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The direct and indirect effects of language and cognitive skills on Chinese reading comprehension

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Abstract

This study examined the direct and indirect relations of foundational language skills (vocabulary, syntactic knowledge, and orthographic knowledge), higher-order cognitive skills (inference making and comprehension monitoring), and word reading to reading comprehension in Chinese. Consistent with the hierarchical relations specified in the Direct and Indirect Effect Model of Reading (DIER, Kim, Journal of Educational Psychology, 112(4):667–684, 2020a; Journal of Learning Disabilities, 2020b), the foundational language skills are considered as lower level skills, and the higher-order cognitive skills and word reading are considered as upper level skills in this study. Participants were 164 Chinese (Mandarin)-speaking third graders. Results revealed that syntactic knowledge, orthographic knowledge, inference making, comprehension monitoring, and word reading made direct contributions to reading comprehension. In addition, syntactic knowledge contributed indirectly to reading comprehension via inference making, comprehension monitoring, and word reading. Orthographic knowledge also contributed indirectly to reading comprehension via comprehension monitoring. Language skills, higher-order cognitive skills, and word reading explained 72% of variances in reading comprehension. The findings highlight both the direct and indirect pathways and effects of various language and higher-order cognitive skills on reading comprehension in Chinese.

Keywords Chinese · Higher-order cognitive skills · Hierarchical relations · Language skills · Reading comprehension

Multiple language and cognitive skills contribute to reading comprehension. These language and cognitive skills have hierarchical and dynamic relations among them, which is captured in the Direct and Indirect Effect Model of Reading (DIER, Kim, 2015, 2017, 2020a, 2020b). The DIER integrates the component skills of the simple view of reading (word reading and language comprehension; Hoover & Gough,

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1990) and the component skills of text comprehension (e.g., vocabulary, grammatical knowledge, inference making, and comprehension monitoring; Cain et al., 2004) into one framework. In terms of the hierarchical relations, word reading and listening comprehension (representing the language comprehension) are considered as upper level skills directly related to reading comprehension (Kim, 2015). Word reading and listening comprehension are predicted by their own component skills. Word reading requires knowledge in phonology, orthography, and semantics (Kim, 2020a). Listening comprehension is supported by higher-order cognitive skills (e.g., inference making and comprehension monitoring), which, in turn, are supported by foundational language skills (e.g., vocabulary and syntactic knowledge). The hierarchical relations of language and higher-order cognitive skills of listening comprehension are based on their mapping to the different levels of representations in the construction-integration model of text comprehension (Hannon & Daneman, 2001; Kintsch & Rawson, 2005). Foundational language skills are placed at the lower level as they are necessary for the building of initial propositions (i.e., textbase representation) by attaching meaning to individual words and sentences. These initial propositions are usually incomplete and sometimes contradictory to each other. Higher-order cognitive skills are necessary to integrate information across sentences, detect inconsistences among initially built propositions, and construct an integrated and coherent mental representation of a text's meaning (a situation model; Cain et al., 2004; Kim, 2015, 2017, 2020b; Oakhill, 2020; Oakhill et al., 2003), and are thus placed at a higher level.

The DIER model also acknowledges the dynamic relations among the predictors of text comprehension, indicating that the relevant weights of contributions of word reading and component skills of language comprehension may change as a function of development (Cain et al., 2004; Kim, 2020a, 2020b; Saarnio et al., 1990). In the early phase of reading development, word reading and its related processes (e.g., orthographic knowledge, phonological knowledge, and morphological knowledge) occupy a large amount of processing capacity, with limited processing capacity left for more complex language comprehension processes (e.g., inferencing making, comprehension monitoring; Hannon & Daneman, 2001; McNamara & Magliano, 2009; Perfetti, 1985). As readers become more fluent and automatized in word reading, more processing capacity is available for higher level language comprehension processes (Garcia & Cain, 2014; LARRC & Yeomans-Maldonado, 2017; Vellutino et al., 2007). Therefore, word reading plays an important role in early reading development and language comprehension and its component skills become the prominent source of variance in reading comprehension in later reading development (Kershaw & Schatschneider, 2012; LARRC & Yeomans-Maldonado, 2017).

The hierarchical relations of language skills, higher-order cognitive skills, and word reading to reading comprehension are supported by evidence from children using alphabetic languages but have not been examined in Chinese, which uses a morphosyllabic orthography. Reading in Chinese involves the same linguistic processes (e.g., phonological, orthographic, semantic, morphological, and syntactic; Cheung et al., 2007; Chik et al., 2012a; Kim et al., 2020; Zhang et al., 2012) and cognitive processes (e.g., comprehension monitoring, inference making; Wong et al., 2017) as reading in alphabetic languages. Although the mechanism behind

reading is believed to be the same across orthographies, the weights of component skills to reading comprehension may differ across orthographies (Florit & Cain, 2011). One major difference between Chinese and alphabetic languages (e.g., English, Korean) is that in Chinese, there is a lack of correspondence between the phonemes and orthographic units as observed in alphabetic languages. In Chinese, phonology is not activated incrementally with each grapheme-phoneme pair as it is done in English. The orthographic unit needs to be recognized as a whole before phonology is activated. While phonological processing is important to reading in alphabetic languages, orthographic skills are more important than phonological processing to reading among Chinese-speaking children (Ho et al., 2004). Besides, the lack of inflectional system and the more extensive use of connectives in Chinese make syntactic knowledge important to Chinese reading comprehension (Cheung et al., 2007; Chik et al., 2012a; Zhang et al., 2012).

In this exploratory study, we intend to examine the hierarchical relations among several key component skills in predicting Chinese reading comprehension: three foundational language skills (e.g., vocabulary, orthographic knowledge, and syntactic knowledge), two higher-order cognitive skills (inference making and comprehension monitoring), and word reading. Consistent with the hierarchical relations specified in the DIER, word reading and the two higher-order cognitive skills were considered as upper level skills and the three foundational language skills were considered as lower level skills. Though the hypothesized hierarchical relations are mainly based on the DIER, our study is not an attempt to test the DIER among Chinese-speaking children. Two differences distinguish our model from the DIER. First, we did not include listening comprehension in the model. Processes of oral text comprehension (listening comprehension) and written text comprehension (reading comprehension) have found to be largely the same except for word reading, which supports reading comprehension only (Kim, 2017; Perfetti et al., 2005). Component skills contributing to the comprehension of oral text and written text are also similar (e.g. vocabulary, syntactic knowledge, inference making, and comprehension monitoring, Cain et al., 2004; Kendeou et al., 2008; Kim, 2017; Yeung et al., 2013). Therefore in our study, we allowed word reading and higher-order cognitive skills to make direct contribution to reading comprehension instead of indirect contribution via listening comprehension, which aligned with evidence from previous literature (Ahmed et al., 2016; Cromley & Azevedo, 2007; LARRC & Yeomans-Maldonado, 2017). Second, we empirically tested the direct and indirect effects of orthographic knowledge on reading comprehension given its importance to word reading and reading comprehension among Chinese children (Cheung et al., 2007; Tong et al., 2009; Yeung et al., 2011, 2013, 2016). By doing so, this study aims to extend the existing research by examining the direct and indirect relations of language skills, higher-order cognitive skills, and word reading in predicting comprehension of written text among Chinese children, who used an orthography that is very different from alphabetic languages. We next review the evidence for the relations between reading comprehension and the component skills included in our study: vocabulary, syntactic knowledge, orthographic knowledge, inference making, comprehension monitoring, and word reading.

