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Why the Simple View of Reading Is Not Simplistic: Unpacking Component Skills of Reading Using a Direct and Indirect Effect Model of Reading (DIER)

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ABSTRACT

Pathways of relations of language, cognitive, and literacy skills (i.e., working memory, vocabulary, grammatical knowledge, inference, comprehension monitoring, word reading, and listening comprehension) to reading comprehension were examined by comparing four variations of direct and indirect effects model of reading. Results from 350 English-speaking second graders revealed that language and cognitive component skills had direct and indirect relations to listening comprehension, explaining 86% of variance. Word reading and listening comprehension completely mediated the relations of language and cognitive component skills to reading comprehension and explained virtually all the variance in reading comprehension. Total effects of component skills varied from small to substantial. The findings support the direct and indirect effects model of reading model and indicate that word reading and listening comprehension are upper-level skills that are built on multiple language and cognitive component skills, which have direct and indirect relations among themselves. The results underscore the importance of understanding nature of relations.

One of the influential models of reading comprehension for developing readers is the simple view of reading. According to this model, reading comprehension is a function of decoding or efficient word recognition and linguistic comprehension (Gough & Tunmer, 1986; Hoover & Gough, 1990). The simple view of reading has been supported in many languages with varying orthographic depths including English, Chinese, Spanish, Greek, Korean, and Malay (Adlof, Catts, & Little, 2006; Catts, Adlof, & Ellis Weismer, 2006; Foorman, Koon, Petscher, Mitchell, & Truckenmiller, 2015; Joshi, Tao, Aaron, & Quiroz, 2012; Kendeou, Papadopoulos, & Kotzapoulou, 2013; Kendeou, van den Broek, White, & Lynch, 2009; Kim, 2011; Lee & Wheldall, 2009; see Florit & Cain, 2011). In particular, when employing a latent variable approach, word reading and listening comprehension explained the vast majority of variance in reading comprehension for children in elementary and middle school grades (Adlof et al., 2006; Kim, 2015; Kim & Wagner, 2015; Foorman et al., 2015; LARRC, 2015).

Despite its seeming simplicity (e.g., Cartwright, 2007; Conners, 2009; Kirby & Savage, 2008; Pressley et al., 2009), the authors of the simple view of reading acknowledged that both word reading and listening comprehension involve complex processes (Gough, Hoover, & Peterson, 1996; Hoover & Gough, 1990). Indeed, research in the last four decades has demonstrated that developing word reading proficiency requires multiple processes and skills such as phonological awareness, orthographic symbol knowledge (knowledge of names and sounds of alphabet letters), orthographic awareness, morphological awareness, and rapid automatized naming (Apel, Wilson-Fowler, Brimo, & Perrin, 2012; Kim, Apel, & Al Otaiba, 2013; Badian, 2005; Barker, Torgesen, & Wagner, 1992; Burgess & Lonigan, 1998; Carlisle, 2004; Carlisle

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& Katz, 2006; Compton, DeFries, & Olson, 2001; Kirby, Parrila, & Pfeiffer, 2003; Nagy, Berninger, Abbott, Vaughan, & Vermeulen, 2003; Schatschneider, Fletcher, Francis, Carlson, & Foorman, 2004; Torgesen, Wagner, & Rashotte, 1994; M. Wolf & Bowers, 1999).

Linguistic comprehension, according to the simple view of reading, is a broad construct that includes "parsing, bridging, and discourse building" (Hoover & Gough, 1990, p. 128), and "the ability to take lexical information . . . and derive sentence and discourse interpretations" (Hoover & Gough, 1990, p. 131; see also Tunmer & Chapman, 2012). Not surprisingly, previous studies operationalized linguistic comprehension in various ways, including vocabulary (e.g., Ouellette, 2006; Ouellette & Beers, 2010), listening comprehension (e.g., Joshi et al., 2012; Lee & Wheldall, 2009; Ouellette & Beers, 2010), or combinations of these (Adlof et al., 2006; Foorman et al., 2015; Kendeou et al., 2009; Protopapas, Simos, Sideridis, & Mouzaki, 2012; Tunmber & Chapman, 2012). Although operationalizing linguistic comprehension with various oral language skills is in line with the simple view of reading, this approach obscures a precise understanding about the nature of relations—differences and hierarchy among oral language skills. Vocabulary is a lexical-level oral language skill, and syntactic knowledge involves postlexical sentence-level processes. Listening comprehension is "the ability to comprehend oral language at the discourse level—including [multi-utterance] conversations, stories, informational oral texts—that involves the processes of extracting and constructing meaning" (Kim & Pilcher, 2016, p. 160). Differences in grain sizes (lexical, sentence, and discourse level) have important implications for complexity of processes involved in linguistic comprehension at these various levels. In particular, listening comprehension has remained a black box as a construct and for its component skills. Recent accumulating evidence, however, has revealed that listening comprehension is complex and draws on a multitude of language and cognitive component skills and abilities, including working memory, inhibitory control, attentional control, vocabulary, grammatical knowledge, inference, perspective taking (as measured by theory of mind), and comprehension monitoring (Kim, 2015a, 2016; Kim & Phillips, 2014; Barnes, Dennis, & Haefele-Kalvaitis, 1996; Daneman & Merikle, 1996; Elleman, Lindo, Morphy, & Compton, 2009; Florit, Roch, & Levorato, 2014; Kendeou, Bohn-Gettler, White, & van den Broek, 2008; Lepola, Lynch, Laakkonen, Silvén, & Niemi, 2012; Nation, Adams, Bowyer-Crane, & Snowling, 1999; Strasser & del Rio, 2014).

Language and cognitive component skills of text/discourse comprehension (comprehension of oral and written texts)

Theoretically, successful listening comprehension is achieved when one constructs an accurate situation model. The situation model is a mental representation of meaning as it is actually expressed by the text (oral or written text; Kintsch & Rawson, 2005) and is established through multiple processes at different levels of mental representation (Graesser, Singer, & Trabasso, 1994; Kintsch, 1988). The lowest level of mental representation, called surface code, is established by parsing sentences and phrases and holding them briefly in memory. Based on the surface code representation, initial propositions or idea units, called the textbase representation, are constructed through semantic analysis. Finally, the highest level of mental representation, the situation model, is established by integrating initial propositions across the text and with the comprehender's background knowledge for deeper understanding of the text.

Accurately encoding meanings at these different levels (i.e., surface code, textbase, and situation model) requires different language and cognitive skills due to differences in nature and complexity, and thus different sets of language and cognitive skills can be mapped onto the mental representations (Kim, 2015a, 2016). According to the direct and indirect effects model of text comprehension (DIET; see Figure 1), language and cognitive skills have a hierarchical structural relations such that lower level processes are necessary for or feed into higher level processes. Domain general, foundational cognitive abilities such as working memory and attentional control are necessary for any learning tasks, including language and literacy. In discourse comprehension, working memory and attentional control are necessary for holding linguistic information in memory (surface code representation). Foundational language skills such as vocabulary and grammatical knowledge are necessary to constructing initial propositions (i.e., textbase representation) as encoding of meanings requires knowledge of meanings of individual words (vocabulary)

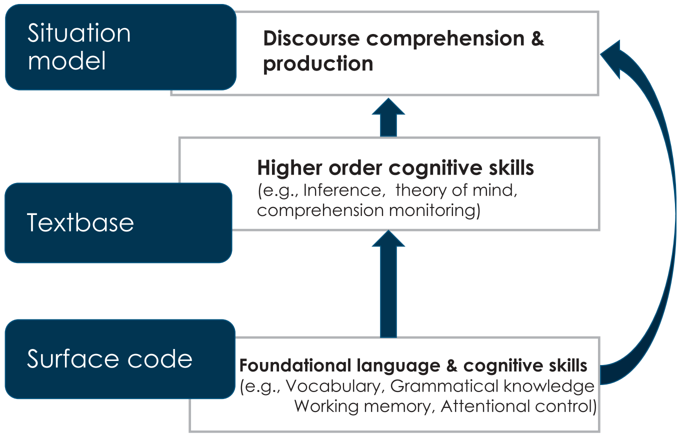

Figure 1. Conceptual model of direct and indirect effects model of text comprehension: In this model, language and cognitive skills are mapped onto the three levels of mental representations, surface code, text base, and situation model (modified from Kim, 2016; reprint with permission).

and combinations of words (grammatical knowledge). However, these foundational cognitive and language skills are not sufficient to construct the situation model (i.e., listening comprehension) because initial and local propositions have to undergo integration processes for which higher order cognitive skills such as inference are needed (Kim, 2015a, 2016; Tompkins et al., 2013). Different types of inferences are involved including knowledge-based inference (inferring from background knowledge) and inference about the characters' and author's intention, thoughts, and feelings (i.e., perspective taking; see Graesser et al., 1994, for typology of inferences). Comprehension monitoring is also necessary because the comprehender needs to evaluate adequacy of propositions compared to those in other parts of the text and against one's background knowledge (Kim & Phillips, 2014; Strasser & del Rio, 2014).

