrated with theoretical models of reading comprehension. Furthermore, the literature associated with multiple component skills that contribute to reading comprehension and listening comprehension (e.g., vocabulary, inference; see above) is also consolidated into a single framework in DIER—these component skills contribute to reading comprehension via listening comprehension, word reading, and text reading fluency.

DIER also recognizes the importance of automaticity in reading development—see Wolf and Katzir-Cohen (2001) about automaticity at different linguistic levels (sublexical, lexical, & text levels) and Ehri's (2005) developmental phases of word reading skills. In particular, text reading fluency—accuracy and speed of reading connected texts with appropriate expression—has received substantial theoretical and empirical attention (Kim, 2015a; Kuhn et al., 2010; Kuhn & Stahl, 2003; NICHD, 2000). Despite numerous studies finding a strong relation of text reading fluency to reading comprehension (e.g., S. K. Baker et al., 2008; Daane et al., 2005; Fuchs et al., 2001; Jenkins et al., 2003; Kim, 2015a; Kim et al., 2014; Kuhn & Stahl, 2003; NICHD, 2000) and widely recognized automaticity theory in reading (LaBerge & Samuels, 1974; Wolf & Katzir-Cohen, 2001), text reading fluency has been glaringly omitted in many extant theoretical models of reading. It is important to note that the term "text" reading fluency, instead of the more widely used terms, "oral" reading fluency or reading fluency, is intentionally used in DIER for a precise articulation of the construct in terms of the following two aspects: (a) It is a text-level reading skill, not lexical-level (e.g., word reading fluency) or sublexical-level skill (e.g., see Kim, 2015a; Wolf & Katzir-Cohen, 2001), and (b) it is not specific to oral reading mode although it is widely measured as such due to ease of assessment. This clarification is important because although the definition and theoretical conceptualization of text reading fluency clearly identify it as a text-level reading skill (Jenkins et al., 2003; Kim, 2015a; Kuhn et al., 2010; NICHD, 2000; Wolf & Katzir-Cohen, 2001), several previous studies have operationalized it using lexical-level tasks (e.g., Adlof et al., 2006) or a mixture of text- and lexical-level tasks (e.g., Silverman et al., 2013). However, word reading fluency is a closely related but theoretically and empirically dissociable skill from text reading fluency (Kim, 2015a; Kim & Wagner, 2015; Nathan & Stanovich, 1991).

The hypotheses of DIER, including component skills and structural relations, are based on a review and synthesis of extant theoretical models and empirical evidence. However, like any theoretical models, the hypotheses in DIER need to be validated and tested using data from various languages and writing systems and from individuals at various developmental phases. The dynamic relations as a function of text characteristics and activity (assessment methods) can be examined in experimental studies where text and assessment characteristics are manipulated or by teasing out variance that is unique to child versus text and assessment characteristics (e.g., using the explanatory item response model; Collins et al., 2019; Francis et al., 2018; Goodwin et al., 2014). The dynamic relations hypothesis as a function of development can be examined using a longitudinal design (i.e., examine relative contributions of component skills across different developmental phases) and experimental design (e.g., intervention studies). The interactive relations

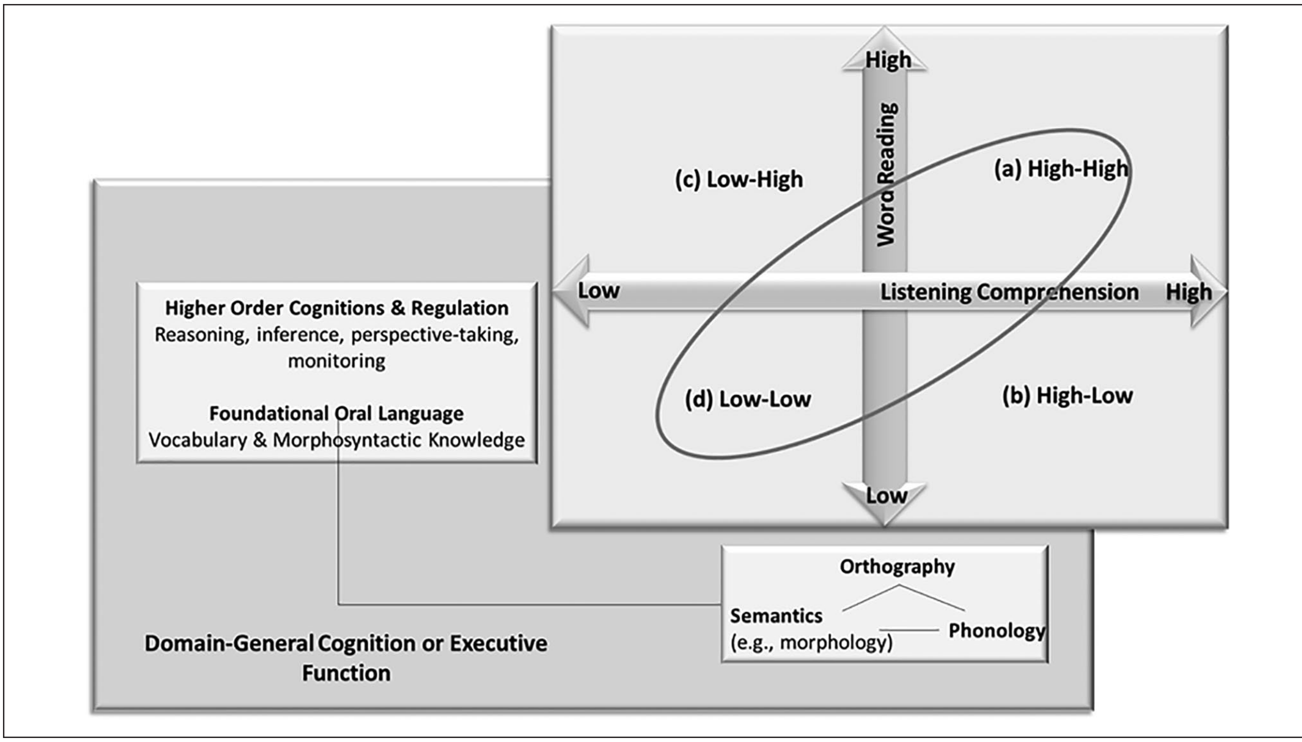

Figure 2. A heuristic of DIER for assessment and instruction, showing four quadrants of groups of children as a function of their word reading and listening comprehension skills, and the overlay of component skills that contribute to these.
Note. The oval represents the proportion of individuals in each quadrant. DIER = direct and indirect effects model of reading.

hypothesis can be investigated using a longitudinal research design (e.g., using cross-lagged model or latent change score model approaches) or experimental design (e.g., whether changes in one construct result in changes in another construct, and vice versa).