Component skills of reading comprehension

Vocabulary is a foundational language skill to reading comprehension. Readers must be able to attach meaning to most words in a text in order to make propositions and initiate the processes of meaning integration and construction. Vocabulary is a powerful predictor of reading comprehension (Cain et al., 2004; Seigneuric & Ehrlich, 2005) and its contribution to reading comprehension might vary as a function of development, with a larger effect in higher grades than in lower grades (Kim, 2020a; Ku & Anderson, 2003; Ouellette & Beers, 2010). Previous studies support the direct contribution of vocabulary to reading comprehension among Chinese-speaking children (e.g., Chik et al., 2012b; Ku & Anderson, 2003).

Though vocabulary is foundational, it is not sufficient on its own. Syntactic knowledge, which is defined as the reader's ability to understand grammatical rules and sentence construction (Tunmer & Hoover, 1992), is needed for reading comprehension as the arrangement of words carries meaning (Cain, 2007; So & Siegel, 1997). Syntactic knowledge facilitates the recognition of word meaning, sentence comprehension, and text comprehension. Syntactic knowledge is especially important to Chinese reading comprehension because of unique characteristics of Chinese (e.g., no inflectional system, more flexible word order, and more extensive use of connectives; Li & Thompson, 1981). Since there is no inflectional system, Chinese readers rely on their syntactic knowledge to solicit information about the degree, tense, number, and class of a word from linguistic constituents and their semantic relations (Lin, 2006). Different from English, Chinese has more flexible word order. Besides the typical subject-verb structure, there is also the topic-prominent structure. Once the topic is established, it can extend to several following sentences (Chik et al., 2012a). Therefore, in Chinese reading it is common to encounter sentences with no subjects. Another feature of Chinese syntax is the extensive use of a group of connectives indicating reason, time, condition, contrast, and progressive relation. Thus, the syntactic knowledge of word order and connectives is important to trace the logic and semantic relations not only among words and phrases within a sentence but also across sentences, thereby contributing to sentence comprehension and text comprehension (Lo et al., 2016; Tong et al., 2014; Yeung et al., 2013). Syntactic knowledge remains a significant direct predictor to Chinese reading comprehension among children from Grade 1 up to Grade 6 (Chen et al., 1993; Chik et al., 2012a, 2012b; Tong et al., 2014).

In addition to vocabulary and syntactic knowledge, orthographic knowledge also plays a significant role when learning to read Chinese (Shu et al., 2000). Chinese is a morphosyllabic orthography, where the basic graphic unit, the character, represents both a morpheme and a syllable (Shu & Anderson, 1997). There are three levels of the orthographic system in Chinese: stroke, radical, and character. A character (e.g., 河) is composed of radicals (e.g., 氵), which in turn is composed of strokes (e.g., 丶). About 80–90% of Chinese characters are phonetic-semantic (Shu et al., 2003), comprising a semantic radical and a phonetic radical.

The semantic radical (e.g., 氵) provides clues to the meaning of a character while the phonetic radical (e.g.,口)gives cues to the sound of a character. Most radicals have a legal position in a character, e.g. the top (e.g., 艹), the bottom (e.g., 灬), the left (e.g., 氵)or the right (e.g., 刂). Orthographic knowledge of Chinese is often assessed by measuring children's ability to distinguish real Chinese characters from a set of pseudocharacters (with radicals in their legal positions) or non characters (with radicals not in their legal positions; Tong et al., 2009). In Chinese, the mapping from orthography to semantics is more rapid than the mapping from orthography to phonology (Yang et al., 2006). Orthographic knowledge makes direct contribution to Chinese reading comprehension (Cheung et al., 2007; Tong et al., 2009) mainly because the orthographic knowledge of semantic radicals provides hints to word meaning or indicates the semantic category of unknown words, and thus facilitates comprehension of words and texts (Ho et al., 2003; Liu et al., 2017; Tong & McBride-Chang, 2010; Yeung et al., 2016). Orthographic knowledge seems to be related to Chinese reading comprehension in both early reading (among kindergarteners, Tong et al., 2009) and later reading development (among fourth graders, Cheung et al., 2007).

The two higher-order cognitive skills included in this study are inference making and comprehension monitoring. To construct a coherent mental representation of information presented in text, readers need to go beyond what is explicitly written in the text and find what is implied. Readers make local coherence inferences to integrate information across adjacent pieces of writing and global coherence inferences to fill in details not explicitly stated in the text (Currie & Cain, 2015; Kintsch, 1994). Thus, inference making skills ensure that information in the text is integrated across sentences and with world knowledge to fill in missing information and build local and global coherence (Florit et al., 2014; Strasser & Rio, 2013). Without inferences, the text becomes a series of unrelated propositions. Skillful readers make more inferences than less skilled readers. Children who have poor reading comprehension skills tend to have problems with inferencing. They may not see the need to infer, or they may generate inferences different than what is intended (Yuill & Oakhill, 1991). Children's inference making skills predict their reading comprehension in English-speaking children and Chinese-speaking children (Kendeou et al., 2008; Oakhill et al., 2003; Wong et al., 2017).

As a text unfolds and new information is integrated, readers employ their comprehension monitoring skills to constantly evaluate and regulate their understanding. Cain (2009) contended that children with strong reading comprehension skills can monitor their comprehension more effectively and are able to identify novel or contradictory information and incorporate it in order to build a situation model. By monitoring their understanding of words and sentences, readers evaluate their propositions and integrate their understanding of word knowledge and usage (Kinnunen et al., 1998). Children with strong comprehension skills are more likely to engage in strategic processing, discover connections between text elements, and activate relevant prior knowledge to facilitate understanding. In contrast, children who struggle with comprehension often fail to monitor their comprehension consistently and have difficulty detecting and repairing inconsistencies within a text (Kinnunen & Vauras, 1995). Empirical research has shown that comprehension monitoring explains

unique variances in reading comprehension after controlling for word reading and various aspects of language comprehension for both English-speaking children and Chinese-speaking children (Cain et al., 2004; Wong et al., 2017).

Efficient word reading constitutes a necessary condition for reading comprehension (Verhoeven & Van Leeuwe, 2012). It involves the ability to decode word forms and transform them into corresponding phonetic codes (Hoover & Gough, 1990). Word reading ability sets a limit on children's early reading development as they allocate a large proportion of their processing ability on mapping sound to printed forms of words. As children become more fluent and automatized in word reading, the contribution made by word reading to reading comprehension decreases (Kershaw & Schatschneider, 2012). Chinese word reading explains a significant amount of variance in sentence and text comprehension among Chinese-speaking children after controlling for variables such as syntactic knowledge, working memory, and listening comprehension (Yeung et al., 2011, 2013). Children with reading difficulties tend to have worse early word reading (Zhang et al., 2014). Studies conducted among Chinese as second language learners in Hong Kong identified Chinese word reading as an important contributor to reading comprehension both concurrently and longitudinally (Wong, 2017, 2019).