Just as lower level mental representations are necessary for higher level mental representations, lower level cognitive skills are necessary for foundational oral language skills, which in turn are necessary for higher order cognitive skills and ultimately text/discourse comprehension. These hypothesized relations are aligned with evidence from previous studies. For instance, working memory and attentional control were related to vocabulary and grammatical knowledge (Gathercole & Baddeley, 1990a, 1990b, 1993; Gathercole, Service, Hitch, Adams, & Martin, 1999) and higher order cognitive skills (Carlson, Moses, & Breton, 2002; Oakhill, Hartt, & Samols, 2005; Slade & Ruffman, 2005). In addition, working memory was related to theory of mind or perspective taking (Davis & Praat, 1995; Slade & Ruffman, 2005). Theory of mind refers to the ability to infer others' mental status (thoughts and emotions) and predict behaviors and, therefore, captures perspective taking (Comay, 2009; McHugh & Stewart, 2012). Although theory of mind has been studied extensively as an outcome (e.g., Caillies & Sourn-Bissaoui, 2008; de Villiers & Pyers, 2002; Norbury, 2005), recent studies have shown its contribution to text comprehension (Kim, 2016; Kim & Phillips, 2014; Pelletier, 2006; Strasser & del Rio, 2014). When the DIET was fitted to empirical data, it described data very well in the context of listening comprehension for Korean-speaking young children and revealed that working memory, vocabulary, and grammatical knowledge were all related to higher order cognitive skills, which in turn were related to listening comprehension (Kim, 2015a, 2016).

Direct and indirect effects model of reading (DIER)

Intriguingly, the growing evidence about component skills of listening comprehension converges with those of reading comprehension—working memory, attentional control, vocabulary, grammatical knowledge, inference, and comprehension monitoring contribute to reading comprehension (Ahmed et al., 2016; Beck, Perfetti, & McKeown, 1982; Bowyer-Crane & Snowling, 2005; Brimo, Apel, & Fountain, in press; Cain, 2006, 2007; Cain & Oakhill, 1999; Cain, Oakhill, & Bryant, 2004; Conners, 2009; Cromley & Azevedo, 2007; Daneman & Carpenter, 1980; Oakhill & Cain, 2012; Seigneuric & Ehrlich, 2005; Seigneuric, Ehrlich, Oakhill, & Yuill, 2000; van den Broek, Young, Tzeng, & Linderholm, 1999). According to theoretical models of text comprehension, processes of text comprehension are largely the same for oral and written texts (Graesser et al., 1994) although reading comprehension for developing readers is constrained by word reading (Perfetti, Landi, & Oakhill, 2005). If processes involved in listening comprehension are highly similar to those for reading comprehension, and listening comprehension is a necessary component skill of reading comprehension (Hoover & Gough, 1990), a naturally rising question is whether language and cognitive component skills (e.g., working memory, inference) are directly related to reading comprehension over and above listening comprehension or whether they are related to reading comprehension indirectly via listening comprehension. As previously noted, the crux of the simple view of reading is that reading comprehension processes can be classified into two parts, word reading and linguistic comprehension. If listening comprehension draws on a similar set of language and cognitive skills to that of reading comprehension, it is reasonable to speculate that the contributions of language and cognitive component skills to reading comprehension would be at least partially mediated by listening comprehension. A recent study examined this question and showed that foundational cognitive ability (working memory), foundational language skills (vocabulary and grammatical knowledge), and higher order cognitive skills (theory of mind and comprehension monitoring) were not directly related to reading comprehension once word reading and listening comprehension were taken into consideration, at least for Korean-speaking beginning readers (Kim, 2015a).

Building on these rich lines of work on reading comprehension and listening comprehension, in the present study we examined pathways of relations among reading comprehension component skills, using a framework called the direct and indirect effects model of reading (DIER). Specifically, in the DIER model, component skills identified by the simple view of reading (word reading and listening comprehension) and component skills of text comprehension (i.e., working memory, vocabulary, grammatical knowledge, inference, and comprehension monitoring) are integrated into a single framework. As shown in Figure 2, DIER hypothesizes that component skills of reading comprehension has a hierarchical structure with direct and indirect relations among them. Word reading and listening comprehension are hypothesized to be upper level skills that make direct contributions to reading comprehension. Language and cognitive skills (e.g., working memory, vocabulary, inference) are hypothesized to be directly and indirectly related to listening comprehension in accordance of the DIET model (Figure 1). Furthermore, foundational cognitive and language skills (i.e., working memory, vocabulary, and grammatical knowledge) are hypothesized to predict word reading proficiency based on a theoretical conceptualization (Bishop & Snowling, 2004) and empirical findings (Kim et al., 2013; Foorman et al., 2015; Ouellette, 2006; Ricketts, Nation, & Bishop, 2007; Vellutino, Tunmer, Jaccard, & Chen, 2007). Note that in the DIER model, unlike the simple view of reading, oral language skills (i.e., vocabulary, grammatical knowledge, and listening comprehension) are differentiated in the hierarchy of relations such that listening comprehension is a discourse-level skill that requires construction of the situation model, whereas vocabulary and grammatical knowledge are foundational skills that are necessary but not sufficient skills for listening comprehension.

The DIER model was tested by four alternative models (see Figures 2a–2d). In Figure 2a, listening comprehension and word reading were hypothesized to completely mediate the relations of language and cognitive component skills. In Figure 2b, working memory was hypothesized to directly relate to reading comprehension over and above all the other skills. In Figure 2c, direct relations of foundational oral language skills (vocabulary and grammatical knowledge) to reading comprehension were examined. Finally, in Figure 2d, direct relations of higher order cognitive skills (inference, theory of mind, and comprehension monitoring) to reading comprehension were tested. Figure 2a model is aligned with the simple view of reading but extends it by specifying component skills and the nature of their relations. The alternative models, 2b–2d, were examined to shed light on any potential direct and unique relations of language and cognitive skills to reading comprehension. For instance,

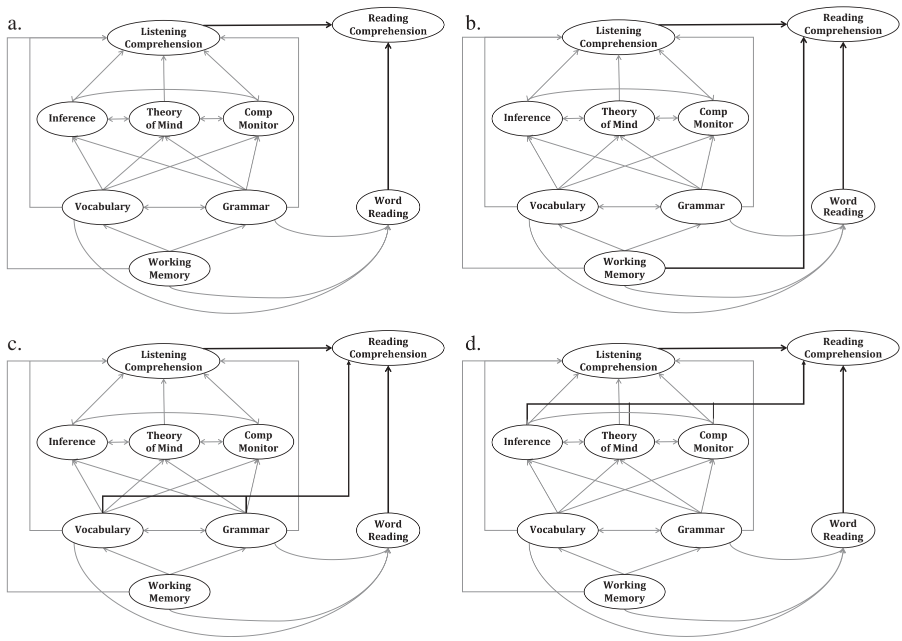

Figure 2. Four alternative models of direct and indirect effect model of reading (DIER). *Note*. In Figure 2a, listening comprehension and word reading completely mediate the relations of inference, theory of mind, comprehension monitoring (Comp Monitor), working memory, vocabulary, and grammatical knowledge to reading comprehension. In Figure 2b, working memory is directly related to reading comprehension over and above the other component skills of reading comprehension. In Figure 2c, foundational oral language (vocabulary & grammatical knowledge) are directly related to reading comprehension over and above the other component skills of reading comprehension. In Figure 2d, higher order cognitive skills (inference, theory of mind, comprehension monitoring) are directly related to reading comprehension. Focal pathways are in black lines. Lines with two sided arrows represent covariances.

Ouellette and Beers (2010) found that vocabulary breadth was independently related to reading comprehension for students in Grade 6 after accounting for listening comprehension as well as phonological awareness, decoding, irregular word reading, and vocabulary depth. Verhoeven and Leeuwe (2008) also found that vocabulary was related to reading comprehension after accounting for word reading and listening comprehension in a longitudinal study with Dutch-speaking children.