A few recent studies examined DIER. For example, Kim (2017b) found that the hierarchical relations were well supported for English-speaking second graders. The dynamic relations hypothesis was also supported but was found to have a complex picture due to the interaction between development factors and text characteristics (see -Kim, 2020, for details).

Implications of DIER for Assessment and Instruction and for Reading Difficulties

A theoretical model has direct implications for assessment and instruction. An essential step for effective instruction is an accurate assessment of students' skills based on theory and evidence. To begin with, the complexity of comprehension as a construct (or the multiple skills that comprehension draws on), and the roles of text factors and assessment methods in one's performance on comprehension tasks behoove greater attention to measurement of comprehension skill (both listening comprehension and reading comprehension). For example, precise measurement of one's comprehension skill would require use of multiple texts with various features (including genres) and multiple assessment methods (see below for future directions to alleviate practical challenges in school settings).

Furthermore, according to DIER, numerous skills contribute to reading development or difficulties, and therefore need to be assessed. However, assessments should be also systematic considering the hierarchical or cascading nature of relations and developmental phase. At a proximal level, children can be classified into four groups or quadrants by their word reading and listening comprehension skills: (a) children who are strong in both word reading and listening comprehension, (b) those who are weak in word reading but relatively strong in listening comprehension, (c) those who are weak in listening comprehension but relatively strong in word reading, and (d) those who are weak in both (see Figure 2). In other words, at a proximal level, there are two pathways by which children can struggle with reading comprehension: via word reading and via listening comprehension. Children with a persistent difficulty with word reading, despite evidence-based instruction, are considered to have dyslexia, which has secondary consequences on reading comprehension. Children with a difficulty with listening comprehension, including those with language impairment, would also struggle in reading comprehension, and many manifest as late-emerging poor readers (Catts et al., 2012).

This classification is not new, and is aligned with the simple view of reading (e.g., Catts et al., 2006; Hoover & Gough, 1990). However, DIER critically extends the four-quadrant idea in several ways. First, DIER provides a clear picture about further diagnostic assessments for those who struggle in word reading, listening comprehension, or both, to identify specific sources that contribute to the difficulties in each area. For word reading skill, phonological, semantic (e.g., morphological), and orthographic skills should be evaluated. For listening comprehension, background knowledge, higher order cognitions and regulation, and foundational oral language skills (vocabulary, syntax) should be assessed. Domain–general cognitive skills are relevant to both (see Figure 2).

Second, once specific sources of students' difficulties and their needs are identified, instruction should address them systematically and explicitly. That is, those who need additional support in word reading and decoding should be provided with instruction on phonological, morphological, and orthographic skills. Those who need additional support in listening comprehension need systematic instruction on background knowledge, foundational oral language skills, and higher order cognitions and regulation. Instruction on working memory (see Note 4) and attentional control are expected to improve component skills of word reading and those of listening comprehension, and ultimately reading comprehension. Using the response to instruction (RTI) and/or multitiered system of support (MTSS) framework, a systematic approach should interweave the cycle of assessment and instruction efforts, employing screening, diagnostic assessment, explicit instruction based on the identified needs, progress monitoring, modification of instruction depending on the students' changing needs, and so on.

Third, the gap between reading comprehension and listening comprehension, in addition to one's performance in word reading skill, is one indicator or symptom of word reading disabilities (see also Spencer et al., 2014). However, DIER indicates that the four-quadrant distinctions in Figure 2 are not as clear cut as they may have appeared initially (beyond the measurement issue in identification raised in Francis et al. (2005) and Waesche et al. (2011)). This is because the vast majority of component skills are not independent, but instead interconnected: The hierarchical relations imply that component skills rely on each other, and the interactive relations imply that component skills develop reciprocally. For example, studies have shown that a large amount of variance is shared between word reading and listening comprehension or oral language skills (see Cutting & Scarborough, 2006; Foorman et al., 2018; Keenan et al., 2008), and children with dyslexia also have weak oral language skills (Snowling & Melby-Lervag, 2016). According to DIER, there are two sources of shared variance between word reading and listening comprehension: (a) the interactive relations between phonology and semantics with foundational language skills (vocabulary and grammatical knowledge; see Figure 1) and (b) the roles of domain–general cognitions. As shown in Figure 1, phonological awareness and morphological awareness not only contribute to word reading but also relate with vocabulary and grammatical knowledge, which contribute to listening comprehension; as a consequence, children's performance on word reading and listening comprehension would be related. The relation between word reading and listening comprehension is also explained by the fact that domain–general cognitions are involved in the component skills of word reading (orthographic, phonological, and semantic processing) *and* those of listening comprehension (e.g., vocabulary, inference; see the literature review section above for empirical evidence). If word reading and listening comprehension share common component skills and thus, are related to each other, then individuals with large discrepancies between word reading and listening comprehension (those who have extremely high word reading and extremely low listening comprehension, and vice versa) would not be as common as it might have appeared. That is, the proportion of children in each of the quadrants would not be equal. Instead, a greater proportion of children would be either high in word reading and listening comprehension (Quadrant a) or low in both (Quadrant d), whereas a smaller proportion of children would be in the high–low or low–high quadrants (Quadrants b and c in Figure 2). The proportion would depend on the strengths of the relations of phonological and semantic processing with vocabulary and grammatical knowledge: the stronger the relation, the smaller the proportion in the low–high and high–low quadrants; the weaker the relation, the larger the proportion in these two quadrants.

Finally, the interconnected nature of the component skills also implies that instruction should address multiple skills to support development. Because higher order skills are built on lower order skills, to be maximally effective in improving reading comprehension and preventing reading difficulties, explicit and systematic instructional efforts are needed to build students' foundational skills and, at the same time, to support their higher order skills. Instruction on particular target skills (e.g., phonological awareness) is absolutely needed to address specific weaknesses but for robust development of overall reading skills, systematic instruction on multiple skills is needed (e.g., Wanzek & Vaughn, 2007).

Present Study

The goal of the present study was to replicate *and* extend the previous studies on the hierarchical relations hypothesis in the context of DIER in three ways. First, we explicitly compared a nonhierarchical, direct relations model (wherein all the component skills are hypothesized to be directly related to reading comprehension) with hierarchical structural relations models, and consequent direct and indirect relations. Second, we included text reading fluency. Third, we examined these using data from Korean-speaking first graders. The hierarchical relations hypothesis has been supported for English-speaking children in Grades 2 and 4 (Kim, 2017b, 2020), but for generalizability, DIER needs to be tested in various languages and orthographies with children in various developmental phases.

The Korean language contrasts with English in oral language and writing system characteristics. Unlike English, Korean is a predicate–final language with a subject–object–verb structure. The Korean language uses an alphasyllabary writing system called Hangul, which, unlike English, is relatively transparent with consistent phoneme–grapheme correspondences (see Note 5; Cho, 2009; Kim, 2011). As noted above, according to DIER, the structural relations are not expected to differ across languages but relative contributions may vary as a function of language features and orthographic depth. Note that the goal of the present study was to examine hierarchical relations using data from Korean-speaking children, not to compare hierarchical relations or relative weights of component skills in different languages as these would require a carefully designed cross-linguistic study.

