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Expanding the Developmental Models of Writing: A Direct and Indirect Effects Model of Developmental Writing (DIEW)

Young-Suk Grace Kim and Christopher Schatschneider
Florida State University and Florida Center for Reading Research

We investigated direct and indirect effects of component skills on writing (DIEW) using data from 193 children in Grade 1. In this model, working memory was hypothesized to be a foundational cognitive ability for language and cognitive skills as well as transcription skills, which, in turn, contribute to writing. Foundational oral language skills (vocabulary and grammatical knowledge) and higher-order cognitive skills (inference and theory of mind) were hypothesized to be component skills of text generation (i.e., discourse-level oral language). Results from structural equation modeling largely supported a complete mediation model among 4 variations of the DIEW model. Discourse-level oral language, spelling, and handwriting fluency completely mediated the relations of higher-order cognitive skills, foundational oral language, and working memory to writing. Moreover, language and cognitive skills had both direct and indirect relations to discourse-level oral language. Total effects, including direct and indirect effects, were substantial for discourse-level oral language (.46), working memory (.43), and spelling (.37); followed by vocabulary (.19), handwriting (.17), theory of mind (.12), inference (.10), and grammatical knowledge (.10). The model explained approximately 67% of variance in writing quality. These results indicate that multiple language and cognitive skills make direct and indirect contributions, and it is important to consider both direct and indirect pathways of influences when considering skills that are important to writing.

Keywords: developmental model of writing, cognitive skills, oral language skills, direct effect, indirect effect

Writing is one of the most complex tasks (Olive, 2004), drawing on a large number of language and cognitive skills. Two prominent models of developmental writing with empirical support include the simple view of writing and not-so-simple view of writing. According to the simple view of writing, writing is a product of two necessary skills, transcription and ideation (also called text generation; Berninger, Abbott, Abbott, Graham, & Richards, 2002; Juel, Griffith, & Gough, 1986). The not-so-simple view of writing expanded the simple view of writing in two ways. First, executive function and self-regulatory processes (e.g., attention, goal setting, reviewing) were included, in addition to text generation and transcription skills (Berninger & Amtmann, 2003; Berninger & Winn, 2006). Second, working memory was hypothesized to be at the center of these three components (text generation, transcription, and self-regulation), needed for accessing long-term memory during planning and composing process and short-term memory during review process (Berninger & Winn, 2006).

Although highly informative, these two models lacked specificity about component skills, particularly for text generation and relations among component skills. In the present study, our goal was to expand the developmental models of writing by investigating component skills of text generation, and their relations to writing quality. To this end, we used data from beginning writers to test a direct and mediated model of text generation (i.e., discourse-level language), and four different variations of the direct and indirect effects models of writing (DIEW).

Developmental Models of Writing and Component Skills of Writing

As writing requires written texts, transcription—the process and physical acts of representing sounds to written symbols, including spelling and handwriting skills (McCutchen, 2000)—is necessary. Lack of accuracy and fluency in transcription skills constrain writing by interfering with higher-order skills such as planning and content generation (Bourdin & Fayol, 1994; Graham, Berninger, Abbott, Abbott, & Whitaker, 1997; McCutchen, 2000). Much evidence has supported the importance of transcription skills in writing (Abbott & Berninger, 1993; Berninger et al., 2002; Berninger et al., 1997; Graham et al., 1997; Graham & Harris, 2000; Kim et al., 2011; Kim, Al Otaiba, Wanzek, & Gatlin, 2015; Kim, Al Otaiba, Sidler, Greulich, & Puranik, 2013; Kim, Park, & Park, 2015; Limpo & Alves, 2013; McCutchen, 1996).

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Young-Suk Grace Kim, College of Education, Florida State University and Florida Center for Reading Research; Christopher Schatschneider, Department of Psychology, Florida State University and Florida Center for Reading Research.

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Correspondence concerning this article should be addressed to Young-Suk Grace Kim, College of Education and Florida Center for Reading Research, Florida State University, 1114 West Call Street, Tallahassee, FL 32306. E-mail: ykim@fcrr.org

Ideation or text generation includes generation and organization of ideas (Juel et al., 1986). Text generation necessarily involves oral language representation (Berninger et al., 2002; Kim et al., 2011; McCutchen, 2006) because generated preverbal ideas and thoughts have to be encoded into oral language before being transcribed into written texts. Therefore, text generation is operationalized as oral language skills. Accumulating evidence has indeed indicated the relation of oral language skills to writing (e.g., Shanahan & Lomax, 1986). Individual differences in vocabulary (Coker, 2006) and grammatical knowledge (Olinghouse, 2008) were related to writing for children in primary grades. Similarly, oral language composed of vocabulary and grammatical knowledge was independently related to writing for primary-grade children after accounting for transcription skills (Kim et al., 2011; Kim, Al Otaiba, Folsom, Greulich, & Puranik, 2014). Furthermore, discourse-level oral language was related to writing after accounting for spelling (Juel et al., 1986; Kim, Al Otaiba et al., 2015) and sentence and reading comprehension (Berninger & Abbott, 2010).

Both the simple view and not-so-simple view of writing have been highly useful as a framework for understanding development of writing skills. However, some critical aspects of these models are underspecified, particularly with regard to interrelations among component skills and pathways of influences of component skills on writing. This underspecification is most prominent with text generation. Although text generation has been described as a complex (Juel et al., 1986) and dynamic process where ideas are produced and represented as language in memory at the word, sentence, and discourse level (Berninger et al., 2002), no further details are elaborated with regard to skills that contribute to text generation (or oral language generation). This contrasts sharply to a greater specification about skills involved in transcription processes, including phonological processing, orthographic knowledge (e.g., print experience, phoneme-grapheme correspondences), and morphological skills (Berninger et al., 2002; Juel et al., 1986). In fact, when Juel, Griffith, and Gough (1986) examined the simple view of writing, they included component skills of spelling (phonological awareness and exposure to print) and pathways of their influences. They found that phonological awareness and exposure to print were directly related to a phonological decoding skill, which directly influenced children's spelling, which, in turn, was directly related to writing. These results suggest that there are multiple component skills necessary for a transcription skill, spelling, and some have direct relations, whereas others have indirect relations to spelling. Critically missing in Juel et al.'s (1986) study, however, was component skills of text generation, which was operationalized as a discourse-level oral language production. An understanding about component skills of discourse-level oral language is critical to the expansion of our knowledge about skills involved in writing development, and has important implications for instruction and assessments. Specifically, a precise understanding about component skills of discourse-level oral language would inform what skills need to be assessed and targeted in instruction in order to improve discourse-level oral language as well as writing.

Component Skills of Discourse-Level Oral Language

Discourse-level oral language refers to comprehension and production of multiple utterances or extended text such as conversations, and narrative and informational oral texts (Kim & Pilcher, in press). Growing evidence indicates that discourse-level oral language is a higher-order skill that draws on a multitude of language and cognitive skills, including foundational oral language skills (vocabulary and grammatical knowledge; Florit, Roch, & Levorato, 2011, 2014; Kim, 2015, 2016; Sénéchal, Ouellette, & Rodney, 2006; Tunmer, 1989), foundational cognitive skills (working memory, inhibitory control, attention; Daneman & Merikle, 1996; Florit, Roch, Altoé, & Levorato, 2009; Kim, 2015, 2016; Kim & Phillips, 2014), and higher-order cognitive skills (e.g., inference and theory of mind; Kendeou, Bohn-Gettler, White, & van den Broek, 2008; Kim, 2015, 2016; Kim & Phillips, 2014; Lepola, Lynch, Laakkonen, Silvén, & Niemi, 2012; Strasser & del Rio, 2014; Tompkins, Guo, & Justice, 2013).

