

## Contribution of discourse and morphosyntax skills to reading comprehension in Chinese dyslexic and typically developing children

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**Abstract** This study aimed at identifying important skills for reading comprehension in Chinese dyslexic children and their typically developing counterparts matched on age (CA controls) or reading level (RL controls). The children were assessed on Chinese reading comprehension, cognitive, and reading-related skills. Results showed that the dyslexic

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children performed significantly less well than the CA controls but similarly to RL controls in most measures. Results of multiple regression analyses showed that word-level reading-related skills like oral vocabulary and word semantics were found to be strong predictors of reading comprehension among typically developing junior graders and dyslexic readers of senior grades, whereas morphosyntax, a text-level skill, was most predictive for typically developing senior graders. It was concluded that discourse and morphosyntax skills are particularly important for reading comprehension in the non-inflectional and topic-prominent Chinese system.

**Keywords** Chinese · Discourse skills · Dyslexia · Morphosyntax skills · Reading comprehension

## Introduction

There is converging research evidence showing that developmental dyslexia is characterized by a central difficulty in word phonological decoding components of the language system (Leong, 2006; Lyon, 1995; Lyon, Shaywitz, & Shaywitz 2003; Shaywitz, 1998) and it may result in “problems in their reading comprehension and reduced experience that can impede growth of vocabulary and background knowledge” (Lyon et al., 2003, p. 9). Reading to comprehend a text is however more complex and sophisticated than word recognition or decoding. As evident in the literature on alphabetic languages, children’s reading comprehension is affected by both word-level reading-related skills, such as word reading efficiency and vocabulary knowledge (Perfetti, 1999; Perfetti & Hart, 2001; Shankweiler, Lundquist, Katz, Stuebing, Fletcher, Brady et al., 1999), and text-level processing skills, such as syntactic and discourse skills (Bishop & Snowling, 2004), working memory capacity, etc. (Oakhill & Cain, 2004; Oakhill, Cain, & Bryant 2003; Perfetti, 1999; Perfetti & Hart, 2001). However, the interrelationships among those word-level and text-level reading-related skills in explaining individual differences in reading comprehension, specifically in different phases of children’s reading development, has yet to be demonstrated (Lerikkanen, Rasku-Puttonen, Aunola, & Nurmi 2004).

Reading comprehension and its associated skills have rarely been examined in Chinese until very recently (e.g., Leong, Hau, Tse, & Loh 2008 on the role of verbal working memory in Chinese children’s reading comprehension in elementary schools; Leong & Ho, 2008 on the role of lexical knowledge in secondary schools). There are even fewer studies that have attempted to show the characteristics of reading comprehension and its related skills in Chinese dyslexic children, as distinct from that of typically developing children. More recently, Ho and her colleagues have showed that Chinese dyslexic children performed less well than average readers matched on reading level in learning irregular words over trials but not the regular ones (Ho, Chan, Tsang, Lee, & Chung 2006); and most of them were found performing poorer than expected of their age in rapid naming and orthographic processing tasks (Ho, Chan, Lee, Tsang, & Luan 2004). Further investigation into text comprehension and its associated cognitive and reading-related skills between dyslexic and typically developing children should be revealing.

The role of verbal working memory for reading comprehension

Working memory refers to a short-duration and limited capacity memory system which is capable of maintaining information (the storage aspect) and at the same time working on

the same or other information (the processing aspect) on completing a task (Bradley, 1986; Bradley & Hitch, 1994). It has been considered as fundamental to building up a mental representation of information in reading comprehension (Just & Carpenter, 1980); in particular, to allocating processing resources in supporting initial interpretation of sentence meaning (including the assignment of syntactic structure) and maintaining the use of sentence meaning to accomplish verbal tasks (Caplan & Waters, 1999). Following from this line, it is hypothesized that poor lower level word reading processes may consume more processing resources, thus leaving insufficient resources for higher level comprehension processes and resulting in poor comprehension (Perfetti, 1985; Perfetti & Hart, 2001; Swanson & Berninger, 1996).

The early investigations by Daneman and colleagues provided support for the hypothesized relationship between verbal efficiency and working memory resource allocation. In their correlational studies, Daneman and Carpenter (1980; 1983) measured working memory by a reading span test. In this test, participants were required to understand groups of unrelated sentences; and for each group, to answer a related comprehension question, while at the same time, recalling the final word of each sentence in the group. The results showed that good comprehension skills (such as recalling facts, identifying inconsistencies, and resolving pronouns from a passage) were often associated with good verbal storage and processing; and vice versa. Daneman and Merikle (1996) further concluded from a meta-analysis that there is a strong linear relationship between verbal working memory and reading comprehension.