Specific research questions in the present study were as follows:

Research Question 1: Are the component skills directly related to reading comprehension?
Research Question 2: Do the hierarchical relations hypothesized in DIER fit the data well? If so, what is the nature of direct and indirect relations of component skills?
Research Question 3: What are the total effects, including direct and indirect effects, of component skills on reading comprehension?

Method

Participants

Data were from a study of primary-grade children's literacy development in Korean. Results on oral language and writing skills have been reported earlier (Kim, 2016; Kim & Park, 2019), and in this study, we focus on reading skills specifically. A total of 201 children in Grade 1 (56% boys; mean age = 6.84 years, SD = 0.30 years) in a single public elementary school in an urban area in South Korea participated in the study. Korea is a highly homogeneous country. In this sample, 94% of the children were native speakers of Korean; only 6% of the children (i.e., n = 12) had a parent whose first language was not Korean. Socioeconomic characteristics of the individual children were not available due its sensitivity, but neighborhood characteristics indicated that the children were largely from middle-class or low middle-class families. None of the participating children had identified disabilities.

Formal schooling in South Korea starts in Grade 1. However, the vast majority of children attend kindergarten and receive some form of literacy instruction prior to formal schooling. The reading curriculum in elementary schools (Grades 1–6) is centralized and uniform across the country.

Measures

Children were assessed on the following constructs approximately 3 months into the academic year: reading comprehension, text reading fluency, listening comprehension, word reading, (knowledge-based) inference, perspective taking (as measured by theory of mind), comprehension monitoring, vocabulary, grammatical knowledge, and working memory. The tasks used in this study were used in prior work and have been found to be reliable and valid. Due to constraints in working in the schools (i.e., limited time to work with children), not all constructs were measured by multiple tasks (word reading, text reading fluency, listening comprehension, and reading comprehension were). All the measures were administered in oral language contexts except for word reading, text reading fluency, and reading comprehension. Unless otherwise noted, children's responses were scored dichotomously (1 = correct, 0 = incorrect) for each item, and all the items were administered to children. Reliability estimates are reported in Table 1.

Reading comprehension. Previously used reading comprehension tasks for primary-grade children learning to read in Korean (Kim, 2015b; Kim et al., 2014) were adapted. There were three tasks where the child was asked to read a total of six (one expository and five narrative) passages and to answer open-ended literal and inferential comprehension questions. Each task included two passages ranging from 23 to 207 words, with 10, 12, and 13 total questions in Tasks 1, 2, and 3, respectively (see Appendix A for an example passage and questions). Most questions were scored dichotomously but a few items were scored from 0 to 2.

Text reading fluency. Three previously used text reading fluency tasks were administered (Kim, 2015a; Kim et al., 2014). In these tasks, the child was presented with a passage and was asked to read words aloud with accuracy and speed in 1 min. The number of characters (or syllables) read accurately in 1 min was the child's score per task.

Word reading. Three word reading efficiency tasks were used where the child was asked to read words of increasing difficulty with accuracy and speed in 45 s. This task was used in previous studies with Korean children (e.g., Kim, 2015a) and was modeled after the Test of Word Reading Efficiency in English (Torgesen et al., 2012). The number of words read accurately was the child's score per task.

Table 1. Descriptive Statistics for Study of DIER.

Variable	α	*M* (*SD*)	Min–Max	Skewness	Kurtosis
Reading comprehension 1	.85	5.58 (3.25)	0–11	−0.30	−1.10
Reading comprehension 2	.85	4.11 (3.49)	0–14	0.41	−0.91
Reading comprehension 3	.89	3.37 (4.18)	0–14	1.07	−0.06
Word reading 1	.93–.95+	29.17 (13.41)	0–63	−0.49	−0.05
Word reading 2	.93–.95+	31.03 (13.78)	0–64	−0.50	0.24
Word reading 3	.93–.95+	30.24 (14.49)	0–64	−0.42	−0.16
Text reading fluency 1	.89–.93+	123.00 (55.22)	0–273	−0.46	0.28
Text reading fluency 2	.89–.93+	112.75 (52.96)	0–262	−0.22	−0.02
Text reading fluency 3	.89–.93+	126.41 (59.19)	0–298	−0.27	0.00
Listening comprehension 1	.96	12.68 (8.73)	0–62	2.84	10.79
Listening comprehension 2	.65	2.05 (1.62)	0–7	0.69	0.29
Knowledge-based inference	.69	7.20 (2.66)	0–12	−0.57	−0.20
Theory of mind	.74	5.24 (2.91)	0–14	0.64	0.20
Comprehension monitoring	.78	15.81 (3.83)	0–22	−0.95	1.52
Vocabulary	.89	30.56 (7.41)	2–47	−0.72	0.95
Grammatical knowledge	.84	10.20 (5.07)	0–25	0.42	−0.14
Working memory	.80	12.97 (6.65)	0–28	−0.46	−0.33

Note. +alternate form reliability (see Table 2). Max is maximum in this sample, not maximum possible score. DIER = direct and indirect effects model of reading.

Listening comprehension. One standardized and normed task (Kim, Cho, & Park, in press) and one experimental task (Kim, 2015b; Kim et al., 2014) were used. In the former, the child heard a series of short stories and was asked to either identify the picture (out of four) that best described the answers to the questions or to answer short open-ended questions. There were a total of 78 test items, and administration was discontinued when the child had three incorrect responses in a single story. In the experimental task, the child heard a single story (with 78 words) and was asked seven open-ended questions (see Kim, 2015b).

Knowledge-based inference. A knowledge-based inference task was developed, modeling after the Inference subtest of the Comprehensive Assessment of Spoken Language (Carrow-Woolfolk, 1999). In this task, the child heard one- to three-sentence scenarios and was asked a question that required inference based on background knowledge (e.g., "Soomin wanted to wear last year's dress to school one day, but when she tried it on, she could not wear it. Why?"). There were two practice items and 12 test items.

Perspective taking (theory of mind). Perspective taking was measured by a theory of mind task, measuring one's knowledge of mental states and perspectives of others (e.g., thoughts and emotions; Astington & Jenkins, 1999). In the present study, one first-order and two second-order false belief scenarios were used, considering the developmental phase of the children. The first-order scenario was an appearance–reality task using a snack box highly familiar to children in Korea (Kim, 2015b). The second-order theory of mind was measured by false belief scenarios involving the context of a bakery and a visit to a farm (Kim, 2015b). Children listened to a series of events presented with illustrations, followed by the assessor's questions that require the children to infer a character's belief (first-order theory of mind) or a character's belief about another character's thoughts (second-order theory of mind). There were three questions in the first-order scenario and six questions for each of the two second-order scenarios, for a total of 15 questions.