According to theoretical models of discourse comprehension and production, there are three levels of mental representations: the situation model, textbase, and surface code (e.g., Fletcher & Chrysler, 1990; Graesser, Singer, & Trabasso, 1994; Kintsch, 1988; van Dijk & Kintsch, 1983). The situation model is the interlocutor's representation of the events, actions, and characters (what the text is about; van Dijk & Kintsch, 1983), and is the highest level of mental representation. The situation model is built on textbase representation (propositional representation—what is expressed in the text), which then requires surface code representation (linguistic input of the text such as words and phrases—how something is expressed in the text). The situation model is more than an assembly of propositions, and requires linking propositions across the text and to general background knowledge in order to integrate and infer meanings and establish a coherent whole (Graesser et al., 1994; Kintsch, 1988; van Dijk & Kintsch, 1983; van den Broek, Risden, Fletcher, & Thurlow, 1996).

Recently Kim (2016) proposed and tested the direct and mediated model of discourse-level language, in which different language and cognitive skills are mapped onto the three levels of mental representations, and are hypothesized to be directly and indirectly related to discourse-level oral language (see Figure 1 for a conceptual model). For the process of establishing global coherence (i.e., situation model), higher-order cognitive skills such as inference and perspective taking (as measured by theory of mind tasks) are important (Kim, 2015, 2016; Kim & Phillips, 2014). Furthermore, vocabulary, grammatical knowledge, working memory, and attentional control are necessary for constructing initial propositions (i.e., textbase representation; Kim, 2015, 2016). Note that in this conceptual model, although all the foundational language and cognitive skills are necessary for surface code representation, working memory and attentional control are hypothesized to be foundational cognitive skills necessary for any learning tasks, including vocabulary and grammatical knowledge. The direct and mediated models of discourse-level language fit data very well for discourse comprehension for elementary grade children (Kim, 2015, 2016) such that discourse-level language comprehension (i.e., listening comprehension) was directly predicted by higher-order cognitive skills (e.g., inference, perspective taking, and comprehension monitoring), which, in turn, were directly predicted by foundational oral language (vocabulary and grammatical knowledge) and cognitive skills (working memory; Kim, 2015, 2016). Furthermore, working memory was also directly related to vocabulary and grammatical knowledge, as well as discourse-level oral language over and above foundational oral language and higher-order cognitive skills (Kim, 2016).

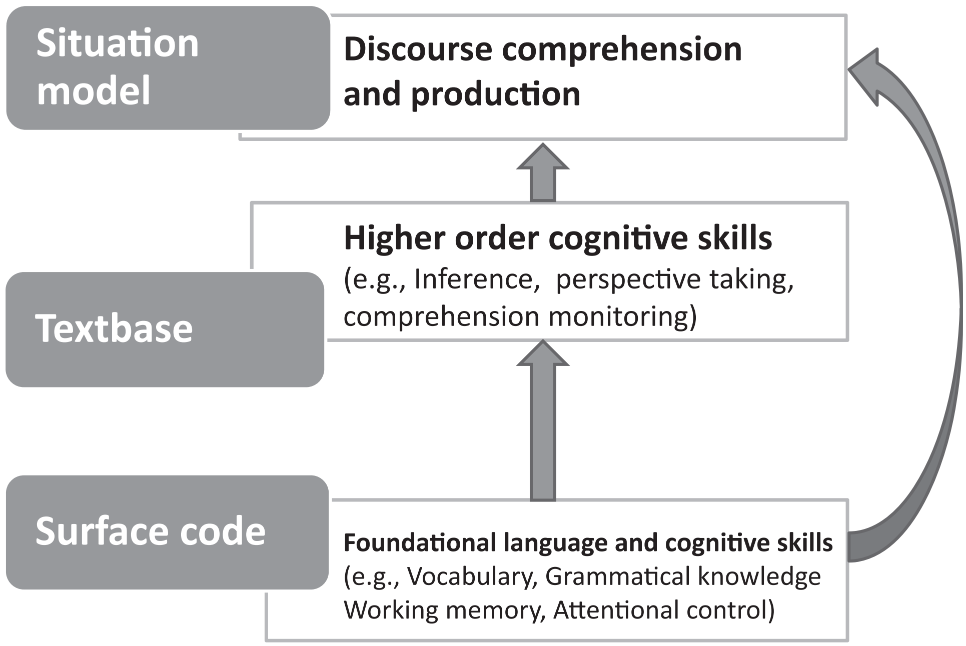

Figure 1. Language and cognitive skills associated with three levels of text representations (modified from Kim, 2016, reprint with permission).

Present Study

Building on this growing evidence about discourse-level oral language, and previous studies about component skills of writing (e.g., transcription skills, working memory, and language skills), the primary goal in the present study was to unpack the nature of relations between various language and cognitive skills and writing for beginning writers. To achieve this goal, we first examined the direct and mediated relations of component skills of discourse-level language production. If discourse-level oral language is an upper-level skill that draws on several language and cognitive component skills, then an important corollary is how all these component skills, including discourse-level oral language, language and cognitive component skills (e.g., working memory, vocabulary, grammatical knowledge, inference, and perspective taking), and transcription skills, fit into the developmental models of writing. For instance, vocabulary and grammatical knowledge were shown to be related to writing (Kim et al., 2014, 2011; Olinghouse, 2008). If this is the case, would they then be directly related to writing over and above discourse-level oral language, or would their relations be primarily mediated by discourse-level oral language?

Additionally, how are higher-order cognitive skills such as inference and theory of mind related to writing? Are they related to writing, and if so, are their relations direct or primarily mediated via discourse-level oral language? Although developmental models of writing did not explicitly specify the roles of higher-order cognitive skills in writing and novice learners tend to rely on less-sophisticated knowledge-telling strategies (Bereiter & Scardamalia, 1987), successful writing, even for beginning writers, might draw on higher-order cognitive skills such as reasoning and perspective taking (e.g., writing for audience; also called metacognitive control, see McCutchen, 1988). In coherent written compositions, ideas within the text are tightly connected with each other and presented in a logical fashion. This would require a writer's reasoning and inferencing skill. Likewise, good writers develop an understanding about the needs of their audience (Engler, Raphael, Anderson, Anthony, & Stevens, 1991) and modulate language accordingly (McCutchen, 1988). Even young children showed planning for a specific audience by adapting oral text production considering audience's needs (e.g., Cameron & Wang, 1999; De Temple, Wu, & Snow, 1991; Littleton, 1998; McCutchen, 1988). Therefore, it is reasonable to speculate that a higher-order cognitive skill, perspective taking as measured by theory of mind tasks, would relate to writing. Theory of mind refers to one's knowledge of the mental status of others (thoughts and emotions) and perspective taking, and is typically assessed by false belief tasks (see Astington & Jenkins, 1999; de Villiers, 2000; Howlin, Baron-Cohen, & Hadwin, 1999; Norbury, 2005). In a typical false belief task, the child listens to a series of events and connects the events to infer characters' cognitive statuses, and thus requires an understanding of different perspectives (Comay, 2009; Kim, 2015; Kim & Phillips, 2014).