More recent research has repeatedly indicated that verbal working memory is strongly predictive of children's reading comprehension in alphabetic writing systems (e.g., Cain, Oakhill, & Bryant 2000, 2004; Oakhill, Cain, & Yuill 1998; Swanson, 1999; Yuill & Oakhill, 1991). It has also been demonstrated that children with developmental dyslexia do not have sufficient capacities for storage and processing (Berninger et al., 2006; Pickering, 2006; Swanson, 2006; Vellutino, Fletcher, Snowling, & Scanlon 2004).

In non-alphabetic languages, Leong and colleagues have recently investigated the role of verbal working memory in Chinese reading comprehension among third to fifth graders (Leong et al., 2008) and less competent comprehenders (Leong, 2007). In both studies, results of structural equation modeling and multiple regression analyses showed that verbal working memory span had the strongest predictive power for Chinese reading comprehension than that of RAN and phonological segmentation. Yet, their studies were set within the context of a few word-level processing skills. The present study further investigated the role of verbal working memory in Chinese reading comprehension in a wider context that encompasses both word- and text-level skills.

#### Word-level reading-related skills: oral vocabulary and word semantics

The relationship between oral language skills and reading comprehension is captured in the "simple view" of reading (Gough & Tunmer, 1986; Hoover & Gough, 1990; Tunmer & Hoover, 1992). In this model, reading comprehension is taken as a product of decoding and listening comprehension (or oral language). Despite its widespread acceptance and empirical support to its hypothesis (Gough & Tunmer, 1986; Hoover & Gough, 1990; Hoover & Tunmer, 1993; Perfetti, 1985; Snowling, 2000; Stanovich, 1991), some researchers doubt if listening comprehension can fully capture the influence of specific language skills, such as vocabulary (e.g., Braze, Tabor, Shankweiler, & Mencl 2007). In particular, the flexibility to include various aspects of linguistic knowledge in defining listening comprehension is considered as problematic for identifying specific aspects of oral

language that are relevant to reading (Ouellette & Beers, 2009). Evidence may be drawn from some recent studies, in which oral vocabulary remained a significant predictor of reading comprehension, after controlling for word reading skills (Ouellette, 2006; Ricketts, Nation, & Bishop 2007), or when the effects of initial word reading, phoneme awareness, and letter knowledge were partialled from the analysis (Muter, Hulme, Snowling, & Stevenson 2004).

In a recent study, Ouellette (2006) tried to differentiate between the breadth and depth of oral vocabulary in examining their influence on different reading skills. In this study, the breadth of oral vocabulary was measured by the number of words the fourth graders could tell in the receptive and the expressive vocabulary tasks, whereas the vocabulary depth was assessed by how well they knew the meanings of the words presented in the word definition and synonym judgment tasks. The results suggested that after the effects of age and IQ were controlled, only depth of oral vocabulary had a significant unique contribution to reading comprehension, whereas receptive vocabulary breadth and expressive vocabulary breadth remained to be significant in predicting decoding and visual word recognition respectively. Similar findings were observed in other studies (e.g., Roth, Speece, & Cooper 2002; Snow et al., 1995) in which oral vocabulary as measured by definitional tasks was shown to be a strong predictor for reading comprehension in early years of schooling.

The important role of oral vocabulary, especially the depth aspect, in reading comprehension, as highlighted in the above-mentioned studies, is compatible with the theoretical postulations that comprehension may be linked to the semantic side or the quality of lexical representations (Perfetti, 1999; Perfetti & Hart, 2001). Likewise, the ability to derive meanings from printed words (through the orthography-semantic pathway), has also been identified as vitally important to reading other than phonology in the “triangle” model proposed by Seidenberg and colleagues (Plaut, McClelland, Seidenberg, & Patterson 1996; Seidenberg & McClelland, 1989). Bishop and Snowling (2004) have further claimed that children weak at using this semantic pathway to make sense of the meaning of words would perform poorly in reading comprehension as well. Their claim was seemingly supported by the recent research studies on the antecedents of reading comprehension among poor comprehenders. The results of these studies showed that poor comprehenders performed significantly less well than the age-matched controls in their semantic skills, as measured by synonym judgment and illustration of semantic categories (Nation & Snowling, 1998), word definitions and similarities (Nation, Clarke, Marshall, & Durand 2004), and recall of abstract semantic associations of words (Weekes, Hamilton, Oakhill, & Holliday 2008); but not in their phonological or orthographic skills.