Comprehension monitoring. Following previous studies, an inconsistency detection task was used to measure comprehension monitoring (e.g., L. Baker, 1984; Cain, Oakhill, et al., 2004; Kim, 2015b). The child heard a short story (e.g., *Jimin's favorite color is green. His bag is green. His pants are green. Jimin's favorite color is red.*) and was asked to identify whether the story made sense or not. If the child indicated that the story did not make sense, she or he was asked to provide a brief explanation. The meaning of "not making sense" was explained in practice items as sentences not going together. There were four practice items and 14 test items (six consistent stories and eight inconsistent stories), which were randomly ordered. For the inconsistent stories, the accuracy of children's explanation was also dichotomously scored. Thus, the total possible score was 22 (14 items + eight explanations).

Vocabulary. A standardized and normed expressive task was used (Kim, Cho, & Park, in press). In this task, the child was asked to identify pictured objects with increasing difficulty. There were four practice items and 52 test items. Test administration discontinued after five consecutive incorrect items.

Grammatical knowledge. Adapted from a task in a previous study (Kim, 2015b), the morphosyntactic knowledge task assessed the child's ability to detect and correct morphosyntactic errors in morphosyntactic markers, tense, and postpositions. The child was asked whether a heard sentence was grammatically correct (yes, no). If grammatically incorrect, the child was asked to correct the sentence. There were two practice items and 18 test items. For grammatically incorrect items, the accuracy of identifying ungrammaticality and correcting the sentence was scored.

Working memory. The listening span task (Daneman & Merikle, 1996; Kim, 2015b, 2016) was used. In this task, the child was presented with a short sentence involving common knowledge to children (e.g., Birds can fly) and was asked to identify whether the heard sentence was correct or not. After hearing two or three sentences, the child was asked to identify the first word in each of the sentences. There were four practice items and 18 experimental items. Testing was discontinued after three consecutive incorrect responses. Children's yes/no responses regarding the veracity of the statement were not scored, but their responses on the first words were given a score of 0 to 2: 2 for correctly identifying all the first words in correct order, 1 for correctly identifying all the first words but in incorrect order, and 0 for incorrectly identifying the first words.

Procedures

Children were individually assessed in a quiet space in the school by rigorously trained research assistants who had to pass a minimum of 95% accuracy in assessment administration before they worked with children. Children's scores in each task were double checked for accuracy by a lead research assistant. The assessment battery was administered in several sessions, with each session 30 to 40 min long.

Data Analytic Strategy

Primary data analytic strategies were confirmatory factory analysis (CFA) and structural equation modeling (SEM), using a full information maximum likelihood estimator in Mplus 7.4 (Muthén & Muthén, 2013). Latent variables were created for reading comprehension, word reading, text reading fluency, and listening comprehension. The other constructs were assessed by single measures, and therefore, observed variables were used. Using latent variables is important from both substantive and measurement perspectives, particularly for comprehension (reading or listening) because of its complexity as a construct. From a substantive perspective, our target constructs of interest are listening comprehension skill and reading comprehension skill that are common across tasks or formats; a latent variable approach captures this common ability. This is also related to the measurement aspect as using a latent variable significantly reduces measurement error, and thus increases precision.

To address the first research question, a direct relations model was fitted, where all the component skills (e.g., word reading, text reading fluency, listening comprehension, inference) were hypothesized to have direct relations to reading comprehension. To address the second research question about the direct and indirect relations, four alternative models shown in Figure 3 were fitted to the data to systematically identify whether any of the language and cognitive component skills were directly related to reading comprehension over and above the proximal skills. Alternative Model 1 (Figure 3A) is a complete mediation model, whereby listening comprehension, word reading, and text reading fluency were hypothesized to completely mediate the relations of other language and cognitive skills to reading comprehension. That is, none of the component skills such as higher order cognitions, vocabulary, grammatical knowledge, and working memory were allowed to be directly related to reading comprehension over and above word reading, listening comprehension, and text reading fluency. In contrast, alternative Models 2 through 4 (Figure 3B–3D) were partial mediation models, whereby select focal language and cognitive component skills were systematically allowed to have direct relations to reading comprehension over and above word reading, listening comprehension, and text reading fluency. In Model 2 (Figure 3B), the higher order cognitions and regulation—inference, theory of mind, and comprehension monitoring—were hypothesized to directly relate to reading comprehension after accounting for all the other variables. In Model 3 (Figure 3C), vocabulary and grammatical knowledge were hypothesized to directly relate to reading comprehension after accounting for all the other variables. Finally, in Model 4 (Figure 3D), working memory was hypothesized to directly relate to reading comprehension over and above all the other variables.

Across all the alternative models, vocabulary, grammatical knowledge, and working memory were initially hypothesized to directly predict word reading, based on prior evidence and the importance of semantic knowledge to word reading (see Adams, 1990; Foorman et al., 2018; Nation & Snowling, 2004). However, preliminary analysis showed that after accounting for one another, grammatical knowledge was not independently related to word reading; therefore, its path to word reading was not retained in the models shown in Figure 3. Focal statistical contrast was between Figure 3A and the other models (Figure 3B–3D) because Figure 3A was most parsimonious; statistical