Pathways of relations of component skills to reading comprehension have been examined in a few previous studies. Cromley and her colleagues (Cromley & Azevedo, 2007; Cromley, Snyder-Hogan, & Luciw-Dubas, 2010) examined direct and indirect relations of component skills to reading comprehension for ninth-grade students (Cromley & Azevedo, 2007) and college students (Cromley et al., 2010). Overall, they found that the direct and indirect model was supported by data such that word reading, background knowledge, and inference were directly related to reading comprehension; vocabulary had a direct relation with reading comprehension as well as an indirect relation via inference; and reading comprehension strategy use was indirectly related to reading comprehension (Cromley & Azevedo, 2007; also see Ahmed et al., 2016). However, in their studies, one of the key skills in the simple view of reading —listening comprehension—was not included. Vellutino et al. (2007) examined direct and indirect relations for children in Grades 2 and 3 and found that word reading mediated the relations of phonological decoding, spelling, vocabulary, and visual analysis to reading comprehension, whereas listening comprehension mediated the relations of semantic knowledge, grammatical knowledge, and phonological coding to reading comprehension. Although informative, Vellutino et al. (2007) did not include higher order cognitive skills that are critical to text comprehension. Important to note, the present study is distinct from these studies because the structural relations about language and cognitive component skills are based on the DIET model for text comprehension.

Present Study

The primary goal of the present study was to investigate pathways of relations of language and cognitive component skills to reading comprehension, using data from English-speaking children in Grade 2. To achieve this, the DIET model (shown in Figure 3) was first examined for the listening comprehension and reading comprehension outcomes. This was followed by fitting data to the simple view of reading, and, finally, four variations of the DIER model (Figures 2a–2d).

Conceptual framework of the DIET model shown in Figure 1 was fitted to listening comprehension and reading comprehension, respectively, by examining alternative statistical models shown in Figures 3a–3c. Figure 3a is an indirect relations model (or complete mediation model) in which higher order cognitive skills were hypothesized to completely mediate the relations of foundational oral language and cognitive skills to text comprehension (listening and reading comprehension). In Figure 3b (DIET model), direct relations of foundational language and cognitive skills to text comprehension were allowed. The Figure 3c also tested the DIET model, but more parsimonious than Figure 3b such that foundational oral language skills were hypothesized to completely mediate the relation of working memory to higher order cognitive skills.

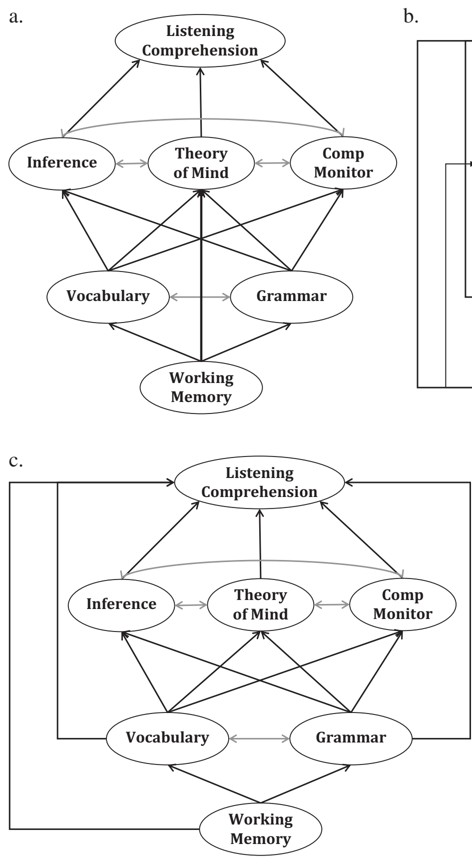

Figure 3. Three alternative models of direct and indirect effects model of text comprehension. *Note*. In 3a (indirect effects model), higher order cognitive skills such as inference, theory of mind, and comprehension monitoring (Comp Monitor) are hypothesized to completely mediate the relations of working memory, vocabulary, and grammatical knowledge to text comprehension. In 3b, higher order cognitive skills such as inference, theory of mind, and Comp Monitor and foundational language and cognitive skills (working memory, vocabulary, and grammatical knowledge) directly and indirectly related to text comprehension. In 3c, paths from working memory to higher order cognitive skills are removed for parsimony. Lines with two sided arrows represent covariances.

These models were fitted for both listening comprehension and reading comprehension outcomes because theoretical frameworks of text comprehension do not differentiate oral versus written text comprehension. Therefore, it is important to examine whether the structural relations of language and cognitive skills fit well for both reading and listening comprehension for generalizability of theoretical models. As previously noted, the DIET model has been fitted for listening comprehension for Korean-speaking children (i.e., Kim, 2015a, 2016), but not for reading comprehension. According to theoretical framework of text comprehension (e.g., construction-integration models by Kintsch, 1988; Landscape model by van den Broek and colleagues, 1996), processes underlying text comprehension are not expected to differ across languages. However, given drastic linguistic differences between Korean (e.g., Korean is a predicate-final language with rich agglutination) and English, it is important to examine the DIET model with English-speaking children for generalizability. Furthermore, although linguistic features may be different between oral and written texts (e.g., lexical density; Biber, 1998, 1991), the overall framework of DIET is likely to apply to reading comprehension because basic processes involved discourse comprehension are expected to be similar, and this hypothesis should be empirically tested.

Understanding the nature of pathways of relations (direct and indirect contributions) is important in several regards. First, knowledge of pathways facilitates integration of results from previous studies. For instance, studies have shown that working memory is a critical cognitive ability for vocabulary (Gathercole & Baddeley, 1990a, 1990b, 1993; Gathercole et al., 1999), grammatical knowledge (Verhagen & Leseman, 2016), listening comprehension (Kim, 2015a, 2016; Daneman & Merikle, 1996; Strasser & del Rio, 2014), and reading comprehension (Cain et al., 2004; Daneman & Carpenter, 1980). On the other hand, working memory did not make an independent contribution to reading comprehension after accounting for other component skills (e.g., listening comprehension and word reading; Ahmed, 2014; Kim, 2016; Van Dyke, Johns, & Kukona, 2014). Examining pathways of relations by including multiple component skills simultaneously can explain these seemingly contracting results—the relation of working memory to reading comprehension may be mediated by other skills.

In addition, examining pathways of relations allows us to estimate total effects of various component skills by accounting for direct and indirect effects on reading comprehension. Using the example of working memory, even if working memory does not make an independent contribution to reading comprehension, estimating its indirect effect via other component skills reveals relative size of its effect on reading comprehension.

Finally, knowledge about pathways has potentially important implications for instructional approaches. If language and cognitive component skills of reading comprehension primarily have indirect relations via listening comprehension, this reinforces the importance of expending instructional efforts and resources on improving listening comprehension as a way to promote development of reading comprehension and prevent reading comprehension difficulties. Furthermore, results about the DIET model for listening comprehension can inform instructional targets to promote development of listening comprehension.

Method

Participants

A total of 350 children in Grade 2 (53% boys; *M* age = 7.54, *SD* = .64) in the southeastern United States participated in the study. The sample size of the present study was determined considering various factors such as factor loadings, strengths of relations among component skills, and amount of R^2 expected to be explained in the outcomes (see E. J. Wolf, Harrington, Clark, & Miller, 2013). The sample consisted of two cohorts of children from the same schools in 2 consecutive years (Cohort 1 n = 165, Cohort 2 n = 185). Distributional properties and bivariate correlations of variables were highly similar for the two cohorts of children (Correlations matrices by cohort can be requested from the author). Therefore, analysis reported here are from the combined sample for statistical power. No children were excluded in the analysis. The sample was composed of approximately 52% Caucasians, 33% African Americans, 6% Hispanics, and 4% mixed race, reflecting demographic composition of the area where the study was conducted. Approximately 74% of the participating children were eligible for free and reduced lunch, a proxy for low socioeconomic status. According to the school district record, 15% of the children received speech services, 1% language impairment services, and 1% learning disability services; 1.8% were English language learners.

Measures

Children were assessed on the following constructs: working memory, vocabulary, grammatical knowledge, knowledge-based inference (integration of background knowledge with information in the text), perspective taking, comprehension monitoring, listening comprehension, reading comprehension, and word reading. Multiple measures were used for word reading, listening comprehension, and reading comprehension, but single measures were used for the other constructs due to time and resource constraints. All the tasks were administered in oral language contexts except for word reading 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.

Working memory

The listening span task (Kim, 2015a, 2016; Daneman & Merikle, 1996) was used. In this task, the child was presented with a short sentence involving common knowledge familiar to children (e.g., "Birds can fly.") and asked to identify whether the heard sentence was correct. After hearing the

Table 1. Descriptive statistics.