In order to investigate the nature of language and cognitive component skills and their relations to writing, we evaluated four different variations of the direct and indirect effects models of writing (DIEW). The DIEW model is built on the extant developmental models, such as the simple view and not-so-simple view of writing, but extends them by explicitly hypothesizing direct and indirect relations among components skills and their relations to writing based on theory and empirical evidence. Prior to fitting the DIEW model, we first examined the relations of language and cognitive skills to discourse-level oral language (see Figure 1). As noted above, working memory was hypothesized to be a foundational cognitive ability necessary for any learning tasks including

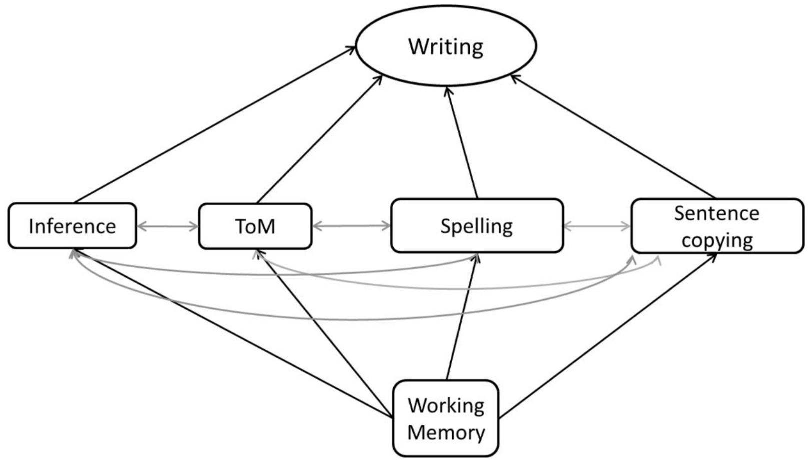

Figure 2. The relations of inference, theory of mind (ToM), spelling, and sentence copying fluency to writing.

vocabulary and grammatical knowledge (see Figure 4). We then investigated the relations of higher-order cognitive skills to writing after accounting for transcription skills (spelling and handwriting) and working memory (see Figure 2). Finally, four alternative models of DIEW (Figures 3a, 3b, 3c, and 3d) were fitted and compared. In the first model (Figure 3a, a complete mediation model), discourse-level oral language and transcription skills (spelling and handwriting fluency) were hypothesized to completely mediate the relations of oral language and cognitive component skills to writing. Discourse-level oral language was hypothesized to be directly predicted by higher-order cognitive skills (inference and theory of mind), and directly and indirectly predicted by foundational oral language skills (vocabulary and grammatical knowledge), and the foundational cognitive skill (working memory). In an alternative partial mediation model, vocabulary and grammatical knowledge (Figure 3b) and higher order skills (Figure 3c) were, respectively, hypothesized to have direct relations to writing over and above discourse-level oral language and transcription skills.

The final DIEW model (Figure 3d) tested whether working memory is directly related to writing after accounting for its contribution to all other component skills. As writing requires coordinating multiple processes such as generating ideas and transcribing those ideas into written products, writing places a great demand on working memory (Kellogg, 1996, 2008; Kellogg, Olive, & Piolat, 2007; McCutchen, 2006). Working memory is necessary to support transcription processes (Berninger et al., 2010), particularly when transcription is not automatic (McCutchen, 1996). Fluent transcription skills would allow working memory to be available for higher-level cognitive processes, such as planning and revising (McCutchen, 2006) and text generation and linguistic encoding (Bereiter & Scardamalia, 1987; Hayes & Chenoweth, 2007; Kellogg, 1996). Furthermore, working memory has been shown to be critical to vocabulary development (Gathercole & Baddeley, 1990a, 1990b, 1993; Gathercole, Service, Hitch, Adams, & Martin, 1999), grammatical knowledge (Kim, 2015, 2016), higher-order cognitive skills (Carlson, Moses, & Breton, 2002; Kim, 2015, 2016; Slade & Ruffman, 2005), and discourse-level oral language (Kim, 2015, 2016; Strasser & del Rio, 2014). Taken together, these studies suggest that working memory is a foundational cognitive capacity for transcription as well as text generation processes. In order to explicitly test the pathway of influence of memory to writing, a direct path from working memory to writing was tested after accounting for all the other language and cognitive component skills.

Method

Participants

A total of 193 children in Grade 1 from 41 classrooms in nine schools (50% boys; mean age = 6.68; $SD = .48$) in the southeastern region of the United States participated in the study. Children with identified intellectual disabilities were excluded from the study and there were no other selection criteria. The sample reflects consented children from each class and was composed of approximately 43% Caucasians, 34% African Americans, 6% Hispanics, 6% Asian Americans, and 7% mixed race. Approximately 6% were designated as English language learners and 29% were eligible for free and reduced lunch. The school districts' records indicated that 1% of these children had language impairment, 2% had speech impairment, and 2% had multiple learning disabilities. The participating schools used explicit instruction on reading using *Imagine it!* (Bereiter, 2010), but no formal district-wide curriculum was used in writing.

Measures

Reliability estimates for the included tasks are reported in Table 1, and most were in the acceptable to excellent range. Unless otherwise noted, children's responses were scored dichotomously (1 = correct; 0 = incorrect) for each item, and all the items were administered to the child.

Writing. Children were administered two prompts from previous studies (Kim et al., 2014, 2015; Kim, Al Otaiba, Sidler, & Greulich, 2013; McMaster, Du, & Pestursdottir, 2009; McMaster et al., 2011). In the first writing task, the children were asked to write about a time something unusual or interesting happened

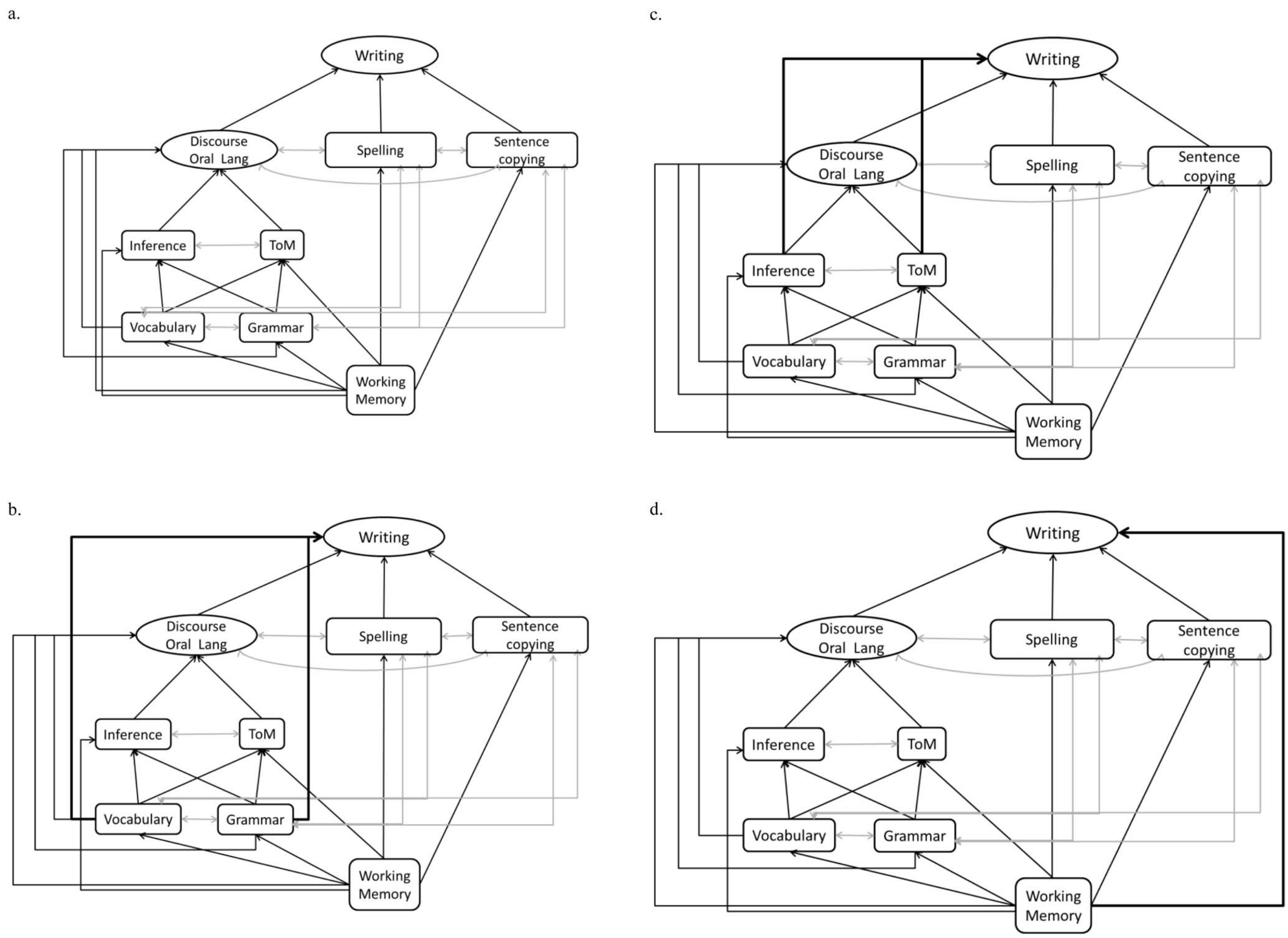

Figure 3. Four alternative models of the direct and indirect effects of developmental writing (DIEW). Black lines represent predictive paths and gray lines represent covariances. Oral lang = Oral language; ToM = Theory of mind; Grammar = Grammatical knowledge.