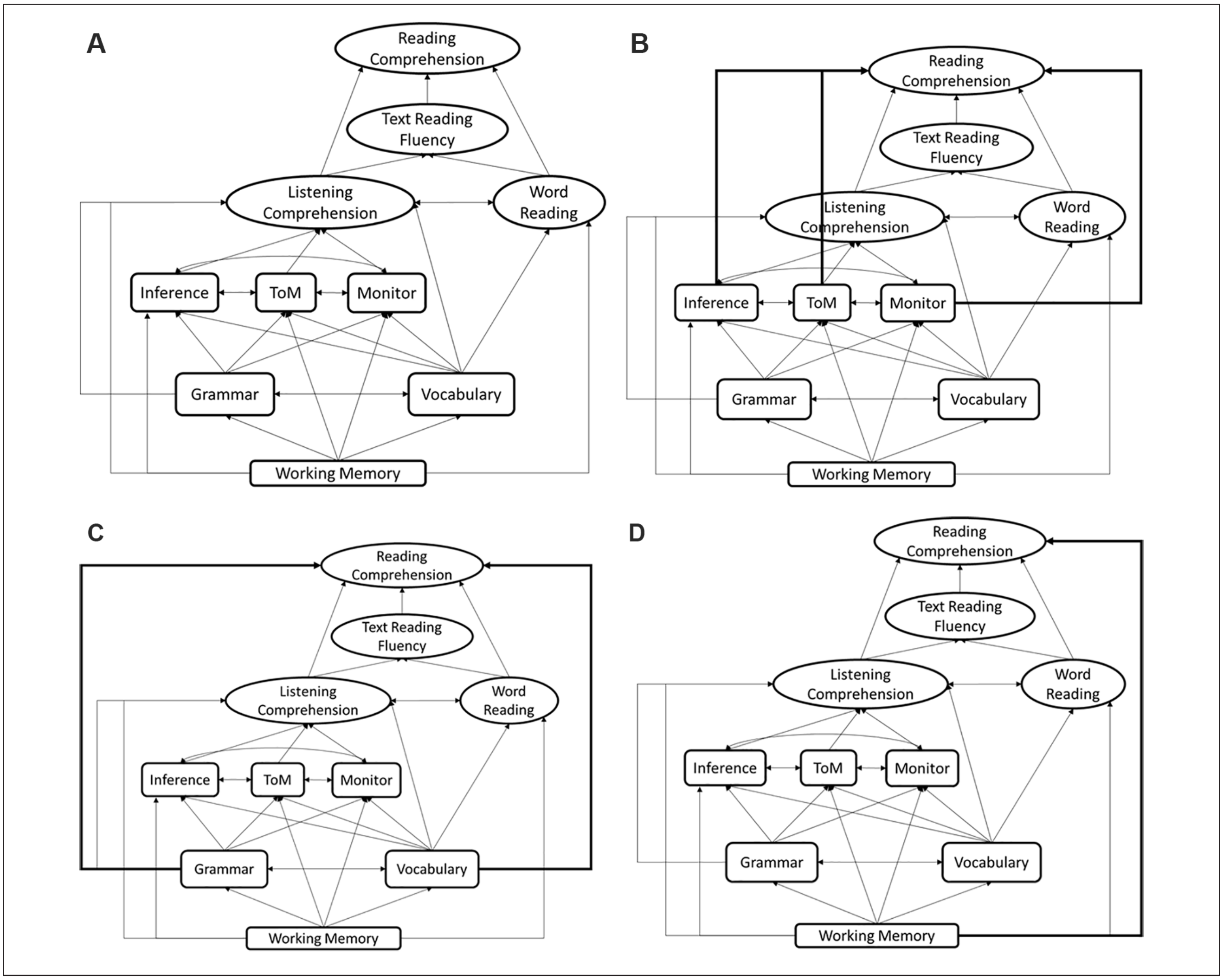

Figure 3. Four alternative models of relations among reading comprehension and component skills.
Note. Bolded lines in (B), (C), and (D) indicate how a model differs from the base model (A). Double-headed arrows represent covariances, whereas single-headed arrows represent predictive relations. Inference = knowledge-based inference; ToM = theory of mind; Monitor = comprehension monitoring; Grammar = grammatical knowledge.

contrast was conducted using chi-square difference tests as the models were nested. Note also that that we did not compare model fits of the direct relations models (first research question) with those of the direct and indirect relations models (second research question) because the goal was to understand the informativeness of the direct versus direct and indirect relations models. Finally, estimates of total effects, Research Question 3, were obtained from the final model in Research Question 2.

Model fit was evaluated by multiple indices such as chi-square statistics, comparative fit index (CFI), Tucker–Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR). Typically, RMSEA values below .05, CFI and TLI values equal to or greater than .95, and SRMR equal to or less than .05 indicate an excellent model fit, and CFI and TLI values greater than .90 and SRMR equal to or less than .10 are considered to be acceptable (Kline, 2005).

Results

Descriptive Statistics and Preliminary Analysis

Table 1 shows descriptive statistics including means, standard deviations, minimums, maximums, skewness, and kurtosis. Children's mean performances on the normed oral language tasks in Grade 1 (i.e., vocabulary and listening comprehension task 1) corresponded to the low average range: 35th percentile rank in the vocabulary task and 37th percentile rank in listening comprehension task 1. There

Table 2. Correlations Between Variables.

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Reading comp 1	—															
2. Reading comp 2	.68	—														
3. Reading comp 3	.53	.72	—													
4. Word reading 1	.63	.54	.49	—												
5. Word reading 2	.64	.54	.52	.94	—											
6. Word reading 3	.64	.57	.52	.93	.95	—										
7. Text reading fluency 1	.65	.55	.48	.84	.89	.88	—									
8. Text reading fluency 2	.65	.58	.57	.86	.90	.91	.89	—								
9. Text reading fluency 3	.62	.53	.52	.84	.88	.90	.90	.93	—							
10. Listening comp 1	.30	.36	.29	.25	.22	.23	.23	.28	.22	—						
11. Listening comp 2	.33	.40	.31	.24	.25	.25	.23	.27	.22	.37	—					
12. Inference	.49	.45	.38	.46	.47	.43	.46	.45	.44	.35	.51	—				
13. Theory of mind	.33	.34	.33	.25	.26	.26	.25	.32	.28	.30	.55	.47	—			
14. Comp monitoring	.38	.35	.28	.33	.35	.35	.34	.33	.33	.34	.44	.52	.44	—		
15. Vocabulary	.51	.53	.51	.54	.53	.55	.49	.55	.51	.31	.41	.56	.33	.45	—	
16. Grammar	.39	.40	.33	.31	.32	.29	.27	.30	.27	.33	.46	.44	.34	.37	.41	—
17. Working memory	.36	.36	.25	.36	.35	.34	.32	.36	.36	.31	.43	.43	.35	.43	.44	.42

Note. All correlations are statistically significant ($p < .05$). Comp = comprehension; Inference = knowledge-based inference; Grammar = grammatical knowledge.

was a slight floor effect in the reading comprehension task 3 such that 42% of the students had a score of 0, whereas the rest of the scores were distributed across the score ranges. However, the skewness value of 1 was within acceptable range (<3; West et al., 1995), and transformations did not make a difference. Distributional properties of other variables were acceptable. Raw values were used in subsequent analysis.

Bivariate correlations between measures are displayed in Table 2. Students' performance on reading comprehension tasks were moderately related with the other skills ($.30 \le r$s $\le .65$). Word reading tasks and text reading fluency tasks were strongly related ($.84 \le r$s $\le .91$), whereas language and cognitive component skills were moderately related to each other ($.33 \le r$s $\le .56$). Latent variables were created for reading comprehension, listening comprehension, text reading fluency, and word reading. CFA was conducted to examine whether word reading and text reading fluency are best conceptualized as a single construct or two associated but dissociable constructs. Results revealed that although word reading and text reading fluency are strongly related ($r = .95$), the two-construct model was superior to the single-construct model: $\Delta\chi^2(1) = 99.17, p < .001$. Correlations between the four latent variables, reading comprehension, listening comprehension, text reading fluency, and word reading, are presented in Appendix B. Factor loadings of the indicators to the latent variables were moderate to strong and statistically significant at the .001 level (see Figure 4).