Mediating roles of higher-order cognitive skills and word reading

According to the DIER, the higher-order cognitive skills (e.g., inference making and comprehension monitoring) and word reading might mediate the relations between the foundational language skills (e.g., vocabulary, syntactic knowledge, and orthographic knowledge) and reading comprehension. This hypothesis is supported by the evidence that the higher-order cognitive skills and word reading are upper level skills that are built on the foundational language skills (Kim, 2017; LARRC & Yeomans-Maldonado, 2017; Ouellette & Beers, 2010; Silva & Cain, 2015). For instance, studies have shown that inference making is predicted by vocabulary and syntactic knowledge (Cain et al., 2004; Oakhill, 2020; Silva & Cain, 2015). Vocabulary is critical for inference making because inferences involve word knowledge (Oakhill, 2020). More specifically, local coherence inferences are often made by mapping meaning of related words such as synonyms or category exemplars (Perfetti et al., 2008). The rich semantic networks of words associated with a topic may facilitate the making of more global inferences (Currie & Cain, 2015). Syntactic knowledge also supports inference making as children can use their knowledge of grammatical rules and cohesive ties to enhance their understanding of the logic and sequence of various propositions for better integration and more accurate inferences (Cain et al., 2004; Silva & Cain, 2015).

Similarly, empirical studies have shown that comprehension monitoring is predicted by vocabulary and syntactic knowledge (Kim, 2015; Kinnunen et al., 1998; Oakhill et al., 2003; Zargar et al., 2020). Vocabulary accounted for variability in comprehension monitoring as the detection of inconsistencies largely depends on readers' vocabulary knowledge. Syntactic knowledge is important to comprehension monitoring as it helps children better understand the grammatical relations

among words and sentences, decide syntactical acceptability, and detect comprehension errors. To the best of our knowledge, no study has investigated the relation between the higher-order cognitive skills of comprehension monitoring and inference making and orthographic knowledge. As orthographic knowledge in Chinese provides hints to word meaning and aids comprehension of words in reading (Ho et al., 2003; Liu et al., 2017; Tong & McBride-Chang, 2010), we predict that it also facilitates the monitoring of comprehension and inference making given that the accurate understanding of word meaning is essential to both cognitive processes (Oakhill, 2020; Zargar et al., 2020).

Word reading is a multivariate process that draws on multiple knowledge such as phonological knowledge, orthographic knowledge, morphological knowledge, syntactic knowledge, and vocabulary (Kim, 2017; Kim et al., 2013; Tong & McBride-Chang, 2010; Wang, et al., 2018; Yeung et al., 2013). Orthographic knowledge is associated with Chinese word reading even after phonological and morphological skills are controlled (Yeung et al., 2011). Chinese children use their orthographic knowledge such as the legal positions of Chinese radicals and phonetic radicals to facilitate word reading (Li et al., 2012). Vocabulary, especially the breadth of vocabulary is linked to word reading (Ouellette & Beers, 2010). As more words enter into one's mental lexicon (i.e., increasing vocabulary size), the phonological representations have to become more specified, leading to better word reading. Syntactic knowledge (e.g., morphological grammar and word order) is found to be associated with word reading among both English-speaking children (Kim et al., 2013) and Chinese-speaking children (So & Siegel, 1997). According to So and Siegel (1997), children use their syntactic knowledge to make predictions about what words appear next in sentences, which is conducive to fluent word reading.

In summary, empirical evidence suggests that higher-order cognitive skills (e.g., inference making and comprehension monitoring) and word reading draw on the foundational language skills of vocabulary, syntactic knowledge, and orthographic knowledge. Yet, as reviewed above, these same skills also contribute to reading comprehension. Thus, it is logical to surmise that higher-order cognitive skills and word reading would act as a mediator—at least a partial mediator—of the relations of foundational language skills to reading comprehension. Several empirical studies support that higher-order cognitive skills and word reading partially mediate the relations between foundational language skills and reading comprehension (Cromley & Azevedo, 2007; Kim, 2017). That is, the foundational language skills make both direct contribution to reading comprehension and indirect contribution via higher-order cognitive skills and word reading. Several other studies, however, favor a complete mediation model, especially studies that include both listening comprehension and reading comprehension in one model (Kim, 2015, 2020a; Vellutino et al., 2007). Word reading and listening comprehension, which is supported by cognitive skills and language skills, completely mediate the relation between language skills and reading comprehension. Given the inconsistent findings, in this study we tested both a partial mediation model and complete mediation model.

Purpose of this study

Despite evidence supporting the importance of vocabulary, syntactic knowledge, orthographic knowledge, comprehension monitoring, inference making, and word reading in Chinese text reading comprehension, these skills have not been examined in the same study. To extend understanding of the pathways of these variables in explaining Chinese text reading comprehension, we included these skills in one model. More importantly, we examined the direct and indirect contributions of language skills, higher-order cognitive skills and word reading to reading comprehension in order to examine their hierarchical relations in Chinese-speaking children. The following two specific research questions guided our study:

1. How do language skills (vocabulary, syntactic knowledge, and orthographic knowledge) relate to higher-order cognitive skills (inference making and comprehension monitoring) and word reading?
2. Do higher-order cognitive skills and word reading completely or partially mediate the relations between language skills and reading comprehension?

With regard to the first research question, we hypothesized that vocabulary and syntactic knowledge would predict both inference making and comprehension monitoring in line with previous research (Kim, 2017; LARRC & Yeomans-Maldonado, 2017; Perfetti et al., 2008; Silva & Cain, 2015). We hypothesized that orthographic knowledge would also predict higher-order cognitive skills because orthographic knowledge in Chinese has potential to facilitate the access of word meaning in reading, which is important to both comprehension monitoring and inference making (Oakhill, 2020; Zargar et al., 2020). Drawing from previous studies (Ouellette, 2006; Tong et al., 2009), we hypothesized that the language skills of vocabulary, syntactic knowledge, and orthographic knowledge would also predict word reading.

With regard to the second research question, we tentatively hypothesized that the higher-order cognitive skills would partially mediate the relations between language skills and reading comprehension, drawing from the results of previous research which did not include listening comprehension in the reading models (Cromley & Azevedo, 2007; Kim, 2017). Word reading was also hypothesized to partially mediate the relations between language skills and reading comprehension based on a recent study demonstrating that language skills were both directly and indirectly related to reading comprehension via word reading in Chinese-speaking second graders (Kim et al., 2020).

Method

Participants

Participants of this study were 164 Chinese third-grade students (92 boys, $M_{age} = 111$ months, $SD = 3.84$) who were all monolingual Chinese speakers from a primary school in an urban area in east China. Reading is not an independent subject, but an important part of the Chinese curriculum in Chinese primary schools. In the Chinese classes, the instruction centers on the teaching and learning of texts from the Elementary Chinese Textbook (2001), a Chinese textbook adopted by many primary schools in China. Usually, teachers focus on analyzing the structure of a text, explaining new words and rhetorical devices used in the text, and asking comprehension questions. Students interact with teachers by answering comprehension questions. After class, students are encouraged to read widely on topics of interest to them. Most students at grade 3 can read age-appropriate chapter books without much difficulty. Participants were reported by their teachers as having no hearing or language impairments. The study was conducted with the permission of parents of the participants.