In Chinese, findings of a handful of reading research studies suggest that semantic skills is a good predictor of children’s reading, especially in senior grades with the growth of reading skills in the early stage of literacy development (Chen, Lau, & Yung 1993; So & Siegel, 1997). This may be related to the central role of semantics in the morpho-syllabic orthography of Chinese. As shown in recent studies on Chinese developmental dyslexia, instead of phonological awareness, orthographic skills as measured by lexical decision and radical knowledge in Chinese reading (e.g., Ho, Ng, & Ng 2003; Shu, Anderson, & Wu 2000; H. Yang & Peng, 1997) and morphological skills, especially in terms of homophone awareness and morpheme construction (e.g., Ku & Anderson, 2003; Li, Anderson, & Zhang 2002; McBride-Chang & Ho, 2005; Shu, Anderson, & Zhang 1995; Shu, McBride-Chang, Wu, & Liu 2006) were shown influential to learning to read Chinese. When testing their computation models, Yang et al. (2006) also noted that while the “triangle” model is applicable to reading in Chinese as in English, more rapid learning of the mappings from orthography to semantics than that from orthography to phonology

in Chinese has been observed. Examining the contribution of semantic skills to Chinese reading comprehension should therefore be of great importance.

#### Text-level reading-related skills: syntactic and discourse skills

Syntactic skills represent the ability to recognize and use the grammatical structures in a language (Gombert, 1992, p. 32). Despite the long established central role of phonological skills in reading in alphabetic languages, it has been repeatedly shown that syntactic skills (as measured by oral cloze, word order, or judgment/error correction task) remained to be a strong predictor of reading comprehension, after controlling for the variance of phonological awareness (Deutsch & Bentin, 1996; Gombert, 1992; Muter et al., 2004; Nation & Snowling, 2000; Plaza, 2001; Plaza & Cohen, 2003, 2004). Muter et al. (2004) have further suggested that when children grow older, syntactic skills, alongside with semantic skills, become more influential in reading comprehension than word decoding. Research on poor readers and children with reading disabilities has also indicated a significant lag in these children's development of grammatical sensitivity or syntactic competence (Bentin, Deutsch, & Liberman 1990; Siegel & Ryan, 1988; Snowling, Gallagher, & Frith 2003; Tunmer, Nesdale, & Wright 1987), besides a greater deficit in phonological processing skills and/or a poorer short-term memory.

The literature about syntactic processing and reading comprehension is relatively thin in Chinese. Yet, the independent role of syntactic skills in text-level reading in the language is well supported by empirical studies. Besides the increasing significance of semantic skills from junior to senior grades, the above-mentioned study by Chen et al. (1993) also demonstrated that syntactic skills (in terms of word insertion and detection of grammatical error in a sentence) in Chinese reading remained important from Grade 1 up to Grade 6. Similar findings were observed in So and Siegel's study (1997) in which both phonological and syntactic skills were strong predictors of children's word reading performance in the early grades, whereas semantic skills became predictive for reading in Grade 4. Despite somewhat different tasks being used in the two studies, their results have provided positive indication that syntactic skills appear to be at least as important as phonological ones.

Consistent with the above lines of research studies, Bishop and Snowling (2004) propose an extension of the "triangle" model of reading by taking into consideration the contextual significance of syntactic skills in facilitating readers' understanding of the meanings embedded within particular sentence structures. They have also argued that in order for the readers to be able to comprehend a passage, it is important for them to develop proper discourse skills in drawing inferences between sentences that together form a meaningful discourse. Their claims are supported by the evidence from a branch of studies that focus on children's reading comprehension and narrative production (Cain, 2003; Cain & Oakhill, 1996; Shapiro & Hudson, 1991). In these studies, children with reading comprehension difficulties often demonstrated deficits in two important elements of narrative production, namely the structural coherence (event structure) and the linguistic cohesion (the use of cohesive devices to show the semantic and logical relations between clauses and sentences) of story organization.

There is a high relevance of syntactic and discourse skills to Chinese reading comprehension, given the characteristics of Chinese syntax. Unlike alphabetic languages such as English, there is no inflectional system, such as subject-verb agreement and case marking in Chinese (Li & Thompson, 1981). Therefore, instead of morphological transformations in alphabetic languages, morphosyntax or word compounding is used to show tense, number, and degree. For example, Chinese has in general no plural form of