			Full Sample[c]				
Variables	Cohort 1[a]: M (SD)	Cohort 2[b]: M (SD)	M (SD)	Min-Max	Skewness	Kurtosis	α
TNL Comp—raw	26.47 (4.95)	25.34 (4.97)	25.87 (4.98)	5–36	−.79	.94	.74
TNL Comp—SS	8.65 (3.07)	7.99 (2.64)	8.30 (2.87)	1–15	−.09	−.04	NA
OWLS Comp—raw	76.90 (12.89)	76.08 (13.17)	76.46 (13.03)	37–103	−.17	−.49	.94
OWLS Comp—SS	98.41 (14.32)	95.92 (15.79)	97.09 (15.15)	44–124	−.46	.08	NA
Expository Comp	10.24 (3.49)	9.21 (3.40)	9.70 (3.48)	1–20	.47	.07	.72
CASL Inference—raw	10.81 (6.92)	10.97 (7.05)	10.89 (6.98)	0–31	.59	−.43	.91
CASL Inference—SS	92.32 (13.15)	92.76 (13.42)	92.55 (13.28)	56–127	.25	−.32	NA
Theory of mind	8.23 (4.03)	7.40 (3.80)	7.79 (3.92)	0–17	.08	−.76	.71
Comp monitoring	7.16 (3.09)	6.45 (2.81)	6.77 (2.96)	1–16	.36	−.50	.69
WJ-III Picture Vocabulary—raw	20.54 (2.87)	20.42 (2.93)	20.48 (2.90)	7–29	−.10	1.14	.69
WJ-III Picture Vocabulary—SS	97.58 (10.52)	96.37 (10.45)	96.94 (10.49)	43–126	−.43	1.86	NA
CASL Grammaticality—raw	33.63 (12.45)	31.38 (12.87)	33.43 (12.71)	2–66	.02	−.15	.94
CASL Grammaticality—SS	97.01 (13.43)	94.86 (13.58)	95.87 (13.53)	50–134	−.43	.76	NA
Working memory	7.94 (3.96)	8.46 (3.85)	8.21 (3.91)	0–20	.02	.20	.71
WJ-III Passage Comp—raw	22.97 (4.23)	23.07 (4.11)	23.02 (4.16)	12–33	.17	−.65	.83
WJ-III Passage Comp—SS	96.36 (11.23)	97.73 (11.40)	97.09 (11.33)	57–122	−.39	.24	NA
WIAT-3 Reading Comp—raw	51.74 (11.35)	50.25 (11.25)	50.94 (11.30)	3–83	−.08	.81	.82
WIAT-3 Reading Comp—SS	96.58 (13.23)	96.88 (13.13)	96.74 (13.16)	40–138	.02	1.25	NA
WJ-III Letter Word ID—raw	42.01 (6.51)	42.14 (6.22)	42.08 (6.35)	25–63	.53	.29	.91
WJ-III Letter Word ID—SS	103.53 (12.43)	105.20 (12.58)	104.42 (12.52)	65–135	−.31	.16	NA
Sight Word Efficiency A—raw	50.99 (11.94)	52.45 (11.78)	51.77 (11.86)	14–75	−.47	−.25	.93[d]
Sight Word Efficiency A—SS	97.39 (15.38)	100.75 (16.13)	99.17 (15.85)	55–131	−.52	.02	NA
Sight Word Efficiency B—raw	51.55 (11.71)	52.64 (12.22)	52.13 (11.98)	13–78	−.37	−.03	.93[d]
Sight Word Efficiency B—SS	98.00 (15.50)	100.76 (16.77)	99.46 (16.22)	55–135	−.44	.01	NA

Note. Unless otherwise noted, Cronbach's alpha estimates are reported. TNL = Narrative Comprehension scale of Test of Narrative Language; Comp = Comprehension; SS = Standard Score; OWLS = Listening Comprehension scale of Oral and Written Language Scales-II; CASL = Comprehensive Assessment of Spoken Language; WJ-III = Woodcock Johnson–III; WIAT-3 = Wechsler Individual Achievement Test–3.

[a]*n* = 165. [b]*n* = 185. [c]*N* = 350. [d]Test–retest reliability (Wagner et al., 2012).

sentences (e.g., two or three sentences), she was asked to identify the last words in the sentences. There were four practice items and 13 experimental items. Testing was discontinued after three incorrect responses. Children's yes/no responses regarding the veracity of the statement were not scored, but their responses on the last words in correct order were given a score of 0–2: 2 was for correctly identifying all the last words in correct order, correct last words in incorrect order were given 1 point, and incorrect last words were given 0 points. A total possible maximum score was 26.

In many previous studies, the listening span task was scored dichotomously by giving a credit for the responses in correct order only. When children's responses were dichotomously scored following this approach, its correlation with the current scoring of 0–2 was very strong (r = .94). When data analysis was conducted using dichotomous scoring, the results were essentially identical with what is reported in the present article.

Vocabulary

A standardized and normed task, the Picture Vocabulary of the Woodcock Johnson-III (WJ-III; Woodcock, McGrew, & Mather, 2001) was used. In this task, the child was asked to identify pictured objects. Test administration discontinued after six consecutive incorrect items.

Grammatical knowledge

A standardized and normed task, the Grammaticality Judgement task of the Comprehensive Assessment of Spoken Language (Carrow-Woolfolk, 1999), was used. The child was asked whether a heard sentence was grammatically correct. If grammatically incorrect, the child was asked to correct the sentence. Test administration discontinued after five consecutive incorrect items.

Knowledge-based inference

There are different types of inferences, including knowledge-based inference (the ability to infer information based on background knowledge), text-based inferences (the ability to infer information based on propositions within the given text), and inferring other's thoughts and feeling (see Graesser et al., 1994, for a summary). In the present study, inference was operationalized as the ability to integrate information from the text with background knowledge (i.e., knowledge-based inference; see Cain et al., 2004, for similar operationalization), and was measured by the Inference task of Comprehensive Assessment of Spoken Language (Carrow-Woolfolk, 1999). In this task, after hearing two- to three-sentence scenarios, the child was asked a question that required inference based on background knowledge. For instance, the child heard "Mandy wanted to wear last year's dress to school one day, but when she tried on, she could not wear it. Why?" The correct responses must reference to the fact that Mandy has grown or the dress does not fit anymore. Test administration discontinued after five consecutive incorrect items.

Perspective taking (Theory of mind)

Perspective tasking was measured by theory of mind tasks—three second-order false belief scenarios involving the context of a bake sale, visit to a farm, and going out for a birthday celebration (Kim & Phillips, 2014) were employed to be developmentally appropriate for second graders. The second-order task examined the child's ability to infer a story character's mistaken belief about another character's knowledge. The scenarios were presented with a series of illustrations, followed by questions. There were six questions in each scenario with a total of 18 items.

Comprehension monitoring

An inconsistency detection task was used (e.g., Kim & Phillips, 2014; Cain et al., 2004). The child heard a short story and was asked to identify whether the story made sense. If the child indicated that the story did not make sense, she was asked to provide a brief explanation and to fix the story so that it made sense. The meaning of "not making sense" was explained as sentences not going together in practice items.

There were two practice items and nine experimental items. Consistent (three items) and inconsistent (six items) stories were randomly ordered. For the six inconsistent stories, the accuracy of children's explanation and repair of the story were also dichotomously scored, and thus a total possible score was 21. Because in many previous studies, inconsistency detection was operationalized by the ability to identify inconsistency (Kim, 2015a, 2016; Kim & Phillips, 2014; Baker, 1984; Cain et al., 2004; Wagoner, 1983), excluding the ability the fix the story, preliminary analysis was conducted excluding the points for fixing stories. The correlation between the two scores were extremely high (r = .98), and therefore analysis reported here included the score on the child's ability to fix inconsistent stories.

Listening comprehension

The following three tasks were used: The Narrative Comprehension subtest of the Test of Narrative Language (Gillam & Pearson, 2004), the Listening Comprehension Scale of the Oral and Written Language Scales–II (Carrow-Woolfolk, 2011), and an experimental expository comprehension task. In the Test of Narrative Language Narrative Comprehension subtest, the child heard three narrative stories and was asked comprehension questions for each story. In the Oral and Written Language Scales–II Listening Comprehension task, the child listened to stimulus sentences and was asked to point to one of four pictures that corresponded to the heard sentences. Test administration discontinued after four consecutive incorrect items. The experimental expository comprehension task was composed of three expository passages (140 words, 200 words, and 282 words, respectively) from Level 2 passages from the Qualitative Reading Inventory–5 (Leslie & Caldwell, 2011) and the Analytical Reading Inventory–9th Edition (Woods & Moe, 2011). Titles of the passages were *Matter, Whales and Fish*, and *Where Do People Live?* After listening to each passage, the child was asked comprehension questions (eight questions in each passage).