when they got home from school. Children were provided with the prompt "One day when I got home from school . . ." on the ruled writing paper (One day hereafter). This task was significantly and moderately related to other standardized and normed writing tasks such as the Wechsler Individual Achievement Test Essay Composition task, and the Woodcock-Johnson Writing Fluency task (Kim, Al Otaiba et al., 2015). In the second prompt, the children were provided with the beginning of a story about a child who discovers a castle that appeared overnight. They were then told to write a story about who the child met and what happened inside the castle (Castle hereafter). Children were given 15 min for each prompt.

Children's written compositions were scored for writing quality, using a modified version of the 6 + 1 trait rubric. Writing quality is typically operationalized as the extent and clarity of idea development and organization (e.g., Graham, Berninger, & Fan, 2007; Graham, Harris, & Chorzempa, 2002; Graham, Harris, & Mason, 2005; Hooper, Swartz, Wakely, de Kruif, & Montgomery, 2002; Kim, Al Otaiba, et al., 2015; Olinghouse, 2008) and a recent study has shown that four of the 6 + 1 traits (i.e., idea development, organization, sentence fluency, and word choice) capture a single dimension (Kim et al., 2014). In the present study, the extent of idea development was scored on a scale of 1 to 5 (see Appendix A), similar to a previous study (Kim et al., 2014). Compositions with detailed and rich ideas were rated higher than those with lower quality idea development. Interrater reliabilities (Cohen's kappa) were established with 45 written compositions for each prompt (a total of 90) and were .73 for the One day prompt and .82 for the Castle prompt.

Working memory. The listening span task (Florit et al., 2009; Kim, 2015, 2016) was used. The children were presented with a sentence and asked to identify whether the heard sentence was correct or not. After hearing sentences, they were asked to recall the last words in the sentences. All the sentences involved common knowledge familiar to children (e.g., pigs can fly). Testing was discontinued after three consecutive incorrect responses. There were four practice items and 14 test items. 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

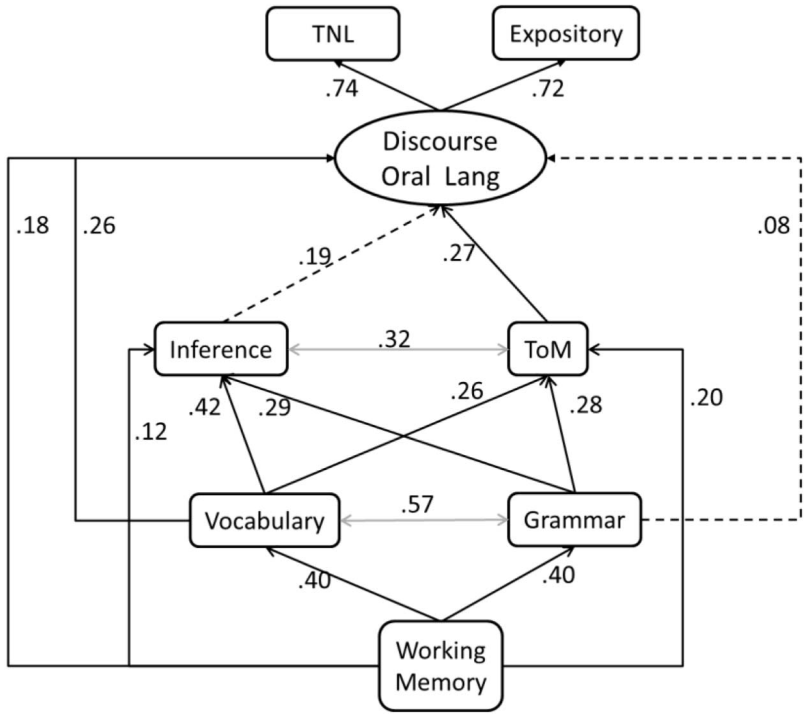

Figure 4. Standardized path coefficients of higher order cognitive skills (inference and theory of mind), foundational language skills (vocabulary, grammatical knowledge), and working memory to discourse level oral language production. Solid lines represent statistically significant relations whereas dashed lines represent nonsignificant relations. Gray lines represent covariances. TNL = test of narrative language; Oral Lang = oral language; ToM = theory of mind; Grammar = Grammatical knowledge.

score of 2, and correct responses in incorrect order were given a score of 1. Therefore, the total possible maximum score was 28.

Spelling. An experimental dictation task was developed, piloted, and used in order to capture the ability to spell words that are relevant to children in Grade 1 (e.g., consonant-vowel-consonant [CVC], CVCe words, vowel digraphs). In this task, the children were asked to spell target words accurately. Target words were presented in isolation, in a sentence, and in isolation again. There were a total of 20 items.

Handwriting fluency. Children were asked to accurately copy a sentence, *The quick brown fox jumps over the lazy dog,* as many times as possible in 1 min. This sentence is a pangram which includes every letter of the English alphabet at least once, and has been used as a measure of handwriting fluency (e.g., Connelly,

Table 1
Reliability and Descriptive Statistics

	Reliability	Mean (*SD*)	Min–Max	Skewness	Kurtosis
Age	NA	6.68 (.48)	6–8.11	−.25	−1.16
Working memory	.74	13.92 (5.64)	0–24	−.59	−.20
EVT	.94	94.16 (14.68)	58–149	−.15	.56
EVT_SS	NA	104.26 (12.77)	72–150	−.07	.35
Grammatical knowledge	.90	26.51 (6.57)	2–36	−1.40	2.39
Inference	.89	14.09 (6.07)	0–25	−.55	−.46
Theory of mind	.79	9.21 (3.39)	2–16	.04	−.72
TNL retell	.87+	30.22 (10.16)	0–51	−.30	−.13
Expository retell	.88+	9.63 (6.11)	0–27	.53	−.4
Spelling	.90	8.86 (4.91)	0–20	.28	−.52
Sentence copying	.90*	34.21 (15.59)	3–105	1.11	2.79
Writing quality: One day	.73+	2.66 (.96)	0–5	−.39	.03
Writing quality: Castle	.82+	2.45 (.99)	0–5	.36	.18

Note. SS = standard score. Reliabilities are Cronbach's alpha except + (Cohen's kappa) and * (exact percent agreement).

Gee, & Walsh, 2007; Wagner et al., 2011; Zhang, McBride-Chang, Wagner, & Chan, 2014) and was related to writing quality (Wagner et al., 2011; Zhang et al., 2014). Children's responses were scored by counting the number of letters copied correctly.

Vocabulary. The Expressive Vocabulary Test–2nd edition (Williams, 2007) was used. The children were asked to identify pictured objects or provide synonyms. Test administration discontinued after six consecutive incorrect items.