Research Question 1: Direct Relations Model

All the component skills (e.g., text reading fluency, word reading, listening comprehension, inference, theory of mind, working memory) were entered as direct predictors of reading comprehension. Model fit was excellent: $\chi^2(80) = 127.81$, $p = .005$, CFI = .98, TLI = .97, RMSEA = .06 [0.04, 0.07], SRMR = .03. However, none of the component skills were statistically significantly related to reading comprehension (ps $\ge .16$) except for text reading fluency (.55, $p = .02$).

Research Question 2: Direction and Indirect Relations

Table 3 shows model fits of the four alternative models of DIER (Figure 3) and comparison of their model fits. All the alternative models fit the data well. When model fits were compared using chi-square difference tests, Model 1 (Figure 3A) did not differ from Model 2 ($p = .24$) or Model 4 ($p = .42$). However, a chi-square difference test revealed that Figure 3C model (Model 3) was superior to Figure 3A model ($p = .03$), and therefore, was chosen as the final model.

Standardized path coefficients of the final model are shown in Figure 4. Text reading fluency had a moderate relation (.51, $p = .01$) and listening comprehension had a relatively weak relation (.22, $p = .01$) to reading comprehension, whereas word reading was not independently related to reading comprehension (.01, $p = .95$) after accounting for the other variables in the model. Text reading fluency was strongly predicted by word reading (.94, $p < .001$) but not by listening comprehension (.05, $p = .10$). Listening comprehension was predicted by knowledge-based inference (.21, $p = .01$), theory of mind (.44, $p < .001$), grammatical knowledge (.24, $p = .002$), and working memory (.15, $p = .04$). Comprehension

Table 3. Alternative Models and Their Model Fit Statistics.

Alternative models	$\chi^2(df)$, p	CFI, TLI	RMSEA [90% CI]	SRMR	Comparison to Model 1
Model 1 (Figure 3A)	149.05(96), $p < .001$	.98, .98	.05 [0.035, 0.068]	.045	—
Model 2 (Figure 3B)	144.84(93), $p < .001$	.98, .98	.05 [0.035, 0.069]	.044	$\Delta\chi^2 = 4.21$; $\Delta df = 3$, $p = .24$
Model 3 (Figure 3C)	141.84(94), $p < .001$	.99, .98	.05 [0.032, 0.067]	.044	$\Delta\chi^2 = 7.21$; $\Delta df = 2$, $p = .03$
Model 4 (Figure 3D)	148.40(95), $p < .001$	.98, .98	.05 [0.036, 0.069]	.044	$\Delta\chi^2 = 0.65$; $\Delta df = 1$, $p = .42$

Note. CFI = comparative fit index; TLI = Tucker–Lewis index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual.

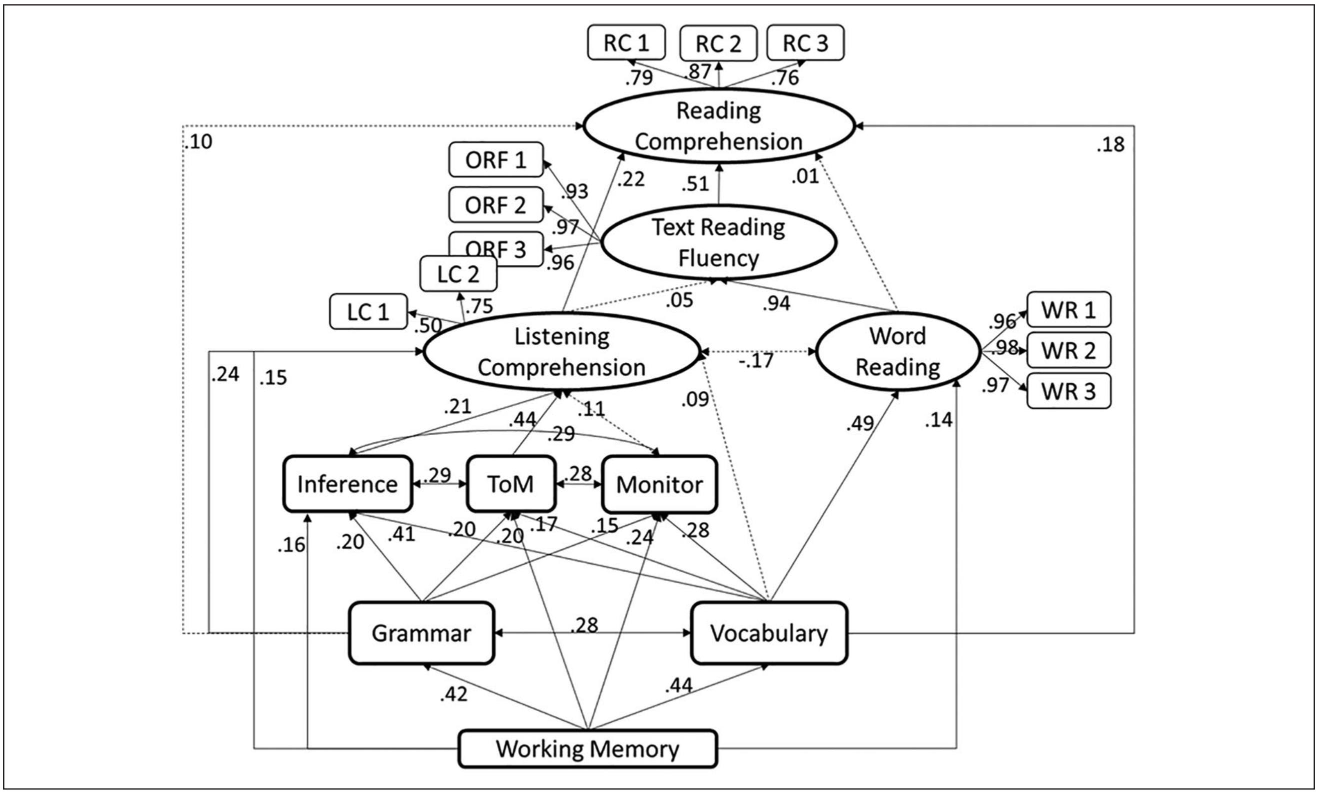

Figure 4. Standardized path coefficients for the final model.
Note. Solid lines are statistically significant ($p < .05$), whereas dashed lines are not. Double-headed arrows represent covariances, whereas single-headed arrows represent predictive relations. RC = reading comprehension; ORF = text (oral) reading fluency tasks; LC = listening comprehension; WR = word reading; Inference = knowledge-based inference; ToM = theory of mind; Monitor = comprehension monitoring; Grammar = grammatical knowledge.

monitoring (.11, $p = .17$) and vocabulary (.09, $p = .29$), however, were not independently related to listening comprehension after accounting for the other variables in the model. Knowledge-based inference, theory of mind, and comprehension monitoring were all predicted by vocabulary, grammatical knowledge, and working memory with weak to moderate magnitudes (.15–.41, ps $\leq .02$). Working memory predicted grammatical knowledge and vocabulary with moderate magnitudes (.42 and .44, respectively, ps $<$ .001). Finally, vocabulary and working memory were moderately (.49, $p < .001$) and weakly (.14, $p = .03$) related to word reading, respectively. The amount of variance explained was as follows: 66% in reading comprehension, 91% in text reading fluency, 82% in listening comprehension, and 32% in word reading.