Reading comprehension

Two standardized and normed tasks were used: the Passage Comprehension of WJ-III (Woodcock et al., 2001), and the Reading Comprehension of the Wechsler Individual Achievement Test–Third Edition (Wechsler, 2009). In the Passage Comprehension, the child read sentences and short passages and filled in blanks. Test administration discontinued after six consecutive incorrect items. In the Reading Comprehension of Wechsler Individual Achievement Test–Third Edition, the child read passages and answered multiple choice questions.

Word reading

Three standardized and normed tasks were used. In the Letter Word Identification of the WJ-III, the child was asked to read aloud a list of words of increasing difficulty. Test administration discontinued after six consecutive incorrect items.

The other tasks were two forms (A & B) of the Sight Word Efficiency task of the Test of Word Reading Efficiency–II (Wagner, Torgesen, & Rashotte, 2012). These are timed tasks such that the child was asked to read words of increasing difficulty with accuracy and speed in 45 s.

Procedures

Children were individually assessed by rigorously trained research assistants in a quiet space in the school. Assessment battery was administered in several sessions with each session lasting 30–40 min.

Data analysis strategy

Primary data analytic strategies were confirmatory factory analysis and structural equation modeling, using MPLUS 7.1 (Muthen & Muthen, 2013). Latent variables were created for listening comprehension, reading comprehension, and word reading, which were assessed using multiple measures. The language and cognitive skills were assessed by single measures for each construct, and therefore observed variables were used. Given a relatively large differences in reliability estimates across language and cognitive skills (see Table 1) and the impact of measurement error on attenuating relations (Cole & Preacher, 2014), we used a single-indicator latent variable approach (Sagan & Paweleck, 2015; also see Ahmed et al., 2016) by accounting for reliabilities of language and cognitive skills measures.

Model fits were evaluated by 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 residual (SRMR). Typically, RMSEA values below .08, CFI and TLI values equal to or greater than .95, and SRMR equal to or less than .05 indicate an excellent model fit, and TLI and CFI values greater than .90 are considered to be acceptable (Kline, 2005). Model fits were compared using chi-square differences for nested models.

Results

Descriptive statistics and preliminary analysis

Table 1 shows descriptive statistics including means, standard deviations, minimum, maximum, skewness, and kurtosis by cohort and for the full sample. Overall, children's mean performances on the normed language (listening comprehension) and cognitive tasks (inference) were in the average or low-average range. Children's mean performances on the literacy measures (word reading and reading comprehension) were in the average range with mean standard scores ranging from 96.74 to 104.42. Distributional properties of the variables were appropriate as indicated by skewness and kurtosis values. Multivariate normality assumptions were checked and were not violated. Subsequent analyses were conducted using raw scores.

Correlations between measures are displayed for the full sample (Table 2). Higher order cognitive skills (knowledge-based inference, theory of mind, and comprehension monitoring) were moderately related to the listening comprehension measures ($.30 \le rs \le .56$) and reading comprehension measures ($.31 \le rs \le .38$). Foundational language skills (i.e., vocabulary and grammatical knowledge) were also moderately the listening comprehension tasks ($.40 \le rs \le .53$) and reading comprehension tasks ($.34 \le rs \le .47$). Working memory was weakly to moderately related to the listening comprehension tasks ($.28 \le rs \le .34$) and reading comprehension tasks (rs = .22 and .38). Magnitudes of these relations are similar to those in previous studies in various languages (e.g., Kim, 2015a, 2016; Cain et al., 2004; Florit et al., 2014; Lepola et al., 2012).

Using confirmatory factory analysis, latent variables were created for listening comprehension, reading comprehension, and word reading. In the word reading latent variable, residual variances between the two forms of sight word efficiency were allowed to covary because both were timed tasks. Listening comprehension ($r = .74$, $p < .001$) and word reading ($r = .94$, $p < .001$) were strongly correlated with reading comprehension. Word reading and listening comprehension were moderately correlated with each other ($r = .33$, $p < .001$). Note that in the subsequent structural equation models, children's age or cohort was not included because of its consistent nonsignificance once other variables were included in the model.

Direct and indirect relations of language and cognitive component skills to listening comprehension and reading comprehension (DIET model)

Indirect relations (Figures 3a) and two alternative DIET models (Figures 3b and 3c) were fitted to the data for listening comprehension. The model fit for the indirect relations model (Figure 3a) was acceptable: $\chi^2(18) = 60.77$, $p <$ 001; CFI = .96, TLI = .92, AIC = 18181.34, BIC = 18320.23, RMSEA = .082, 90% confidence interval (CI) [.06, .106], and SRMR = .045. The Figure 3b model had an excellent fit, $\chi^2(12) = 19.81$, $p = .07$; CFI = .99, TLI = .98, AIC = 18148.38, BIC = 18302.70, RMSEA = .043, CI [.00, .076], and SRMR = .021; so did the Figure 3c model: $\chi^2(15) = 22.36$, $p = .10$; CFI = .99, TLI = .98, AIC = 18148.922, BIC = 18299.381, RMSEA = .037, CI [.00, .07], and SRMR = .023. The two DIET models (i.e., Figures 3b and 3c) were superior to

Table 2. Correlations among measures for combined sample.

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. TNL	—												
2. OWLS	.44	—											
3. Expository comp	.60	.42	—										
4. Inference	.56	.40	.49	—									
5. Theory of mind	.51	.37	.47	.44	—								
6. Comp monitoring	.47	.30	.42	.48	.33	—							
7. Vocabulary	.46	.47	.40	.45	.36	.29	—						
8. Grammaticality judgement	.53	.41	.44	.58	.32	.41	.44	—					
9. Working memory	.34	.33	.28	.25	.24	.21	.36	.33	—				
10. WJ Passage Comp	.45	.35	.41	.38	.36	.34	.47	.46	.38	—			
11. WIAT Reading Comp	.43	.31	.40	.36	.34	.31	.34	.43	.22	.50	—		
12. Letter Word Identification	.26	.26	.25	.22	.15	.22	.32	.43	.29	.74	.46	—	
13. TOWRE SWE A	.15	.11	.10	.11	.06	.09	.21	.27	.16	.65	.42	.75	—
14. TOWRE SWE B	.07	.05	.08	.10	.03	.06	.16	.25	.17	.62	.39	.73	.92

Note. N = 350. Coefficients less than .10 are not statistically significant at .05 level. TNL = Narrative Comprehension scale of Test of Narrative Language; OWLS = Listening Comprehension scale of Oral and Written Language Scales–II; Comp = Comprehension; WJ = Woodcock Johnson–III; WIAT = Wechsler Individual Achievement Test–3; TOWRE SWE = Sight Word Efficiency subtest of Test of Word Efficiency.

the indirect relations model: 3a versus 3b, $\Delta\chi^2(6) = 40.96$, $p < .001$; ΔAIC = 32.96, ΔBIC = 17.53; and 3a versus 3c, $\Delta\chi^2(3) = 38.41$, $p < .001$; ΔAIC = 32.42, ΔBIC = 20.85. Models 3b and 3c were not statistically different, $\Delta\chi^2(3) = 2.55$, $p = .47$, and therefore, the 3c model was chosen as the final model for parsimony.

Standardized path coefficients of the final DIET model (3c) for listening comprehension are shown in Figure 4. Working memory was related to vocabulary ($\gamma = .52$, $p < .001$) and grammatical knowledge ($\gamma = .41$, $p < .001$) but was not directly related to listening comprehension, just shy of conventional .05 statistical significance level ($\gamma = .11$, $p = .06$). Vocabulary was statistically significantly related to knowledge-based inference ($\beta = .32$, $p < .001$), theory of mind ($\beta = .43$, $p < .001$), and comprehension monitoring ($\beta = .22$, $p = .01$) after accounting for working memory and grammatical knowledge. Grammatical knowledge was related to knowledge-based inference ($\beta = .45$, $p < .001$), theory of mind ($\beta = .16$, $p = .046$), and comprehension monitoring ($\beta = .39$, $p < .001$) after controlling for working memory and vocabulary. Vocabulary ($\beta = .23$, $p = .004$) and grammatical knowledge ($\beta = .17$, $p = .006$) were also directly related to listening comprehension after accounting for all other predictors in the model. Theory of mind ($\beta = .37$, $p < .001$) and comprehension monitoring ($\beta = .23$, $p = .001$) were independently related to listening comprehension. However, knowledge-based inference ($\beta = .12$, $p = .08$) was not statistically significant after accounting for the other variables in the model. Approximately 86% of total variance in listening comprehension were explained by the included predictors.

Direct, indirect, and total effects of the language and cognitive component skills on listening comprehension are displayed in Table 3. Substantial amount of total effects was observed for

Table 3. Direct, indirect, and total effects of language and cognitive skills (standard error) based on the results in Figures 4, 5, and 7.