Grammatical knowledge. The grammaticality judgment task of the Comprehensive Assessment of Spoken Language (CASL; Carrow-Woolfolk, 1999) was used. This task is normed for children in Grades 2 and above, and therefore a few easy items were developed modeling the items in the CASL. These items were then piloted and used in the first few items. In other words, the items in this task included a few experimental items as well as items in the grammaticality judgment task of CASL. Children's performance on the grammaticality judgment task was related to syntax construction ($r = .66$) and grammatical morphemes ($r = .66$; Carrow-Woolfolk, 1999). In this task, the children heard a sentence (e.g., *The children are run*) and were asked whether the sentence was grammatically correct. If grammatically incorrect, the child was asked to correct the sentence. There were three practice items and 20 test items. Test administration discontinued after five consecutive incorrect items. Of the 20 test items, 17 items included grammatically incorrect sentences (see the example above), and for these items, a total 2 points were possible (1 for identifying grammatical inaccuracy, and 1 for accurately correcting the sentence). Therefore, the total possible maximum in the grammatical knowledge task was 36.

Inference. The inference task of CASL (Carrow-Woolfolk, 1999) was used. Similar to the grammaticality judgment task described above, this task is normed for children in Grade 2 and above, and therefore, several easy items were developed, piloted, and used in the first few test items. In this task, the children were asked to infer information from heard sentences based on their background knowledge. They heard two to three sentence stories, and were asked a question that required inference based on background knowledge. For instance, the children heard "*Mother called to four-year-old Sandra and says 'Be sure to bring your bathing suit. And don't forget your shovel and bucket.' Where are they going?*" The correct responses include "to the beach" or "to go swimming" or something similar. There were two practice items and 25 test items. Test administration discontinued after five consecutive incorrect items. Performance on the inference task was reported to be strongly related to the nonliteral language task ($r = .73$; Carrow-Woolfolk, 1999).

Theory of mind. One first-order false belief scenario and two second-order false belief scenarios were used (Kim, 2015; Kim & Phillips, 2014). The first-order task examines the child's ability to infer a story character's mistaken belief whereas the second-order task examines the child's ability to infer a story character's mistaken belief about another character's knowledge (see Caillies & Le Sourn-Bissaoui, 2008 for further details). The first-order false belief task involved the location of a basketball in school, and the other two second-order tasks involved the context of a bake sale and going out for a birthday celebration. The assessor presented stories to the children using a series of illustrations, followed by the assessor's questions. There were a total of 16 questions.

Discourse-level oral language. The Test of Narrative Language (TNL; Gillam & Pearson, 2004) and an experimental expository task were used. In the TNL test, only Story 1 (Task 1) has a retell task. However, in the present study, we adapted the TNL test so that the children were asked to retell three narrative stories (Tasks 1, 3 and 5) after they heard each story. The experimental expository task was composed of three expository passages (85 words, 76 words, and 140 words, respectively) from the Qualitative Reading Inventory-5 passages (Leslie & Caldwell, 2011). Titles of the passages were *Air*, *The brain and the five senses*, and *Changing matter.* After listening to each passage, the children were asked to retell each story.

Children's retell was recorded using a digital recorder, Olympus VN 8100 pc, and was transcribed verbatim following Systematic Analysis of Language Transcription (SALT; Miller & Iglesias, 2006) guidelines. Children's retell quality was evaluated using transcribed data. Narrative retell quality was determined by the extent to which key narrative elements (e.g., main characters, setting, events, problem, and resolution) and key details were included (e.g., Barnes, Kim, & Phillips, 2014; Scott & Windsor, 2000). Narrative quality using this approach was moderately related to discourse comprehension (Barnes et al., 2014; Scott & Windsor, 2000). Children's performance on each element was rated on a scale of 0–3, with the exception of the resolution element for Task 1, which was on a scale of 0–2. The children received 0 for no inclusion of the story elements, 1 for a partially correct or implicitly stated element, 2 for a correct but imprecise statement, and 3 for a precise statement. For expository retell, the number of a priori identified key details (each worth a point) was counted. Interrater reliability was estimated using 40 transcripts and Cohen's kappa (see Table 1).

Procedures

Children were assessed by rigorously trained research assistants in a quiet space in the school. Assessment battery was administered in several sessions and each session was approximately 30 to 40 min. Writing, spelling, and handwriting fluency tasks were administered in a group setting (3–4 children), and the other tasks were individually administered.

Data Analysis Strategy

Confirmatory factory analysis and structural equation Modeling (SEM) were primary data analytic strategies, using Mplus 7.1 (Muthén & Muthén, 2013). Latent variables were created for writing and discourse-level oral language. The language (e.g., vocabulary), cognitive skills (e.g., inference), and transcription skills were assessed by single measures for each construct, and therefore observed variables were used. Model fits were evaluated by the following indices: chi-square statistics, comparative fit index (CFI), the Tucker-Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residuals (SRMR). Excellent model fits include RMSEA values below .08, CFI and TLI values equal to or greater than .95, and SRMR equal to or less than .05 (Hu & Bentler, 1999). TLI and CFI values greater than .90 are considered acceptable (Kline, 2005). Model fits were compared using chi-square differences for nested models.

Table 2
Bivariate Correlations Between Measures

	1	2	3	4	5	6	7	8	9	10
1. Working memory	1.00									
2. Vocabulary: EVT	.40	1.00								
3. Grammar	.40	.64	1.00							
4. Inference	.41	.66	.61	1.00						
5. Theory of mind	.42	.52	.53	.61	1.00					
6. TNL retell	.34	.50	.46	.53	.48	1.00				
7. Expository retell	.42	.47	.41	.43	.47	.55	1.00			
8. Spelling	.39	.46	.39	.30	.21	.30	.37	1.00		
9. Sentence copying	.24	.31	.30	.31	.26	.32	.27	.56	1.00	
10. Writing quality: One day	.33	.35	.35	.40	.31	.25	.35	.51	.42	1.00
11. Writing quality: Castle	.30	.42	.36	.32	.24	.37	.43	.44	.37	.49

Note. All coefficients are statistically significant at .05.

Results

Descriptive Statistics

Table 1 displays descriptive statistics. Children's mean performance on the normed and standardized task, vocabulary, was in the average range. In the other experimental measures, there was sufficient variation around the means, and skewness and kurtosis values were in the accepted range. Subsequent analysis was conducted using raw scores.

Table 2 shows bivariate correlations between measures. All the tasks were somewhat weakly to moderately related to writing measures ($.25 \leq rs \leq .51$). Working memory was also weakly to moderately related to all other skills ($.24 \leq rs \leq .42$). Correlations between other measures were in the expected range and direction. Multivariate normality was tested using Henze-Zirkler's multivariate normality test (Henze & Zirkler, 1990), and results indicated that multivariate normality assumption was met ($HZ = .995$, $p = .14$).

Direct and Mediated Model of Discourse-Level Language

The model shown in Figure 1 fit the data very well, $\chi^2(4) = 5.67$, $p = .23$, CFI = 1.00, TLI = .98, RMSEA = .048, SRMR = .016. As shown in Figure 4, theory of mind ($\beta = .27$, $p = .003$), vocabulary ($\gamma = .26$, $p = .007$), and working memory ($\gamma = .18$, $p = .02$) were directly related to discourse-level oral language, whereas inference ($\beta = .19$, $p = .058$) and grammatical knowledge ($\gamma = .08$, $p = .39$) were not. Inference and theory of mind were predicted by vocabulary, grammatical knowledge, and working memory ($ps \leq .04$). Approximately 61% of total variance in discourse-level oral language was explained by the included language and cognitive skills.