Research Question 3: Direct, Indirect, and Total Effects

Direct, indirect, and total effects (standardized regression weights) of component skills on reading comprehension based on Figure 4 are displayed in Table 4. Total effects of

Table 4. Direct, Indirect, and Total Effects as Measured by Standardized Regression Weights of Component Skills on Reading Comprehension in Grade 1.

	Reading comprehension		
Variable	Direct effect	Indirect effect	Total effect
Text reading fluency	.51 (0.20)	—	.51 (0.20)
Word reading	.01 (0.21)	.48 (0.19)	.49 (0.06)
Listening comprehension	.22 (0.09)	.03 (0.02)	.25 (0.09)
Knowledge-based inference	—	.05 (0.03)	.05 (0.03)
Theory of mind	—	.11 (0.04)	.11 (0.04)
Comprehension monitoring	—	.03 (0.02)	.03 (0.02)
Vocabulary	.18 (0.07)	.31 (0.05)	.49 (0.06)
Grammatical knowledge	.10 (0.07)	.09 (0.04)	.19 (0.06)
Working memory	—	.44 (0.05)	.44 (0.05)

Note. Standard errors are shown in parentheses.

several component skills were substantial, including text reading fluency (.51), word reading (.49), vocabulary (.49), and working memory (.44), followed by listening comprehension (.25), grammatical knowledge (.19), theory of mind (.11), knowledge-based inference (.05), and comprehension monitoring (.03).

Discussion

In the present study, we formally proposed DIER as a theoretical model that integrates evidence from multiple lines of work and that specifies the nature of relations among component skills (i.e., hierarchical, dynamic, and interactive relations). We also investigated one of the hypotheses about the structural relations—hierarchical relations (or direct and indirect relations) of component skills to reading comprehension—using data from first graders in Korean. Overall, the present findings add to the growing body of evidence on the hierarchical nature of relations among component skills of reading comprehension (Kim, 2017b, 2020).

Hypothesized hierarchical relations were investigated by fitting and comparing a direct relations model and variations of the hierarchical relations model. In the direct relations model, none of the component skills were statistically significant, except for a higher order reading skill, text reading fluency. These results are not unexpected according to DIER as higher order skills would mask the contributions of lower order skills and demonstrate the importance of specifying and examining structural relations among component skills. The direct relations model (or such a data-analytic approach [e.g., multiple regression]) is useful for the purpose of isolating unique predictors. However, such an approach does not reveal structural relations among component skills and can mislead or create a misconception that lower-level or distal skills or those that are not statistically significant in a statistical model do not contribute to an outcome.

DIER specifies hierarchical relations based on large bodies of evidence and the mapping of component skills to various mental representations (Kim, 2016). The hypothesized hierarchical relations among component skills were supported (Figure 4) such that working memory predicted vocabulary and grammatical knowledge, higher order cognitions and regulation, and listening comprehension. Vocabulary and grammatical knowledge also predicted higher order cognitions and regulation, which, in turn, predicted listening comprehension. In addition, vocabulary and working memory were independently related to word reading, supporting the roles of semantics and domain–general cognition in word reading, in line with DIER. It is of note that perspective taking as measured by theory of mind was moderately and independently related to listening comprehension after accounting for the other variables in the model. This is convergent with previous studies with children from various linguistic backgrounds (Kim, 2015b, 2017b; Kim & Phillips, 2014; Pelletier & Beaty, 2015; see Dore et al., 2018; Kim, 2016, for details about the role of theory of mind or perspective taking in comprehension).

The structural blueprint of DIER in Figure 1 explains and elucidates pathways of relations. By specifying pathways, cascading, multichanneled indirect contributions of low-level or distal skills via higher order and proximal skills are captured, in addition to direct contributions. Although the majority of language and cognitive component skills were not directly related to reading comprehension, many of their indirect effects were substantial (see Table 4). As an example, working memory, as a foundational domain–general cognition, was related to vocabulary and grammatical knowledge as well as higher order cognitions and regulation; thus, its contribution to reading comprehension, albeit indirect, was substantial (.44). Similarly, vocabulary had a substantial indirect effect (.31) via higher order cognitions, listening comprehension, and word reading as well as a direct effect (.18).

Based on theoretical models (Kuhn et al., 2010; LaBerge & Samuels, 1974; Wolf & Katzir-Cohen, 2001) as well as empirical evidence (e.g., Daane et al., 2005; Jenkins et al., 2003; Kim, 2015a; Kim et al., 2014), text reading fluency is included in DIER as a text-level reading skill that mediates the relations of listening comprehension and word reading to reading comprehension. In the present study, DIER including text reading fluency described the data very well. However, the relation between text reading fluency and word reading was very strong, and word reading did not make a unique contribution to reading comprehension once text reading fluency and listening comprehension were accounted for. Prior work showed that the mediating role of text reading fluency varies with development such that in the beginning phase of reading development, text reading fluency does not mediate the relations (e.g., in Grade 1 for English-speaking children), and with development, it partially mediates the relation of word reading to reading comprehension, and with further development, it completely mediates the relation of word reading to reading comprehension (e.g., Grade 2 for English-speaking children; Kim, Wagner, & Lopez, 2012). A similar pattern of developmental progression was observed in a language with transparent orthography, Korean, but the complete mediation pattern was found at an earlier grade (end of kindergarten), most likely because word reading skill develops at a faster rate in Korean due to the transparency of the orthography and to early reading instruction in the Korean context (Kim, 2015a).

Vocabulary had a direct relation to reading comprehension over and above the other component skills including listening comprehension. This is not inconsistent with DIER as specified in the dynamic relations hypothesis as a function of text characteristics. If passages in text comprehension tasks (i.e., listening comprehension and reading comprehension) include a relatively high demand of vocabulary, then vocabulary would make an independent, direct contribution to text comprehension over and above other skills. Our informal observation suggests some differences in vocabulary demands in listening comprehension tasks versus in reading comprehension tasks—reading comprehension tasks included more sophisticated words such as *disappointment, reservation*, and *amiably*. This might explain the direct relation of vocabulary to reading comprehension over and above listening comprehension in the present study. Further careful, in-depth analysis of systematic differences in the texts using corpus data in Korean was beyond the scope of the present study, and future studies are warranted to examine the effects of text characteristics on the relations of component skills to reading comprehension. Consideration of text characteristics of comprehension tasks in a theoretical model of reading is in line with work in the measurement of text comprehension (e.g., Cutting & Scarborough, 2006; Keenan et al., 2008; see Francis et al., 2018).