	Listening Comprehension			Reading Comprehension			Reading Comprehension		
Variable/Outcome	Direct	Indirect	Total	Direct	Indirect	Total	Direct	Indirect	Total
Listening comp	NA	NA	NA	NA	NA	NA	.45 (.04)	—	.45
Word reading	NA	NA	NA	NA	NA	NA	.74 (.03)	—	.74
Inference	.12 (.07)[a]	—	.12[a]	−.10 (.09)[a]	—	−.10[a]	—	.05 (.03)[a]	.05[a]
Theory of mind	.37 (.07)	—	.37	.20 (.08)	—	.20	—	.18 (.03)	.18
Comp monitoring	.23 (.07)	—	.23	.17 (.09)[a]	—	.17	—	.10 (.03)	.10
Vocabulary	.23 (.08)	.25 (.05)	.48	.37 (.10)	.09 (.04)	.46	—	.23 (.04)	.23
Grammar	.17 (.06)	.20 (.05)	.37	.27 (.08)	.05 (.04)	.32	—	.15 (.03)	.15
Working memory	.11 (.06)[a]	.40 (.05)	.51	.15 (.08)	.37 (.05)	.52	—	.23 (.03)	.23

Note. Comp = comprehension; Inference = knowledge-based inference; Grammar = grammatical knowledge.
[a]Not statistically significant.

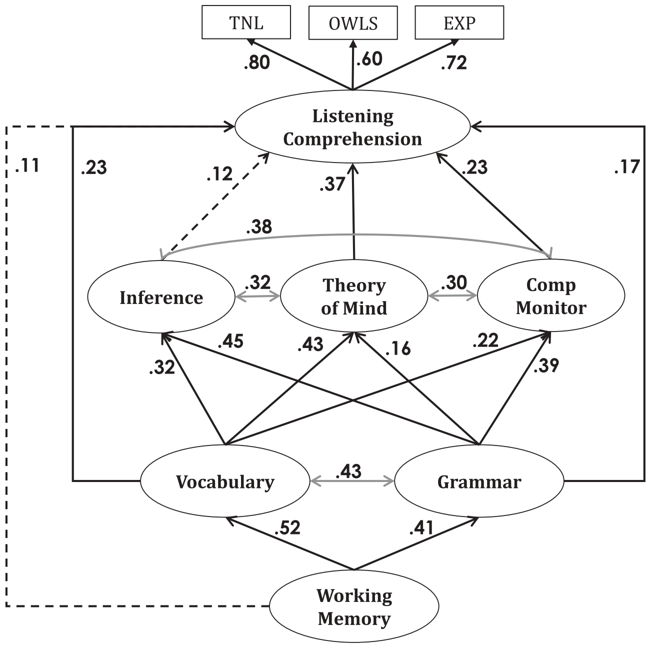

Figure 4. Standardized structural regression weights for the direct and indirect effects model of text comprehension for *listening comprehension. Note*. Two-sided arrows represent covariances. TNL = Test of Narrative Language; OWLS = Listening Comprehension scale of Oral and Written Language Scales–II; EXP = experimental expository task; Comp Monitor = comprehension monitoring.

working memory (.51), vocabulary (.48), theory of mind (.37), and grammatical knowledge (.37), followed by comprehension monitoring (.23) and knowledge-based inference (.12).

The DIET models in Figures 3a to 3c were also fitted for reading comprehension. The indirect relations model (Figure 3a) did not fit well: $\chi^2(11) = 71.21$, $p < .001$; CFI = .92, TLI = .80, AIC = 16205.23, BIC = 16332.54, RMSEA = .13, CI [.098, .154], and SRMR = .058. Similar to the results for the listening comprehension outcome, the direct and indirect model shown in Figures 3b and 3c had similarly excellent fits to the data: Figure 3b, $\chi^2(5) = 10.41$, $p = .06$; CFI = .99, TLI = .96, AIC = 16156.43, BIC = 16306.89, RMSEA = .056, CI [.00, .10], and SRMR = .017; Figure 3c, $\chi^2(8) = 12.86$, $p = .12$; CFI = .99, TLI = .98, AIC = 16152.88, BIC = 16291.77, RMSEA = .042, CI [.00, .082], and SRMR = .019. They were superior to Figure 3a model: 3a versus 3b, $\Delta\chi^2(6) = 60.80$, $p < .001$; ΔAIC = 48.8, ΔBIC = 25.65; and 3a versus 3c, $\Delta\chi^2(3) = 58.35$, $p < .001$; ΔAIC = 55.35, ΔBIC = 40.77. Figure 3c model was chosen for parsimony. As shown in Figure 5, working memory ($\gamma = .15$, $p = .04$), vocabulary ($\gamma = .37$, $p < .001$), grammatical knowledge ($\gamma = .27$, $p < .001$), and theory of mind ($\beta = .20$, $p = .02$) were directly related to reading comprehension whereas knowledge-based inference ($\beta = –.10$, $p = .26$) and comprehension monitoring ($\beta = .17$, $p = .06$) were not. A total of 66% of variance in reading comprehension was explained by the included language and cognitive skills. As shown in Table 3, direct, indirect, and total effects of language and cognitive skills on reading comprehension varied from negative but nonsignificant (–.10 for knowledge-based inference) to large (.52 for working memory and .46 for vocabulary).

Relations of component skills to reading comprehension—testing four variations of DIER model

Prior to examining the focal alternative models shown in Figures 2a to 2d, the simple view of reading was fitted and the model fit was good: $\chi^2(17) = 59.59$, $p < .001$; CFI = .98, TLI = .96, AIC = 17134.87, BIC = 17238.96, RMSEA = .085, CI [.062, .109], and SRMR = .048. As shown in Figure 6, listening

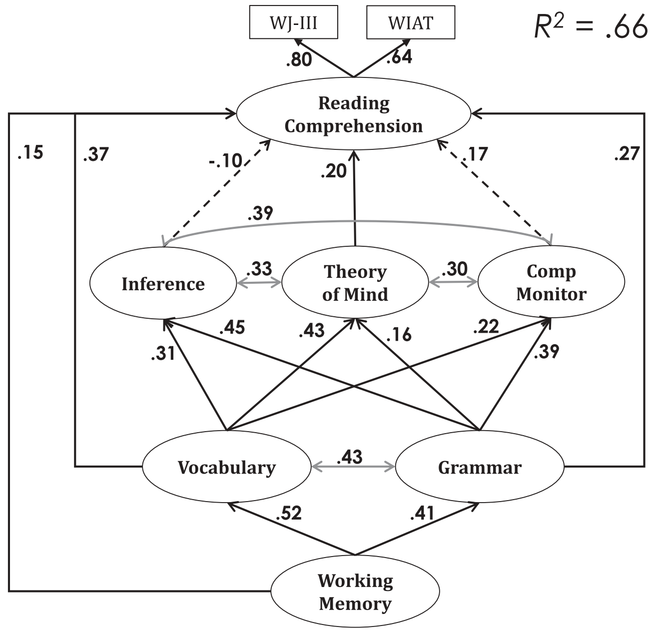

Figure 5. Standardized structural regression weights for the direct and indirect effects model of text comprehension for *reading comprehension*. *Note*. Two-sided arrows represent covariances. WJ-III = Woodcock Johnson-III Passage Comprehension; WIAT = Wechsler Individual Achievement Test-3 Reading Comprehension; Comp Monitor = comprehension monitoring.

comprehension (γ = .45, $p < .001$) was moderately related, and word reading (γ = .76, $p < .001$) was strongly related to reading comprehension. A total of 100% of variance in reading comprehension was explained by listening comprehension and word reading.

When the four alternative DIER models were fitted, all the models fitted data very well (see Table 4). In these models, residual variance for reading comprehension was set at 0 due to small but negative variance (Chen, Bollen, Paxton, Curran, & Kirby, 2001). Comparison of model fits revealed somewhat inconsistent findings. When examining chi-square differences, the Figure 2c model was statistically superior to models in Figures 2a, 2b, and 2d (.009 ≤ *p*s ≤ .04), whereas models of Figures 2a, 2b, and 2d were not different from one another (*p*s ≥ .31). Our focal comparison is specifically between Figure 2a model and Figure 2c model because model fit for Figure 2a was not different from Figures 2b and 2d, and Figure 2a is the most parsimonious model. The ΔAIC of 2.99 between Figure 2c and Figure 2a was negligible (see Kass & Raftery, 1995; Raftery, 1995) and Figure 2c model had a larger, not smaller, BIC value than Figure 2a model. Moreover, the superior fit of Figure 2c model was due to a suppression effect of grammatical knowledge on reading comprehension (β = –.12, $p = .02$) after accounting for all the other variables in the model. This suppression is difficult to interpret due to the complexity of the model. Given the inconsistent results between AIC, BIC, and chi-square difference tests combined with a small chi-square difference and a suppression effect, Figure 2a was chosen as the final model for parsimony. Standardized coefficients for the Figure 2a DIER model are shown in Figure 7.