The Relations of Higher-Order Cognitive Skills to Writing Quality

In order to examine the relation of higher-order cognitive skills (inference and theory of mind) to writing, the model shown in Figure 2 was fitted to the data. Model fit was excellent, $\chi^2(17) = 28.76$, $p = .04$, CFI = .99, TLI = .98, RMSEA = .06, SRMR = .017. As shown in Figure 5, inference ($\beta = .27$, $p = .003$) was independently related to writing, whereas theory of mind ($\beta = .08$, $p = .36$) was not, after accounting for spelling, handwriting fluency, and working memory. A total of 59% of variance in writing was explained.

Testing the DIEW Models

Four alternative DIEW models shown in Figures 3a to 3d were tested. In all these models, covariances were allowed between component skills (e.g., vocabulary and grammar; vocabulary and spelling). Exceptions were between higher-order cognitive skills (inference and theory of mind) and transcription skills because of nonsignificance in preliminary analysis.

The complete mediation model (Figure 3a) fit the data well, $\chi^2(24) = 41.33$, $p = .02$, CFI = .98, TLI = .95, RMSEA = .062 (.027–.093), SRMR = .031. The partial mediation models also had good fit to the data: $\chi^2(22) = 40.74$, $p = .0088$, CFI = .98, TLI = .94, RMSEA = .067 (.033–.10), SRMR = .031 for the model in Figure 3b; and $\chi^2(22) = 39.37$, $p = .01$, CFI = .98, TLI = .95, RMSEA = .065 (.030–.097), SRMR = .030 for the model in Figure 3c; and $\chi^2(23) = 41.21$, $p = .011$, CFI = .98, TLI = .95, RMSEA = .065 (.031–.096), SRMR = .031 for the model in Figure 3d. Chi-square difference tests showed no differences between these models ($0.12 \leq \Delta\chi^2 \leq 1.96$; $1 \leq \Delta df \leq 2$, $.16 \leq p \leq .73$). Furthermore, in the partial mediation models, the direct paths from the component language and cognitive skills to writing were, respectively, nonsignificant ($ps \geq .19$; see Appendix B). Therefore, based on parsimony and the chi-square test results, the complete mediation model (Figure 3a) was chosen as the final model.

Figure 6 displays standardized path coefficients of the complete mediation model. Discourse-level oral language ($\beta = .46$, $p < .001$), spelling ($\beta = .37$, $p < .001$), and handwriting fluency ($\beta = .17$, $p = .047$) were all directly related to writing quality. Discourse-level oral language was directly predicted by the two higher-order cognitive skills, inference ($\beta = .21$, $p = .035$) and theory of mind ($\beta = .26$, $p = .003$). Vocabulary ($\beta = .42$, $p < .001$) and working memory ($\beta = .19$, $p = .012$) were also directly related to discourse-level oral language after accounting for all the other variables in the model. Inference and theory of mind were predicted by vocabulary ($\beta s = .42$ and .26, $ps \leq .001$), grammatical knowledge ($\beta s = .29$ and .28, $ps < .001$), and working memory ($\gamma s = .12$ & .20, $ps \leq .04$). Vocabulary and grammatical knowledge were predicted by working memory ($\gamma s = .40$ & .40,

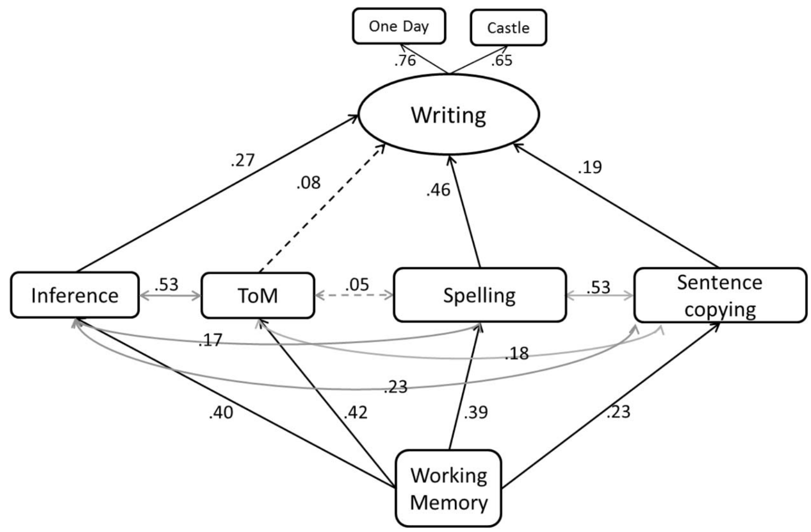

Figure 5. Standardized path coefficients of higher order cognitive skills (inference and theory of mind) and transcription skills (spelling and sentence copying fluency) to writing. Solid lines represent statistically significant relations whereas dashed lines represent nonsignificant relations. Gray lines represent covariances. ToM = theory of mind.

*p*s < .001). Working memory also predicted spelling (γ = .39, *p* < .001) and handwriting fluency (γ = .23, *p* = .001). A total of 67% of variance in writing and 62% of variance in discourse-level oral language were explained.

Table 3 displays direct, indirect, and total effects of the component skills. The largest effects were found for discourse-level oral language (.46), working memory (.43), and spelling (.37); followed by vocabulary (.19), handwriting (.17), theory of mind (.12), inference (.10), and grammatical knowledge (.10).

Discussion

The primary aim of the study was to examine direct and indirect relations of language and cognitive component skills to writing. Based on the simple view of writing and not-so-simple view, we hypothesized that text generation and transcription are necessary for writing development. Furthermore, we specified component skills of discourse-level oral language based on growing evidence, and examined the nature of their relations to writing.

The direct and mediated model of discourse-level language fit the data very well, such that foundational language and cognitive skills and higher-order cognitive skills were directly and indirectly related to discourse-level oral language. Although inference did not quite reach the conventional statistical significance (*p* = .058), the overall structure of relations found in the present study is in line with previous studies (Kim, 2015, 2016). These results indicate that the discourse-level oral language is an upper-level skill, predicted by not only the ability to use vocabulary and to combine words to represent meanings (grammatical knowledge), but also by higher-order cognitive skills to connect propositions, and to understand other's thoughts and take perspectives (Florit, Roch, Altoè, & Levorato, 2009; Florit et al., 2014; Kendeou et al., 2008; Lepola et al., 2012; Strasser & del Rio, 2014; Tompkins, Guo, & Justice, 2013). Furthermore, higher-order cognitive skills are predicted by foundational language and cognitive skills, convergent with previous studies (Carlson, Moses, & Breton, 2002; Kim, 2015, 2016; Kim & Phillips, 2014; Slade & Ruffman, 2005). It is worth noting that previous investigations of component skills of discourse language involved "comprehension," whereas in the present study we expanded it to discourse language "generation" or "production." Convergent results for comprehension and production are in line with the direct and mediated model in Figure 1 and the construction-integration model (Kintsch, 1988), as both of these models incorporate comprehension and production at the discourse level.

When it comes to the direct and indirect relations model of writing (DIEW), a complete mediation model described the data best. Discourse-level oral language and transcription skills (spelling and handwriting fluency) had direct relations to writing. In contrast, all the other language and cognitive component skills were indirectly related to writing via discourse-level oral language and transcription skills. Moreover, discourse-level oral language had a substantial—and in fact, the largest—direct effect on writing (.46). Transcription skills also had sizable effects on writing (.37 for spelling and .17 for handwriting fluency).