Measures

Children were measured on their vocabulary, syntactic knowledge, orthographic knowledge, comprehension monitoring, inference making, word reading, and reading comprehension. Children's answers were dichotomously scored (correct = 1; incorrect = 0) for each item unless otherwise noted.

Vocabulary. Children's vocabulary was measured by using the Chinese version of the Peabody Picture Vocabulary Test-Revisited (PPVT-R, Dunn & Dunn, 1981; Sang & Miao, 1990). In this task, each word item is accompanied by four picture illustrations. The children heard a word and were asked to identify the picture that corresponded to the word. The children received instructions and had two trial items before they were given the test items. The task included 60 items with increasing difficulty. The reliability of PPVT-R in this study was 0.84.

Syntactic knowledge. Children's syntactic knowledge was assessed by using a conjunction cloze task adapted from Tong et al. (2014). This task was chosen because the wide use of conjunctions is an important feature of Chinese syntax and knowledge about conjunctions can reflect syntactic knowledge (Li & Thompson, 1981). This task included two practice items and 13 complex sentences in which one of a pair of conjunction words was missing and replaced by a blank. Children were asked to fill in the blank with the appropriate conjunction word to make the sentence sound complete and correct. The 13 paired conjunction words belong to either coordinating conjunctions or subordinating conjunctions, representing conjunction relationships such as time (e.g., 起初…然后, first…then…), reason(e.g., 因为…, 所以…, because), progressive relation (e.g., 不但…而且, not only…but also), condition (e.g., 如果… 就 provided that), and contrast (e.g.,

虽然…但是…, though). The reliability of the conjunction cloze task in this study was 0.71.

Orthographic knowledge. Children's orthographic knowledge was measured using a Chinese character decision task adapted from the Hong Kong Test of Specific Learning Difficulties in Reading and Writing (Ho et al., 2000). This task assessed children's awareness of the internal structure of a character and their ability to distinguish real Chinese characters from a set of noncharacters. There were 20 real characters and 20 noncharacters in this task. The real characters were all low frequency words most primary school children do not know (e.g.,畜). The noncharacters had the radicals in illegal positions (e.g., 劳). Children were asked to underline the items they thought were real characters. The task included 40 items and thus the maximum score was 40. The reliability of this task was 0.84.

Inference making. Children's inference making was measured by an inference making task adapted from LARRC and Muijselaar (2017). It included two stories at the difficulty level appropriate for grade-3 readers. Each story is followed by eight questions to assess children's ability to generate local and global coherence inferences. The stories and questions were translated into Chinese by the researchers, who are proficient in both English and Chinese and have rich experiences in translating. This task was administered individually. Children were asked to read the story silently first. After reading the story, children were presented the questions aurally and asked to answer the questions orally. The reliability of this measure in this study is 0.65.

Comprehension monitoring. Children's comprehension monitoring skills were assessed with an inconsistency detection test adapted from Kim (2015). The task assessed children's ability to detect inconsistencies in stories. It included two practice items and 11 test items. This task was administered individually. In the task, children read each story in silence and after reading the story they were asked whether the story made sense. The meaning of "not making sense" was explained to children during the practice session. If children said the story did not make sense, they were asked to explain orally why it did not make sense. There were 3 consistent stories and 8 inconsistent stories. An example of a consistent story is: "We see spiders in many places. Spiders build webs to catch their food, flies. Spiders have many legs. Spiders use webs to get their food." An example of an inconsistent story is: "There was a rabbit named Pangpang, his food was always a carrot. He often hopped around in a garden. Pangpang ate cabbage for all of his meals." For the 6 inconsistent stories, the accuracy of children's explanations was also dichotomously scored, 1 for the correct explanation and 0 for the incorrect explanation. Therefore, the total possible score for this task was 19 (11 + 8). The reliability of this measure was 0.78.

Word reading. A word reading task adopted from Luo et al. (2013) was administered to children in this study. The task consisted of 150 unrelated characters, with increasing difficulty. Children were asked to read the characters aloud. The test stopped when the child misread 10 characters consecutively. One point was awarded for each character read correctly and the maximum score was 150. The reliability of this task in this study was 0.97.

Reading comprehension. Children's reading comprehension was measured using three reading passages. Two passages were adapted from *Comprehensive*

Reading Inventory (CRI; Cooter et al., 2006). Each of the two passages was followed by eight comprehension questions, including multiple choice questions and short answer questions. The passages were translated into Chinese by the researchers, who had rich experiences in translating. The difficulty level of the two passages were regarded by three primary Chinese teachers as appropriate for 3rd grade Chinese students. The third passage was taken from the *Progress in International Reading Literacy Study* (PIRLS, 2006), which is an international reading test targeting 9 year old children. This passage was followed by 11 comprehension questions, either in multiple choice format or short answer format. Children read the passages and completed the comprehension questions in silence. One point was awarded for each correct answer. The reliability of the three reading comprehension passages was 0.64, 0.70, and 0.60 respectively.

Procedures

The tasks were administered to children in one individual session and two group sessions by three rigorously trained graduate students majoring in applied linguistics. The duration for each session was about 40 min. Tasks administered individually were comprehension monitoring, inference making, and word reading. Tasks administered in groups were reading comprehension, vocabulary, orthographic knowledge, and syntactic knowledge.

Data analysis strategy

Structural equation modeling was the primary data analysis strategy in this study. The SEM analyses were carried out using the R package lavaan (Rosseel, 2012). Reading comprehension was specified as a latent outcome variable indicated by three reading passages. Other skills were assessed by single measures and therefore observed variables were used. Model fits were evaluated by the following indices: the $\chi 2$ statistic, comparative fit index (CFI), Tucker-Lewis index (TLI), root mean square error of approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR). Generally speaking, a good model fit is indicated by CFI and TLI values equal to or greater than 0.95, RMSEA values equal to or below 0.06, and SRMR values equal to or less than 0.08 (Hu & Bentler, 1999). The chi-square difference test was used to compare the relative fit of models.