Table 3 shows magnitudes of direct, indirect, and total effects of the language and cognitive component skills, word reading, and listening comprehension on reading comprehension. Word reading (.74) and listening comprehension (.45) had substantial total effects, followed by vocabulary (.23), working memory (.23), theory of mind (.18), grammatical knowledge (.15), comprehension monitoring (.10), and knowledge-based inference (.05).

Table 4. Model fit indices for models shown in Figures 2a to 2d.

	χ^2 (*df*), *p*	CFI (TLI)	AIC /BIC	RMSEA [CI]	SRMR	Model Comparison (*p* for $\Delta\chi^2$)	Model Comparison ΔAIC & ΔBIC
Figure 2a	120.52 (60), < .001	.98 (.97)	28722.66/28950.28	.054 [.04, .07]	.049		
Figure 2b	120.26 (59), < .001	.98 (.96)	28724.40/28955.88	.054 [.04, .07]	.049	to Figure 2a: .61	1.74 & 5.6
						to Figure 2d: .31	−1.69 & −9.4
Figure 2c	113.53 (58), < .001	.98 (.97)	28719.67/28955.00	.052 [.04, .07]	.049	to Figure 2a: .03	−2.99 & 4.72
						to Figure 2b: .009	−4.73 & −.88
						to Figure 2d: .04	−6.42 & −10.28
Figure 2d	117.95 (57), < .001	.98 (.96)	28726.09/28965.28	.055 [.04, .07]	.049	to Figure 2a: .46	3.43 & 15.00

Note. CFI = comparative fit index; TLI = Tucker-Lewis index; AIC = Akaike information criterion; BIC = Bayesian information criterion; RMSEA = root mean square error of approximation; CI = confidence interval; SRMR = standardized root mean square residual.

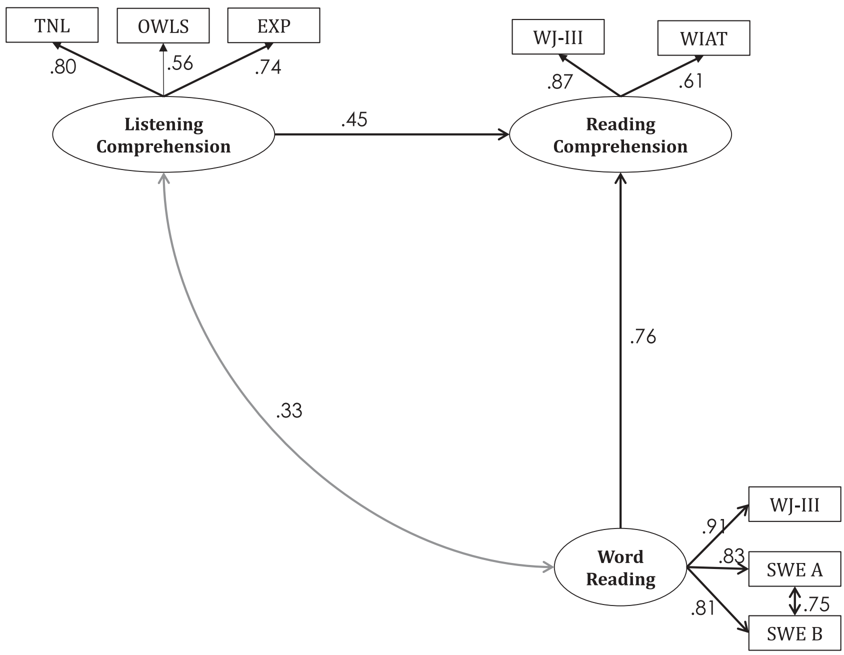

Figure 6. Standardized regression weights for *the simple view of reading*. *Note*. The two-sided arrow represents covariances. TNL = Test of Narrative Language; OWLS = Listening Comprehension scale of Oral and Written Language Scales–II; EXP = experimental expository task; WJ-III = Woodcock-Johnson–III; WIAT = Wechsler Individual Achievement Test–3; SWE A = Sight Word Efficiency of TOWRE form A; SWE B = Sight Word Efficiency of TOWRE form B.

Discussion

Successful reading comprehension requires establishing an accurate situation model from written texts. The simple view of reading proposed that reading comprehension can be essentially described as processes involved in word reading and linguistic comprehension. However, in the simple view of reading, linguistic comprehension was underspecified in terms of processes, component skills, and structural relations. In this study, we hypothesized that although linguistic comprehension includes lexical-level to discourse-level skills, the discourse-level skill, listening comprehension, mediates the relations of other language skills such as vocabulary and grammatical knowledge as well as cognitive skills to reading comprehension. Overall, the goal of the present study was to unpack the nature of

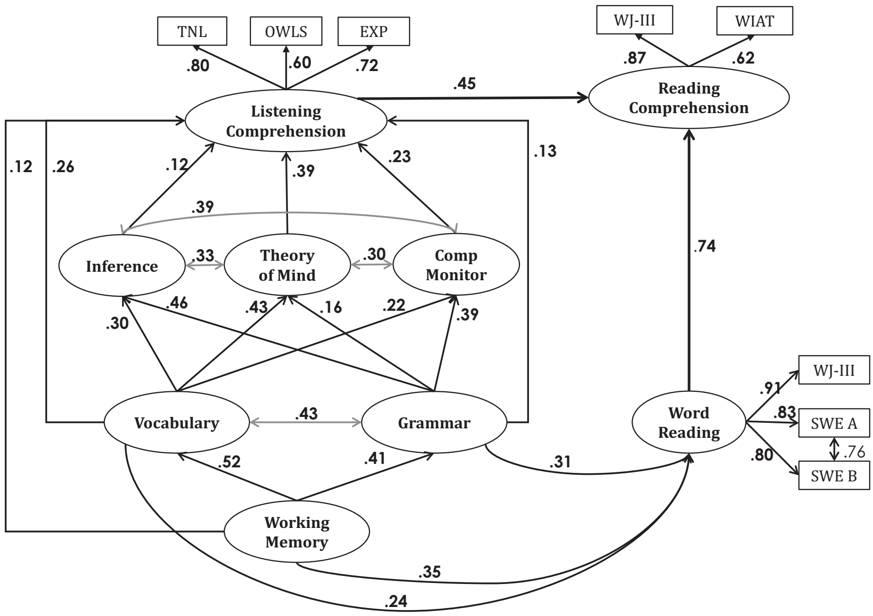

Figure 7. Standardized structural regression weights for *the final DIER model. Note*. Two-sided arrows represent covariances. TNL = Test of Narrative Language; OWLS = Listening Comprehension scale of Oral and Written Language Scales-II; EXP = Experimental expository task; WJ-III = Woodcock Johnson-III; WIAT = Wechsler Individual Achievement Test-3; SWE A = Sight Word Efficiency of TOWRE form A; SWE B = Sight Word Efficiency of TOWRE form B; Comp Monitor = comprehension monitoring.

relations among multiple language and cognitive skills identified by the simple view of reading and text comprehension studies, using the DIET and DIER models.

The DIET model hypothesizes a hierarchical structure of relations among language and cognitive component skills of text comprehension such that working memory and attentional control are domain-general, foundational cognitive skills for learning, including language and literacy. Foundational language skills such as vocabulary and grammatical knowledge are necessary for higher order cognitive skills such as inference, perspective taking, and comprehension monitoring. All these foundational cognitive and language skills, and higher order cognitive skills are necessary for listening comprehension, which is a discourse-level oral language comprehension. The present findings supported the DIET model both in oral and written contexts. The large amount of variance explained by the included language and cognitive component skills is striking: 86% in listening comprehension and 66% in reading comprehension. The former is similar to a study with Korean-speaking children (Kim, 2016). The latter is substantial, particularly considering that word reading was not included in the DIET model. The results that multiple language and cognitive skills are involved in text comprehension are in line with previous work (Ahmed et al., 2016; Cain et al., 2004; Cromley & Azevedo, 2007; Florit et al., 2009, 2013; Kim, 2015a, 2016; Lepola et al., 2012); and the DIET model is in line with theoretical framework of text/discourse comprehension (Graesser et al., 1994; Kintsch, 1988, 2005; Perfetti & Stafura, 2014; van den Broek, Rapp, & Kendeou, 2005; van den Broek et al., 1999; Van Dijk & Kintsch, 1983). The present findings, however, expand previous studies and frameworks by specifying the nature of structural relations among language and cognitive component skills.