Working memory was found to be a foundational cognitive capacity for component language and cognitive skills. It was directly related to foundational oral language skills (vocabulary and grammatical knowledge), higher-order cognitive skills (inference and theory of mind), and transcription skills (spelling and handwriting fluency). Furthermore, it appears that working memory constrains discourse-level oral language even after accounting for the effects of foundational oral language and higher-order cognitive skills. Producing coherent oral text at the discourse level places a great demand on working memory, as the interlocutor has to temporarily hold propositions and ideas while simultaneously generating and interconnecting ideas for flow and logic. Importantly, however, working memory was no longer directly related to writing once all the language and cognitive skills were accounted

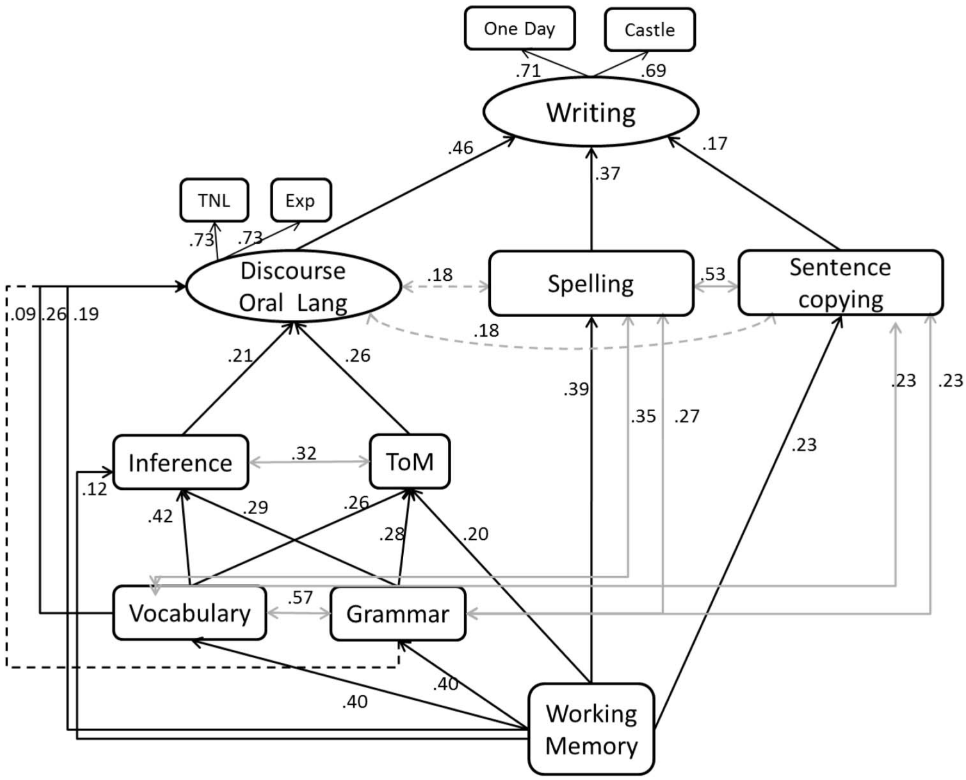

Figure 6. Standardized path coefficients showing the relations of oral language and cognitive component skills of discourse-level oral language, discourse-level oral language, spelling, and sentence copying fluency to writing. Solid lines represent statistically significant relations whereas dashed lines represent nonsignificant relations. Gray lines represent covariances. TNL = test of narrative language; Exp = Expository texts; Oral Lang = oral language; ToM = theory of mind; Grammar = Grammatical knowledge.

for. Despite its indirect nature, though, the total effect of working memory on writing was substantial (.43), suggesting that working memory is one of the key cognitive abilities that underpin writing skill.

The present findings also revealed that a higher-order cognitive skill, inference, was independently related to writing, after accounting for theory of mind and transcription skills, suggesting that children's ability to connect ideas and propositions to background knowledge is important to writing quality. As stated above, interconnecting propositions and ideas are important for establishing global coherence across the text. Although novice writers may not exhibit the sophisticated writing strategies found in expert writers (e.g., elaborated planning or revising), children's inferencing ability appears to be important to writing quality. However, these results do not negate the importance of theory of mind to writing, as it appears that the effect of theory of mind on writing is largely indirect, shared with inference (see fairly strong bivariate correlation, r = .61).

Our findings further highlight that the effects of higher-order cognitive skills are primarily mediated by discourse-level oral language skill. In a similar vein, the relations of foundational oral language skills (such as vocabulary and grammatical knowledge) to writing were completely mediated by discourse-level oral language. Although previous studies have shown the relations of vocabulary and grammatical knowledge to writing after accounting for transcription skills (Kim et al., 2014, 2011; Olinghouse, 2008), these studies did not include discourse-level oral language skills.

The DIEW model is in line with the simple view and not-so-simple view of writing, but expands them in several important ways. First, the model explicitly specified direct and indirect relations among component skills and their relations to writing. In particular, discourse-level oral language and transcription skills are upper-level skills that subsume a complex array of component skills. A large body of previous studies has shown component skills of transcription skills (Apel, Wilson-Fowler, Brimo, & Perrin, 2012; Bourassa, Treiman, & Kessler, 2006; Deacon & Bryant, 2005; Kim, 2010; Kim, Apel, & Al

Table 3
Direct, Indirect, and Total Effects of Language and Cognitive Skills (Standard Error) on Writing Based on the Results in Figure 6

Variable	Direct effect	Indirect effect	Total effect
Discourse-level oral language	.46 (.09)	—	.46
Spelling	.37 (.087)	—	.37
Handwriting	.17 (.094)	—	.17
Inference	—	.10 (.057)	.10
Theory of mind	—	.12 (.049)	.12
Vocabulary	—	.19 (.053)	.19
Grammatical knowledge	—	.10 (.046)	.10
Working memory	—	.43 (.062)	.43

Otaiba, 2013; Nagy, Berninger, Abbott, Vaughan, & Vermeulen, 2003; Roman, Kirby, Parrila, Wade-Woolley, & Deacon, 2009; Treiman, 1993), and the present study showed component skills of discourse-level oral language, in line with recent evidence (Kim, 2015, 2016; Lepola et al., 2012; Tompkins et al., 2013). Although the hypothesis that writing draws on two skills, discourse-level oral language and transcription skills, might appear to be too simple, a close look reveals a complex picture of multiple skills involved in these two upper-level skills. Second, in the DIEW model, working memory was explicitly hypothesized to be a foundational cognitive capacity that supports other component skills. The present study indicates its essential role in other component skills, and showed that its relation to writing is primarily mediated by other component skills. Third, in the DIEW model, writing component skills are hypothesized to be correlated and not orthogonal (also see Hayes, 1996 for a similar view). For instance, foundational oral language skills such as vocabulary and grammatical knowledge have been shown to be correlated (Brimo, Apel, & Fountain, 2015; Conboy & Thal, 2006; Hagtvet, 2003; Kim, 2015, 2016). Similarly, these oral language skills have also been correlated with transcription skills (Cunningham & Stanovich, 1991; Kim, Apel et al., 2013; Yeong, & Liow, 2011). Therefore, these skills are dissociable but correlated.

Limitations, Implications, and Conclusion

The results of the present study should be interpreted with the current design in mind such as included predictors and sample. Several limitations and related future directions are worth noting. First, it would have been ideal to include other known predictors of writing. In particular, the not-so-simple view of writing specifies self-regulatory factors such as attention and goal setting, and therefore, future studies including these factors would be informative. Whether these skills form a separate factor or their contributions to writing are indirect via discourse-level oral language and transcription skills is an open question. For instance, a recent study suggested that the relation of attentional control to discourse-level oral language is primarily indirect via other component skills (e.g., vocabulary and grammatical knowledge; Kim, 2016). Second, due to practical constraints, we were not able to administer multiple measures per construct and use latent variables, which is ideal. Third, reliabilities estimate of working memory (.76) and theory of mind (.79) did not quite reach the typically desired value of .80.[1]

Future directions include replicating the present findings with children in different developmental phases of writing. As children develop their writing skills, the nature of relations and relative importance of various component skills might vary. For instance, the relations of higher-order cognitive skills to oral language and to writing might be stronger for older children as their cognitive skills are further developed and writing tasks become more demanding. Moreover, it would be informative to replicate the present study with a larger sample size. Although the sample size was overall sufficient to detect patterns of relations, some nonsignificant relations (e.g., inference to discourse-level language; see Figure 4) might be partly due to the sample size. Finally, in the present study, we examined the DIEW model for writing quality (operationalized as idea development). An important way to expand the DIEW model is to examine the relations of component skills to different writing outcomes. For instance, recent studies have shown that writing quality and productivity are associated but separable dimensions (Kim et al., 2014; Kim, Al Otaiba et al., 2015; Puranik, Lombardino, & Altmann, 2008; Wagner et al., 2011), and the relation of component skills to writing varies for different writing outcomes (Kim et al., 2014; Kim, Al Otaiba et al., 2015).