Two alternative models were tested: the complete mediation model (Fig. 1) and the partial mediation model (Fig. 2). In the complete mediation model, higher-order cognitive skills and word reading completely mediated the relations between language skills and reading comprehension. In the partial mediation model, language skills had direct relations with reading comprehension in addition to indirect relations via higher-order cognitive skills and word reading. The indirect effects of the language skills on reading comprehension via higher-order cognitive skills and word reading were tested using bootstrapping with 1000 bootstrap samples, and the indirect effects were deemed statistically significant if the 95% bias-corrected and accelerated bootstrap confidence intervals (CIs) did not contain zero (Preacher &

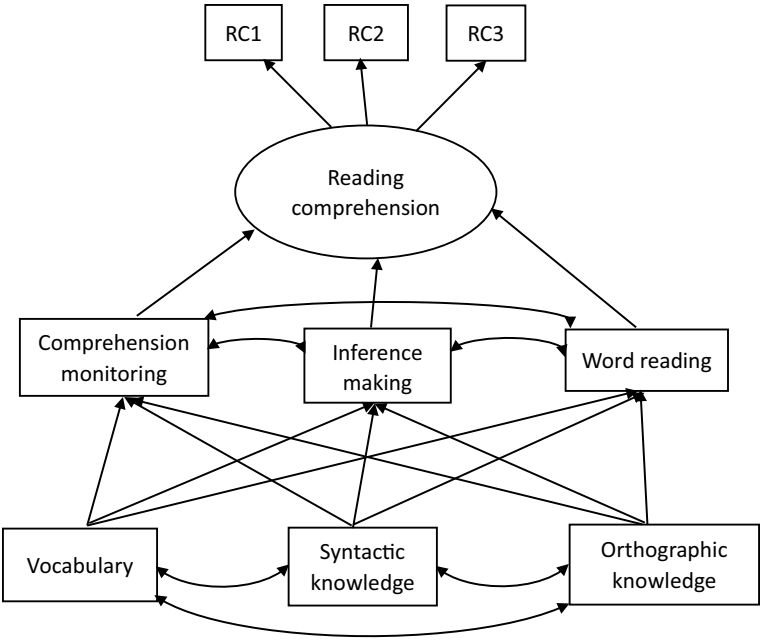

Fig. 1 Complete mediation model. RC 1/2/3 = Reading comprehension task 1/2/3

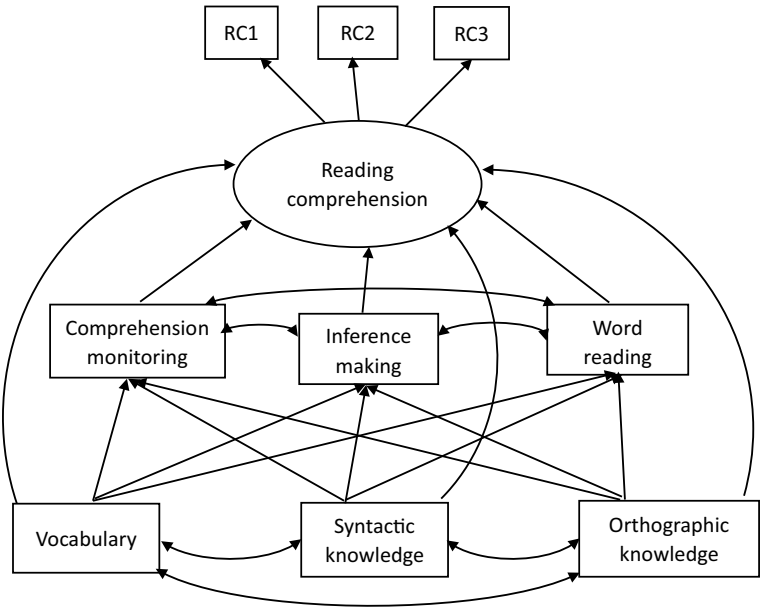

Fig. 2 Partial mediation model. RC 1/2/3 = Reading comprehension task 1/2/3

Hayes, 2004). The standardized indirect effects (*ab*) and the corresponding CIs were reported.

Results

Table 1 presents the descriptive statistics and intercorrelations of the variables in this study. The three language skills (vocabulary, syntactic knowledge, and orthographic knowledge) were weakly to moderately related to reading comprehension ($0.27 \le r \le 0.49$). The higher-order cognitive skills (inference making and comprehension monitoring) and word reading were moderately to strongly related to reading comprehension ($0.32 \le r \le 0.57$). Vocabulary and syntactic knowledge were moderately to strongly related to the two higher-order cognitive skills ($0.34 \le r \le 0.55$) and orthographic knowledge was weakly related to the two higher-order cognitive skills ($0.16 \le r \le 0.23$). Vocabulary and syntactic knowledge were moderately related to each other ($r = 0.41$) but not related to orthographic knowledge. Inference making and comprehension monitoring were strongly related to each other ($r = 0.51$). Word reading was moderately to strongly related to vocabulary, syntactic knowledge, inference making, and comprehension monitoring ($0.39 \le r \le 0.61$) but not related to orthographic knowledge.

Table 1 Descriptive statistics and bivariate correlations among study variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Vocabulary	–								
(2) Syntactic knowledge	0.41**	–							
(3) Orthographic knowledge	0.11	0.03	–						
(4) Comprehension monitoring	0.36**	0.43**	0.23*	–					
(5) Inference making	0.34**	0.55**	0.16*	0.51**	–				
(6) Word reading	0.39**	0.61**	0.11	0.39**	0.60**	–			
(7) Reading comprehension 1	0.31**	0.49**	0.27**	0.44**	0.51**	0.57**	–		
(8) Reading comprehension 2	0.32**	0.48**	0.29**	0.45**	0.50**	0.42**	0.55**	–	
(9) Reading comprehension 3	0.31**	0.33**	0.27**	0.32**	0.41**	0.35**	0.41**	0.48**	–
Min	32	1	7	2	4	23	0	0	2
Max	59	13	40	19	16	145	8	8	11
M	50.06	8.52	28.98	13.74	13.03	113.34	5.55	5.65	5.81
SD	6.53	2.73	5.89	3.67	1.99	21.70	1.60	1.98	2.16
Skewness	− 0.77	− 0.89	0.63	− 0.77	− 1.41	− 1.70	− 0.81	− 0.73	0.12
Kurtosis	0.06	0.19	0.55	0.11	3.41	3.94	0.49	-0.37	-0.38

* $p < 0.05$

** $p < 0.01$

The model fit for the complete mediation model (Fig. 1) was acceptable, with $\chi^2(N=164,\ df=15)=34.19,\ p<0.01$; CFI = 0.96; TLI = 0.90; RMSEA = 0.088 (0.049–0.128); SRMR = 0.046. The ratio of cases to free parameters for this model is 4.21:1 (164:39). The partial mediation model (Fig. 2) had a good model fit, with $\chi^2(N=164,\ df=12)=13.47,\ p=0.34$; CFI = 1.00; TLI = 0.99; RMSEA = 0.027 (0.000–0.087); SRMR = 0.022. The ratio of cases to free parameters for this model is 3.90:1 (164:42). The chi-square difference test showed that the partial mediation model was superior, $\Delta\chi^2=20.72,\ \Delta df=3,\ p<0.001$. The model parameter estimates of the partial mediation model were shown in Fig. 3. Reading comprehension was predicted by inference making ($\beta=0.23,\ p<0.01$), comprehension monitoring ($\beta=0.20,\ p<0.01$), word reading ($\beta=0.22,\ p<0.05$), syntactic knowledge ($\beta=0.27,\ p<0.01$), and orthographic knowledge ($\beta=0.23,\ p<0.001$) but not vocabulary ($\beta=0.07,\ p=0.36$). Inference making was predicted by syntactic knowledge ($\beta=0.53,\ p<0.001$) but not vocabulary ($\beta=0.11,\ p=0.13$) or orthographic knowledge ($\beta=0.12,\ p=0.07$). Comprehension monitoring was predicted by vocabulary ($\beta=0.18,\ p<0.05$), syntactic knowledge ($\beta=0.37,\ p<0.001$), and orthographic knowledge ($\beta=0.19,\ p<0.01$). Word reading was predicted by vocabulary ($\beta=0.15,\ p<0.05$) and syntactic knowledge ($\beta=0.57,\ p<0.001$), but not orthographic knowledge ($\beta=0.07,\ p=0.25$). Inference making covaries with comprehension monitoring ($\beta=0.30,\ p<0.001$) and word reading ($\beta=0.34,\ p<0.001$). Word reading did