A notable finding from the present study is that word reading and listening comprehension completely mediated the relations of the language and cognitive component skills to reading comprehension. Convergent with previous studies (Bowyer-Crane & Snowling, 2005; Cain & Oakhill, 1999; Cain et al., 2004; Daneman & Carpenter, 1980; Foorman et al., 2015; Hoover & Gough, 1990; Joshi et al., 2012; Kendeou et al., 2009; Oakhill & Cain, 2012; Seigneuric & Ehrlich, 2005), the simple view of reading fit the data very well (see Figure 6), as did direct and indirect model of text comprehension for listening comprehension (Figure 4) and reading comprehension (Figure 5), suggesting that both listening comprehension and reading comprehension rely on foundational cognitive and language skills and higher order cognitive skills and that higher order cognitive skills draw on foundational cognitive and language skills. When all the language and cognitive component skills were modeled jointly with word reading and listening comprehension, the model in which word reading and listening comprehension completely mediated their relations described the data best. That is, working memory, vocabulary, grammatical knowledge, knowledge-based inference, perspective taking (measured by theory of mind), and comprehension monitoring were indirectly related to reading comprehension via listening comprehension and word reading.

These findings support the DIER model and are in line with overall hypothesis of the simple view of reading—word reading and linguistic comprehension underpin reading comprehension. Unlike the simple view of reading, however, the DIER model specified language and cognitive component skills of word reading and listening comprehension, and the nature of relations (hierarchical, and direct and indirect relations) among language and component skills. Word reading and listening comprehension are upper-level skills that directly contribute to reading comprehension while they are predicted by a constellation of language and cognitive skills. Word reading is predicted by foundational cognitive and language skills (working memory, vocabulary, and grammatical knowledge) as well as phonological, morphological, and orthographic processes not included in the present study, and listening comprehension is predicted by foundational cognitive and language skills as well as higher order cognitive skills. These language and cognitive component skills have direct and indirect relations with listening comprehension while they have indirect relations with reading comprehension, completely mediated by word reading and listening comprehension. The present findings and the DIER model are also in line with the Reading Systems framework by Perfetti and his colleagues (Perfetti, 1999; Perfetti et al., 2005; Perfetti & Stafura, 2014), according to which, knowledge about orthographic system and linguistic system is necessary for reading comprehension, and both systems have its own processes, which interact and influence each other.

An understanding about structural relations among component skills is vital to reveal total effects, accounting for both direct and indirect effects. Many previous investigations examined unique and direct relations (i.e., whether a focal predictor is *independently* or *uniquely* related to reading comprehension after accounting for convariates, using multiple regression analytic approach), but this approach masks indirect contributions. As shown in Table 3, indirect effects made substantial differences in accounting for total effects of various language and cognitive skills on listening comprehension and reading comprehension. For instance, the direct effect of working memory on listening comprehension was .11, albeit it was just shy of conventional statistical significance ($p = .06$). However, after accounting for its indirect effects via vocabulary, grammatical knowledge, and higher order cognitive skills, its total effect was substantial (.51 = .11 direct effect +.40 indirect effect). Similarly, although working memory did not have a direct effect on reading comprehension, its indirect effect via various pathways including word reading and listening comprehension was also sizable (.23). These underscore the importance of taking into consideration both direct and indirect effects.

It is striking that latent variables of word reading and listening comprehension (the simple view and the DIER model) explained all the variation in reading comprehension (100%). This is in line with recent work using latent variables of word reading and listening comprehension (Adlof et al., 2006; Kim, 2015; Kim & Wagner, 2015; Foorman et al., 2015) and contrasts with prior work using observed variables that explained smaller amounts of variance in reading comprehension (e.g., 31%–75%; Joshi et al., 2012; Ouellette & Beers, 2010). This difference in approach might also explain discrepancies between the present findings and previous studies that found a unique contribution of vocabulary to reading comprehension over and above word reading and listening comprehension (e.g., Ouellette & Beers, 2010; Verhoeven & Leeuwe, 2008). The present study used latent variables with multiple indicators for the key constructs, word reading, listening comprehension, and reading comprehension, measuring these constructs with greater precision; and vocabulary, which was measured with a single construct, was corrected for its reliability. Using a single observed variable for a construct is vulnerable to measurement error (Cole & Preacher, 2014), which likely influenced results of previous studies (e.g., Ouellette & Beers, 2010; Verhoeven & Leeuwe, 2008). An alternative explanation is that in Ouellette and Beers's (2010) study and Verhoeven and Leeuwe's (2008) study, passages in reading comprehension tasks might have had particularly high demands in vocabulary that were not adequately captured in the listening comprehension task. Texts (oral or written) differ in linguistic and cognitive demands (e.g., vocabulary, the extent to inference; Schleppegrell, 2001; Seigneuric et al., 2000). This underscores the importance and need for using multiple indicators and/or to using precise measures to capture underlying constructs.

Given that many second graders are still developing important decoding-related skills, the relatively stronger contribution of word reading to reading comprehension is in line with the developmental hypothesis of the simple view of reading (Hoover & Gough, 1990) and previous findings (Adlof et al., 2006; Kim, 2015a, b; Kim & Wagner, 2015; Foorman et al., 2015; Language and Reading Research Consortium, 2015). Furthermore, perspective taking measured by theory of mind was independently related to listening comprehension and reading comprehension even after accounting for knowledge-based inference, comprehension monitoring, and the other foundational language and cognitive skills. This is in line with the theoretical conceptualization that inferences others' thoughts and emotions (i.e., perspective taking) is one of the important higher order cognitive skills for text comprehension and growing evidence of its role in text comprehension (Kim, 2015a, 2016; Kim & Phillips, 2014; Graesser et al., 1994; Kendeou et al., 2008). However, knowledge-based inference was not uniquely related to text comprehension (listening comprehension and reading comprehension) after accounting for all the other variables in the model (see Figures 4 and 5). This does not negate the contribution of knowledge-based inferences to text comprehension. Instead, it appears that its contribution is largely shared with the other higher order cognitive skills such as perspective taking and comprehension monitoring.

Limitations and future directions

As with any studies, the results of the present study should be interpreted keeping the study design and associated limitations in mind. One limitation is that although the included language and cognitive skills were relatively comprehensive, other potential predictors of reading comprehension were not included. Those include predictors of word reading proficiency such as phonological awareness, orthographic symbol knowledge, orthographic awareness, and morphological awareness (Apel et al., 2012; Kim et al., 2013; Schatschneider et al., 2004), as well as those for reading comprehension such as background knowledge, text reading fluency, and text structure knowledge (Kim, 2015b; Kim, Wagner, & Lopez, 2012; Kim & Wagner, 2015; Cain et al., 2004; Cromley & Azevedo, 2007; also see Compton, Miller, Elleman, & Steacy, 2014). In the present study, knowledge-based inference task was used, and therefore this measure presumably taps into background knowledge to some extent. However, the extent to which this task measures background knowledge or accessing background knowledge to infer missing information (e.g., Barnes et al., 1996) is unclear. Future studies including these predictors would further expand the DIER model and our understanding about factors associated with reading comprehension.

Furthermore, due to resource constraints and practicality of administering a large battery of assessment in school settings, observed variables rather than latent variables were used for the language and cognitive component skills. Although variation in measurement error among the language and cognitive tasks were accounted for in the data analysis, future replications using latent variables for predictors would be informative.

Future studies should also examine potential bidirectional relations. Although directionality of relations in the present study were based on theory and empirical evidence, some possible bidirectional relations were not tested, as this was beyond the scope of the present study. For instance, although working memory has been hypothesized as necessary for language skills such as vocabulary

(Baddeley, Gathercole, & Papagno, 1998; Gathercole & Baddeley, 1993; Gathercole et al., 1999), oral language has been argued to be necessary for working memory tasks as well (MacDonald & Christiansen, 2002).

Finally, the present study was a cross-sectional examination using data from children in Grade 2. Therefore, an important future direction is to test the DIER model with children at different phases of reading development (e.g., upper elementary or secondary schools), as well as longitudinal studies. This will illuminate whether basic structure of the DIER model for reading comprehension—listening comprehension and word reading completely mediate the relation of language and cognitive component skills to reading comprehension—is generalizable across developmental phases and whether skills have bidirectional relations over development.

Implications and conclusion

Findings offer preliminary but critical implications for assessment and intervention efforts. A widely used approach based on the simple view of reading is to classify children into four profiles: those whose difficulty in reading comprehension is primarily due to word reading, primarily due to listening comprehension, or due to weaknesses in both word reading and reading comprehension, and those who are relatively strong in both word reading and listening comprehension. However, listening comprehension was underspecified in the simple view of reading, and evidence about its component skills was not available until recently. The present study, together with growing evidence, suggests that there are multiple sources for children's weakness in listening comprehension, and therefore multiple language and cognitive skills should be considered for assessment and instruction (e.g., Bianco et al., 2010). Therefore, preventive efforts for reading comprehension failure do not have to wait until the child develops word reading skills, but instead assessing and intervening children's listening comprehension and associated language and cognitive skills at an early age would be a more promising approach.

The present study was an effort to unpack pathways of relations for multiple language and cognitive skills to reading comprehension and reveal both direct and indirect effcts. Overall, the present findings highlight the importance of disentangling direct and indirect pathways and effects of various language and cognitive skills on text comprehension. Future cross-sectional and longitudinal studies in different languages are needed to further inform the complex processes of comprehension.

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