The present findings offer some preliminary yet important implications. First, there is a complex array of potential sources of breakdown in writing development. Therefore, in order to find out locus of writing failure, discourse-level oral language and transcription skills should be assessed and targeted in instruction—children may be weak in discourse-level oral language or transcription skills, or in both. Importantly, further assessments can be conducted to find out sources of weaknesses in discourse-level oral language and/or transcription skills, and provide targeted instruction based on the child's profiles of strengths and weaknesses. For transcription skills, phonological, orthographic, and morphological awareness can be included (Apel et al., 2012; Bourassa et al., 2006; Deacon & Bryant, 2005; Kim, 2010; Kim et al., 2013; Nagy et al., 2003; Treiman, 1993). For discourse-level oral language skill, instruction and assessment should include skills such as vocabulary, grammatical knowledge, and higher-order cognitive skills such as making inferences and perspective-taking. Vocabulary has received much attention as part of oral language assessment and instruction (e.g., Baumann & Kame'enui, 2004; Biemiller, & Boote, 2006; Coyne, McCoach, & Kapp, 2007; Graves, 2006; Beck, McKeown, & Kucan, 2002; Silverman & Hartranft, 2015). Although vocabulary is highly important, the present study, as well as growing evidence, indicates that more multifaceted systematic attention beyond vocabulary would be beneficial to improve discourse-level oral language.

Together with previous studies, findings of the present study show a complex array of skills that contribute to writing, and thus, development of writing is likely to require development of multiple language and cognitive skills. Future longitudinal studies are warranted.

[1] For Cohen's kappa values used for writing and discourse-level oral language skills, .61–.80 are considered substantial and .81–1.00 as almost perfect agreement (Cohen, 1960).

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Appendix A

Writing Quality Rubric

Score	Description
0 (not scorable)	• Protocol is blank • Handwriting is illegible • Student simply rewrites prompt with nothing else
1	• Main idea is not relevant to the prompt or no topic emerges or the idea is difficult to understand. • No details are provided.
2	• At least one relevant idea is represented and many times, one simple statement captures the topic • The idea is conveyed in a very general way with few details • The writing reads as a list of activities.
3	• The writing is made up of one or more ideas with a few details. • Flow of ideas is somewhat choppy. • The writing may read as a list of activities and a few places might be repetitive.
4	• A sense of coherent story is emerging with relatively clear main idea and details, and the writing makes a point. • Reads somewhat like a cohesive story. • The writing is on topic but could be narrower and more focused.
5	• One clear main idea is developed and the writing reads as a cohesive story in general. • Topic is narrow and focused although could benefit from some additional work. • Supportive details are accurate and developed, and elaborated. • The writer uses relevant and interesting details.

(*Appendices continue*)

Appendix B

Results of Partial Mediation Models

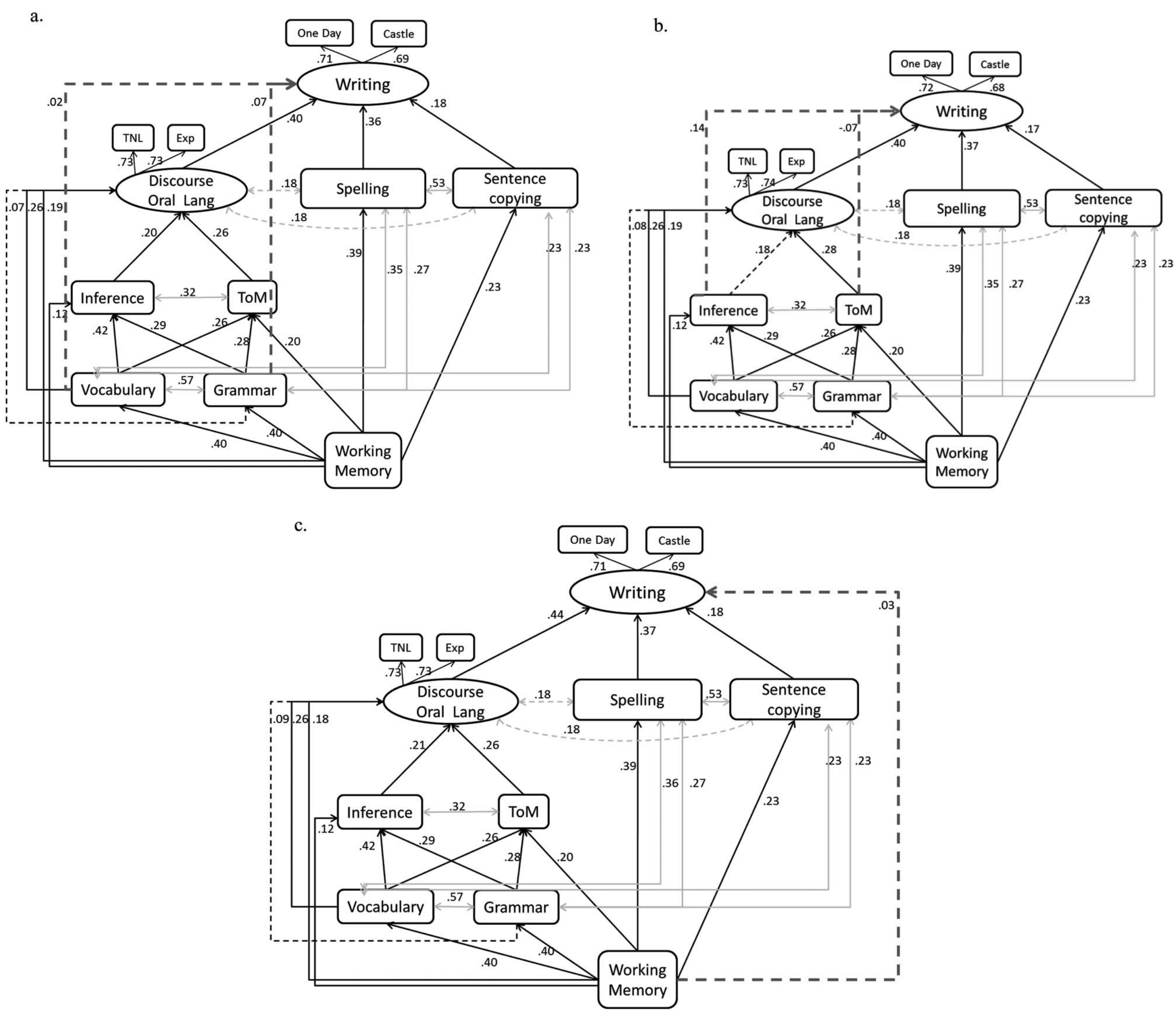

Figure FA1. The relations of oral language (vocabulary and grammatical knowledge) to writing (a); higher order cognitive skills (inference and theory of mind) to writing (b); and working memory to writing (c), after accounting for discourse-level oral language, spelling, and sentence copying fluency. Solid lines represent statistically significant relations whereas dashed lines represent nonsignificant relations. Gray lines represent covariances. TNL = test of narrative language; Exp = Expository texts; Oral Lang = oral language; ToM= theory of mind; Grammar = Grammatical knowledge.

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