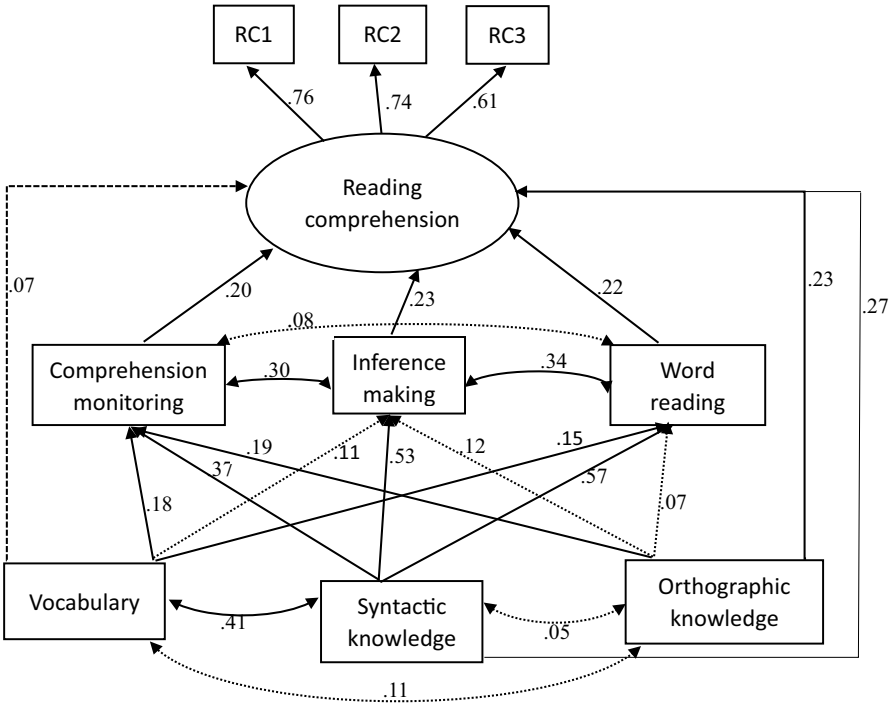

Fig. 3 Standardized structural regression weights of the partial mediation model. Solid lines represent statistically significant paths and dotted lines statistically insignificant paths

not covary with comprehension monitoring (β = 0.08, $p = 0.34$). The amount of total variances explained in each outcome variable was: 72% in reading comprehension, 42.9% in word reading, 36.2% in inference making, and 27.6% in comprehension monitoring.

We then conducted tests for the indirect effects of language skills on reading comprehension via the higher-order cognitive skills (inference making and comprehension monitoring) and word reading. Statistically significant evidence was found for the indirect effect of syntactic knowledge on reading comprehension via inference making ($ab = 0.123$, 95% bootstrap CI [0.011, 0.098], comprehension monitoring ($ab = 0.074$, 95% bootstrap CI [0.004, 0.066]), and word reading ($ab = 0.128$, 95% bootstrap CI [0.006, 0.123]. The indirect effect of orthographic knowledge on reading comprehension via comprehension monitoring was also statistically significant ($ab = 0.039$, 95% bootstrap CI [0.001, 0.018]). No statistically significant evidence was found for the indirect effect of vocabulary on reading comprehension via inference making ($ab = 0.025$, 95% bootstrap CI [-0.001, 0.014]), comprehension monitoring ($ab = 0.036$, 95% bootstrap CI [0.000, 0.018]), or word reading ($ab = 0.033$, 95% bootstrap CI [0.000, 0.016]). No statistically significant evidence was found for the indirect effect of orthographic knowledge on reading comprehension via inference making ($ab = 0.027$, 95% bootstrap CI [-0.001, 0.016]) or word reading ($ab = 0.015$, 95% bootstrap CI [-0.004, 0.011]). In conclusion, we found statistical evidence for the positive direct effects of inference making, comprehension monitoring, syntactic knowledge, orthographic knowledge, and word reading on reading comprehension. In addition, we found positive indirect effects of syntactic knowledge on reading comprehension via inference making, comprehension monitoring, and word reading. Finally, we found a positive indirect effect of orthographic knowledge on reading comprehension via comprehension monitoring. Table 2 shows the direct, indirect, and total effects of the included predictors on

Table 2 Direct, indirect, and total effect estimates of the model predictors on reading comprehension

	Direct effect	Indirect effect via			Total effect
		Comprehension monitoring	Inference making	Word reading	
Vocabulary	0.07(0.01)	0.04(0.005)	0.03(0.004)	0.03(0.004)	0.17(0.015)
Syntactic knowledge	0.27(0.04)	0.07(0.016)[a]	0.12(0.023)[a]	0.13(0.030)[a]	0.59(0.041)
Orthographic knowledge	0.23(0.01)	0.04(0.005)[a]	0.03(0.004)	0.02(0.004)	0.32(0.017)
Comprehension monitoring[b]	0.20(0.03)				–
Inference making[b]	0.23(0.05)				–
Word reading[b]	0.22(0.01)				–

The values reported are the standardized coefficients and the corresponding standard errors are in parentheses

[a]The indirect effects were statistically significant with bootstrapping

[b]Only direct paths were tested for comprehension monitoring, inference making, and word reading in the model

reading comprehension. Amount of total effects observed for vocabulary was 0.17, syntactic knowledge was 0.59, orthographic knowledge was 0.32, inference making was 0.23, comprehension monitoring was 0.20, and word reading was 0.22.

Discussion

The primary goal of this study was to unpack the nature of the relationships among foundational language skills (vocabulary, syntactic knowledge, and orthographic knowledge), higher-order cognitive skills (inference making and comprehension monitoring), word reading, and reading comprehension. In particular, we tested the hierarchical relations among foundational language skills, higher-order cognitive skills, and word reading in predicting Chinese reading comprehension. These hierarchical relations have been supported by English-speaking children in Grade 2 (Kim, 2017) and Korean-speaking children in Grade 1(Kim, 2020a). We extended prior research by (a) including orthographic knowledge and higher-order cognitive skills (inference making and comprehension monitoring) and testing direct and indirect relations and (b) using data from Chinese-speaking third graders. Our results provide evidence on the hierarchical nature of relations among component skills of reading comprehension for Chinese-speaking children in Grade 3. Below, we discuss the findings more thoroughly in relation to theory and previous research.

In the present study, we explained sizable (72%) variance in reading comprehension by the language skills, higher-order cognitive skills, and word reading. We believe the substantial variance explained in our study is partially due to the inclusion of measures to assess syntactic knowledge, orthographic knowledge, inference making, and comprehension monitoring, which are critical to reading comprehension.