Limitations and Future Directions

Due to constraints related to working in a school setting (i.e., limited assessment time allowed to the research team), many constructs were assessed using a single task. Measuring a construct using latent variables with multiple tasks is preferred to measure constructs with precision and minimize measurement error. Similarly, future work should examine the roles of the factors not included in the present study (e.g., child factors such as phonological and morphological processing, background knowledge and affect/motivation, text features [e.g., genre], and assessment methods; see Figure 1) and their relations in the context of DIER. Furthermore, the present study should be replicated with a larger sample.

The present results are from first graders in Korea, who were predominantly from average or low-average socioeconomic backgrounds; thus, generalizability of the findings is limited to a population with similar characteristics. As noted above, theoretically, the overall structural relations specified in DIER are not expected to differ across languages, but the relative contributions of component skills are hypothesized to differ due to linguistic and orthographic characteristics. Thus, future replications with children learning to read in different languages, and those learning to read in unfamiliar languages (e.g., second language learners) are warranted.

In addition, DIER theoretically applies across developmental phases and individuals at various skill levels, and thus, an important future direction includes validation of DIER for students at various developmental phases, including those with reading disabilities. For instance, according to the dynamic relations hypothesis, the relations of language skills (e.g., vocabulary) and higher order cognitive skills to reading comprehension would be weaker for students with word reading difficulties than their peers in the same grade without word reading difficulties. Importantly, future efforts and research are needed in the instruction and assessment of *comprehension* for students with reading disabilities. Although rich literature already exists for this population, the literature disproportionately focuses on word reading processes without sufficient attention to comprehension. This may not be surprising because by definition, dyslexia is a specific disability in word reading, and rigorous work on word reading difficulties (e.g., identifying causes, identification of students, and effective instruction) is absolutely necessary. However, this may have inadvertently and adversely narrowed scope of work in the literature. For example, widely used screening and progress monitoring assessments in the U.S. context such as Dynamic Indicators of Basic Early Literacy Skills (DIBELS) or AIMSweb measure skills that are critical to word reading development, but not those for listening comprehension. After all, word reading is important for its gatekeeping role in reading comprehension, and so is listening comprehension (and its associated component skills). In addition, word reading and listening comprehension are linked via the connections of phonology and morphology with vocabulary and grammatical knowledge. Therefore, it is imperative that future efforts address the assessment and early identification needs related to comprehension—assessment tools and identification approaches that are reliable, valid, precise (high sensitivity and specificity), and efficient and practical in school settings (accurate identification without requiring long assessment time). Efficiency and practicality are important given the multiplicity of skills that need to be assessed and time constraints in school settings. A carefully developed adaptive assessment system with a systematic approach to administration (e.g., a gated screening; Compton et al., 2010) is needed. This will allow early identification of children who are at risk of word reading difficulties *and* comprehension difficulties. In the current assessment system in the United States, for example, identifying children who struggle with reading comprehension primarily due to weakness in comprehension is delayed (e.g., not until Grade 3; see the example of late emerging reading difficulties; Catts et al., 2012). Similar efforts are also necessary in instruction, including research on maximally effective instruction approaches that address identified needs in word reading *and* comprehension and that are feasible and usable in school settings.

Appendix A

Example Reading Comprehension Passage and Questions Translated into English

A noodle dish. It was Tuesday night. Dad told Youngsoo, "Should we surprise Mom?" Youngsoo and Dad decided to make Chapchae (a noodle dish in Korea), Mom's favorite dish. Dad sliced carrots, onions, and cucumbers. Youngsoo helped Dad by panfrying the carrots, onions, and cucumbers. Dad boiled the noodles. "Okay, now it is time to mix vegetables with the noodles and season with soy sauce. Oh, we can finish with sesame seed oil." Dad added soy sauce. Then, there was no sesame seed oil. "Gee, it looks like we are out of sesame seed oil," said Dad with disappointment. Then, Mom came into the kitchen. Mom said with a smile, "It smells very good in here." Youngsoo said, "Yes, Dad and I made Chapchae, one of your favorite dishes. But we have no sesame seed oil. Mom, what should we do? Chapchae is not good without sesame seed oil." Mom said, "Is that right? What should we do?" and took something out of her bag. "How about this?" said Mom. It was a bottle of sesame seed oil. Youngsoo asked, "Wow! Mom, where did you get it?" "I bought it at a store on the way home because I noticed last night that we are out of it," said Mom. The family enjoyed the Chapchae with sesame seed oil in it.

1. Question 1. What is the name of the child in this story?
2. Question 2. Where did the story occur?
3. Question 3. What kind of vegetables were included in Chapchae?
4. Question 4. How did Youngsoo help his dad?
5. Question 5. What was the main problem in this story?
6. Question 6. How was the problem solved?
7. Question 7. What was used to season Chapchae?

Appendix B

Bivariate Correlations Between Latent Variables.

Variable	1	2	3
1. Word reading	—		
2. Listening comprehension	.40	—	
3. Text reading fluency	.95	.43	—
4. Reading comprehension	.70	.67	.73

Note. All the coefficients are statistically significant at .001 level.

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Notes

1. Reasoning is a broad construct that includes various taxonomies (deductive, inductive) and aspects (e.g., relational, visuospatial reasoning). Higher order cognitive skills in DIER not only include reasoning as a broad construct but also highlight the roles of specific types of reasoning skills such as inference and perspective taking given literature and theoretical models (e.g., Kim, 2016; van den Broek et al., 2005). DIER recognizes the role of other types of reasoning skills in

comprehension (e.g., visuospatial reasoning would be important in constructing accurate mental representations for texts with greater spatial reasoning demands [e.g., in terms of text content and texts with graphs or visual presentations; see, for example, Gattis & Holyoak, 1996]).

2. The term *proximal* is used in this article instead of previously used terms such as *upper tier skills* or *upper level skills* (Kim, 2017b, 2019) because the latter terms can be misconstrued as higher order skills when one of the proximal skills, word reading, is not a higher order skill.
3. For example, it is an open question whether retell or free recall, as a measure of comprehension, captures one's inference-making processes to the same extent as open-ended or multiple-choice tasks that have prompting questions designed to capture inference processes (i.e., inferential comprehension questions).
4. The effect of working memory training on distal outcomes such as reading comprehension is not clear yet (Melby-Larvag et al., 2016; Schwaighofer et al., 2015). According to the hierarchical relations hypothesis of direct and indirect effects model of reading (DIER), making a robust impact on reading comprehension would require improving not only working memory but also other component skills that mediate the relation of working memory to reading comprehension.
5. In Hangul, letters that represent phonemes are composed into syllable blocks so that the syllable and the phoneme are both visually represented in the script. Details about the Korean writing system that are relevant for word reading are not provided here because the focus in the present study was not predictors of word reading. For details about the Korean writing system and predictors, see Cho (2009) and Kim (2011).

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