Syntactic knowledge was directly related to the higher-order cognitive skills (inference making and comprehension monitoring) and word reading. The finding is consistent with empirical evidence that syntactic knowledge is necessary for making inferences (Cain et al., 2004; Silva & Cain, 2015). Children's syntactic knowledge of conjunctions may enhance their understanding of the sequence and logic of initial propositions, leading to better integration and more accurate inference. The finding aligns with previous finding that syntactic knowledge aids comprehension monitoring (Kim, 2015; Kinnunen et al., 1998; Oakhill, et al., 2003). Specifically, the syntactic knowledge of conjunctions as measured in the present study enables children to judge the grammatical acceptability of sentences and better understand relations among words and sentences, making it easier to detect comprehension errors. This finding also conforms to previous studies supporting the positive relation between syntactic knowledge and word reading (Kim, 2015; So & Siegel, 1997). In the Chinese context, syntactic knowledge benefits word reading in at least two ways. On the one hand, syntactic knowledge helps children to make predictions about what words appear next in the sentence and thus facilitates word reading (So & Siegel, 1997). On the other hand, children use syntactic knowledge to elicit information about the degree, number, tense, and class of a Chinese word in reading, improving the quality of lexical representations. As more information of a word is stored and

interconnected in one's mind, it is easier to be accessed including both its sound and meaning. It needs to be pointed out that the strong relation between syntactic knowledge and word reading might be partially due to the exclusion of morphological skills in our study. Syntactic knowledge might have explained part of the variances in word reading that can be attributed to morphological skills because syntactic knowledge and morphological knowledge (especially compounding knowledge) are strongly related, both of which contribute to word reading (So & Siegel, 1997; Yeung et al., 2013).

Syntactic knowledge was also directly related to reading comprehension, confirming previous studies showing that syntactic knowledge facilitates text comprehension (Tong et al., 2014; Yeung et al., 2013). In our study, syntactic knowledge was measured using a conjunction cloze task. Therefore, our finding extends previous studies by confirming that besides word order and morphosyntactic knowledge (Chik et al., 2012a, 2012b; Lo et al., 2016; Yeung et al., 2011, 2013), the syntactic knowledge of conjunctions is also important for text reading comprehension (Tong et al., 2014). Children use their knowledge of conjunctions to follow the logical and semantic relations between clauses and sentences, which facilitate the building of both initial propositions and the final coherent mental representation of a text.

As syntactic knowledge was found to be both directly and indirectly related to reading comprehension via inference making, comprehension monitoring, and word reading, we may conclude that the higher-cognitive skills and word reading partially mediated the relation between syntactic knowledge and reading comprehension. This finding is consistent with previous literature that higher-order cognitive skills (e.g., inference making) and word reading partially mediate the relations of foundational language skills to reading (Cromley & Azevedo, 2007; Kim, 2017; Kim et al., 2020). Our study extended the findings of previous studies by showing multiple pathways by which syntactic knowledge is directly and indirectly related to reading comprehension (i.e., via inferencing making, comprehension monitoring, and word reading). These indirect effects made substantial differences in accounting for total effects of syntactic knowledge on reading comprehension. Specifically, the direct effect of syntactic knowledge was 0.27. However, after accounting for its indirect effects via inference making, comprehension monitoring, and word reading, its total effect was substantial (0.59 = 0.27 direct effect + 0.32 indirect effect). Taken together, our results support the important role of syntactic knowledge in reading comprehension and highlight the multiple ways syntactic knowledge contributes to reading comprehension in Chinese.

Orthographic knowledge was directly related to one higher-order cognitive skill, comprehension monitoring, suggesting that knowledge about orthographic systems is a foundational language skill important to comprehension monitoring. Orthographic knowledge may contribute to comprehension monitoring by facilitating the access to the semantic meaning of words (Liu et al., 2017), which is necessary to detect comprehension errors. Another possibility is that the orthographic knowledge measure in our study, a Chinese character judgement task, might have involved similar processes and procedures as those of the comprehension monitoring task in that both tasks require children to detect anomalies. The Chinese character judgement task involved the detection of noncharacters among

a group of real characters. The comprehension monitoring task asked children to decide if the story made sense, which drew children's attention to the detection of inconsistencies. However, orthographic knowledge did not make direct contributions to the other cognitive skill, inference making. The lack of a direct relation between orthographic knowledge and inference making could be explained by a shared role with syntactic knowledge. Syntactic knowledge is a more powerful predictor of inference making as it enables children to trace the logical relations among clauses and sentences and thus aides the integration of information at both the sentence level and discourse level. Given that there are no published studies that discern the relations between orthographic knowledge and higher-order cognitive skills, our findings are critically important and lead to improved understanding of the mechanism by which orthographic knowledge may influence cognitive skills.

Contrary to several previous studies (e.g., Ho et al., 2003; Yeung et al., 2016), orthographic knowledge did not predict word reading among the Grade 3 Chinese children in our study. There are two potential explanations for this finding. First, this discrepancy may be attributed to the different orthographic measures used in these studies. Our orthographic knowledge measure was a Chinese character judgement task, assessing children's knowledge of internal structure of a character. In Yeung et al. (2016), orthographic knowledge was assessed using several different measures including measures assessing phonetic radical knowledge and semantic radical knowledge. In their study, phonetic radical knowledge contributed to word reading while semantic radical knowledge contributed to reading comprehension. Therefore, it is likely that word reading is more related to the phonetic radical knowledge than to semantic radical knowledge or knowledge of internal structure as is measured in our study. Second, the insignificant relation between orthographic knowledge and word reading may reflect a developmental change of this relation. Our finding conforms to Wei et al. (2014) which indicates that orthographic knowledge predicts word reading at early literacy development (preschool and Grade 1) but the effect becomes insignificant in later development (Grade 2 and Grade 3). Therefore, orthographic knowledge might contribute more to initial learning and processing of Chinese characters; however, as children become familiar with radical information and rules of constructing a character, other skills such as morphological skills become more important in word reading and the contribution of orthographic knowledge decreases (Wei et al., 2014).

Results also showed that orthographic knowledge made a direct contribution to reading comprehension. This finding is in line with previous studies that showed the relation of orthographic knowledge to Chinese text reading comprehension (Cheung et al., 2007; Chik et al., 2012a, 2012b; Lo et al., 2016; Tong et al., 2009, 2014). Orthographic knowledge provides reliable clues to the meaning or semantic category of unknown Chinese words readers encounter in text (Liu et al., 2017; Tong & McBride-Chang, 2010; Yeung et al., 2016). For instance, 荬 is a low frequency word in Chinese and not likely known by primary school students. When children come across this word in reading, they can make a good guess that it is the name of a certain plant with the basic orthographic knowledge about the semantic radical "艹", which indicates plant.

Orthographic knowledge was found to be both directly and indirectly related to reading comprehension via comprehension monitoring. This finding confirms our hypothesis that comprehension monitoring partially mediates the relation between orthographic knowledge and reading comprehension. It indicates that orthographic knowledge is a foundational language skill that makes both direct contribution to Chinese reading comprehension and indirect contribution via comprehension monitoring. When accounting for the indirect effect, the total effect of orthographic knowledge on reading comprehension was sizable (0.32).

A different pattern was observed for another foundational language skill, vocabulary. Vocabulary was related to comprehension monitoring, which is in line with a previous finding (Kim, 2015) and shows that vocabulary underpins comprehension monitoring. Vocabulary was also related to word reading, which aligns with Ouellette and Beers (2010) showing that the breadth of vocabulary is associated with word reading. The more words there are stored in one's mental lexicon, the more sophisticated the phonological processing becomes, which is conducive to word reading. However, vocabulary was not related to either inference making or reading comprehension after accounting for the other variables. This result is divergent with the literature that reported the importance of vocabulary in inference making (Currie & Cain, 2015) and reading comprehension (Chik et al., 2012a, 2012b; Kim et al., 2020; Ku & Anderson, 2003). It is also notable that the total effect of vocabulary on reading comprehension was smallest (0.17) of all the included language and cognitive skills. One potential explanation may be that in these previous studies, depth of vocabulary (the richness of word knowledge) was measured, whereas this study focused on breadth of vocabulary (number of words known) as measured by the PPVT. In fact, research has shown that measures of vocabulary depth are better predictors of inference making and reading comprehension than assessments of breadth of vocabulary (Oakhill et al., 2015; Ouellette, 2006). Alternatively, the insignificant relation between vocabulary and reading comprehension may be explained from a developmental perspective. Vocabulary makes more contribution to reading comprehension among higher grades children than lower grades children (Kim, 2020a; Ku & Anderson, 2003; Ouellette & Beers, 2010). For instance, in Ouellette and Beers (2010) the breadth of vocabulary predicts Grade 6 reading comprehension but not Grade 1 reading comprehension. Children in grade 3 in our study may be in a transitional period from early reading development to more advanced level and thus the contribution of vocabulary to reading comprehension was not significant. Vocabulary might become more important to reading comprehension as children becomes more proficient readers and read material that involves a high demand of vocabulary (Kim, 2020a; Ouellette & Beers, 2010).

The higher-order cognitive skills of inference making and comprehension monitoring were both independently related to reading comprehension. These findings support that the construction of a model of a text's meaning requires making inferences and monitoring comprehension (Cain et al., 2004; Oakhill et al., 2003). Inference making has been shown to be important to reading comprehension (Kendeou et al., 2008; Oakhill et al., 2003), and the present study showed that both local and global coherence inferences contributed to reading comprehension. The direct relation of comprehension monitoring to reading comprehension suggests that

constructed propositions have to go through evaluation processes to make connections and establish coherence to build the situation model. This finding is consistent with previous studies showing the relation between comprehension monitoring and reading comprehension (Cain et al., 2004; Wong et al., 2017).

It is also notable that word reading was moderately related to reading comprehension. The direct effect of word reading on reading comprehension was 0.22. The direct relations of word reading to reading comprehension in Korean-speaking first graders (direct effect = 0.49; Kim, 2020b) and English-speaking second graders (direct effect = 0.79; Kim, 2017) were stronger than its relation to reading comprehension with Chinese-speaking third graders found in the present study. The relatively weaker contributions of word reading to reading comprehension supports the developmental nature of relation showing a decreasing role of word reading in reading comprehension as children develop reading skills (Adlof et al., 2006; Kim & Wagner, 2015). Another notable finding from the current study is that word reading partially mediated the relations of syntactic knowledge to reading comprehension. The indirect relation via word reading adds to our growing understanding of the nature of relations among component skills.

Limitations

In light of these findings, some limitations warrant note. First, we measured language skills, higher-order cognitive skills, and word reading using a single task due to resource constraints. Measuring a construct using latent variables with multiple tasks is preferred because this approach significantly reduces measurement error and increases reliability of the estimates (Kline, 2004). Thus, future work should use latent constructs based on common variance rather than single variables. Second, although we included language and higher-order cognitive skills and word reading in the model, we did not include other variables such as phonological knowledge, morphological knowledge, theory of mind, and working memory, which are important to reading comprehension (Kim, 2015, 2017, 2020a; Kim et al., 2020; Oakhill, 2020; Pan et al., 2016; Zhang et al., 2012). In addition, listening comprehension is a necessary skill for reading comprehension according to the simple view of reading (Hoover & Gough, 1990) but was not included in the current study. The exclusion of listening comprehension might impact the direct and indirect relations of component skills to Chinese reading comprehension. An important future direction should include these variables in order to expand the direct and indirect model of reading comprehension in Chinese. Third, given the correlational nature of the data, the observed relations of language skills and higher-order cognitive skills to reading comprehension are not causal in nature. In addition, our results are from Chinese-speaking students in grade 3 learning to read in Chinese. The relative contributions of these skills to reading comprehension change across age/grade (Kim, 2020b). Experimental and longitudinal research involving children at various developmental phases is needed to determine the causal and longitudinal relations between these language and higher-order cognitive skills and reading comprehension. Fourth, the ratio of cases to free parameters of our models is lower than 5:1, the threshold of

widely recommended case to free parameters ratio. Future studies are recommended to use a larger sample. Finally, children who participated in the current study were monolingual speakers of Chinese who are typically developing children without disabilities. Thus, it is not clear if these findings can be generalized to other populations, including children with reading disabilities and children learning to read in other languages. Research efforts designed to study the direct and indirect relations of language and higher-order cognitive skills to reading comprehension on a more general population of children are needed.

Implications and conclusion

Despite the limitations, these findings indicate that multiple language and higher-order cognitive skills and word reading are involved in reading comprehension in Chinese and these skills have both direct and indirect relations to reading comprehension. These findings provide important implications for reading assessment and instruction. First, given the importance of syntactic knowledge, orthographic knowledge, inference making, comprehension monitoring, and word reading in reading comprehension, assessments in these skills should be used to identify children who are potentially at risk for reading difficulties in the future. Second, the current findings suggest that to promote development of children's reading skills, instruction needs to target multiple skills together, rather than training reading comprehension alone. Besides word reading and vocabulary that are commonly stressed in Chinese classrooms, the higher-order cognitive skills of inference making and comprehension monitoring are suggested to be taught directly in class. Teachers may use questions to draw children's attention to the possible understanding gaps in reading and the need to make inferences for successful comprehension of text (Wong et al., 2017). Furthermore, the direct and indirect relations found in this study indicate a need for a systematic instructional approach. As word reading and the cognitive skills are built on the foundational language skills, explicit and systematic instruction of foundational language skills would have cascading effects on inference making, comprehension monitoring, and word reading, as well as on reading comprehension. For example, systematic instruction on syntactic knowledge would not only facilitate reading comprehension but also inference making, comprehension monitoring, and word reading. The direct instruction on orthographic knowledge may improve both comprehension monitoring and reading comprehension.

In conclusion, these findings underscore the importance of disentangling direct and indirect pathways and effects of various language skills, higher-order cognitive skills, and word reading on reading comprehension in Chinese. This work expands theoretical understanding of reading and has critical implications for assessment and instruction.

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