nouns. Characters like 狗, 椅, 菜 can denote either singular or plural form—*dog/dogs*, *chair/chairs*, and *vegetable/vegetables*. To decide the plurality of these characters require the reader to look for more syntactic information from the given linguistic constituents (e.g., quantifiers like 一些 *some*, 許多 *many*) or their semantic relationships within and among sentences in the text (e.g., 把椅子排成一列 *Put the chair(s) in a row*). Thus, reading to understand Chinese texts meant for the reader to be able to solicit syntactic information from the given linguistic constituents and their semantic relationships within and among sentences in the text (Chao, 1968; Li & Thompson, 1981). Specifically, Chinese is a topic-prominent language (Chao, 1968; Li & Thompson 1981). Once a topic word or phrase has been established, it can be extended across succeeding sentences. In other words, although the canonical word order in written Chinese is Subject–Verb–Object, as that in English, the subject noun/phrase can be omitted given that a topic has been established among a group of sentences, for example: 瑪莉我見過了。很漂亮。也很能幹。 *Mary [the topic] I have just met. [The topic, i.e., Mary is] Very pretty. [The topic, i.e., Mary is] Very capable as well.*

### Aims of the present study

As mentioned earlier, relatively few attempts have examined the association of Chinese text comprehension with cognitive and reading-related skills in Chinese children, especially children with dyslexia. As indicated in the past research, there is a range of cognitive skill (verbal working memory), word-level reading-related skills (oral vocabulary and word semantics), and text-level reading-related skills (syntactic and discourse skills) that have been shown significant or highly relevant to comprehending Chinese texts, given the characteristics of the writing system. The present study was set out to examine these skills among Chinese dyslexic and typically developing children in elementary schools in an attempt to address the following questions: (1) what are the important cognitive and reading-related skills for Chinese reading comprehension at junior elementary grade levels (Grades 1 to 3) and senior ones (Grades 4 to 5)? (2) Do Chinese dyslexic children perform significantly poorer in text reading comprehension and text-level reading-related skills than expected of their age? (3) Is there any difference between the predictors for reading comprehension in Chinese dyslexic and typically developing children in junior and senior elementary grades?

To answer the above questions, different groupings of children in the sample were used in this study. For Question (1), we focus on typically developing children in junior grades (Grades 1 to 3) and senior grades (Grades 4 to 5). Dyslexic children in Grades 3 to 5 were compared with their reading level controls in Grades 1 to 4 and the same-aged controls in Grades 3 to 5 on various tasks for Question (2), whereas predictors for reading comprehension in Chinese dyslexic children in senior grades (Grades 4 to 5) were compared with those for typically developing children in junior grades (Grades 1 to 3) and senior grades (Grades 4 to 5) to trace for possible different developmental patterns of the dyslexic participants in reading comprehension related skills, i.e., Question (3).

It is expected that both verbal working memory and the word-level reading-related skills would be predictive of reading comprehension in typically developing children in junior elementary grades, who are in the initial stage of acquiring the language in formal settings. While the influence of verbal working memory should remain for the senior graders, it is anticipated that the text-level reading-related skills would begin to show importance since they are gradually exposed to more and more advanced features of the language. It is also expected that Chinese dyslexic children would perform less well than expected of their age in reading comprehension and both word- and text-level reading-related skills.

## Method

### Participants

There were altogether 303 Hong Kong primary school children taking part in this study and they were divided equally into three groups (the Dyslexia group, the Chronological age control group, and the Reading level control group). The dyslexic children were recruited from 15 local primary schools. Their mean age was 9 years and 9 months. All of them had normal intelligence (with IQ 80 or above). Their literacy composite score and at least one cognitive composite score were at least one standard deviation below their respective age means in the Hong Kong Test of Specific Learning Difficulties in Reading and Writing (HKT-SpLD). The HKT-SpLD is a diagnostic tool developed to identify Hong Kong primary school students with dyslexia by assessing their literacy and cognitive functioning (Ho, Chan, Tsang, & Lee 2000). The children were carefully screened to ensure that they had sufficient learning opportunities (for instance, new immigrants were excluded) and they did not have any suspected brain damage, uncorrected sensory impairment, serious emotional, or behavioral problems.

The two control groups were typically developing children recruited from the same participating schools. These children had grade-appropriate reading achievement and normal intelligence. They were carefully selected to match on age, IQ, and reading level of those in the Dyslexia group (see Table 1). All the children in this study spoke Cantonese. Cantonese was used as the medium of instruction in school though Mandarin and Pin-yin were often taught as a subject in school.

### Materials and procedures

All the children in this study were assessed on a nonverbal intelligence test, a Chinese word reading test, two reading comprehension tasks, a verbal working memory task, two tasks on word-level reading-related skills (oral vocabulary and word semantics), and three tasks on text-level reading-related skills (word order, morphosyntax, and discourse skills). Materials of the verbal working memory task and those on word-level and text-level reading-related skills were recorded and presented orally to the children through MP3 players during testing. All the tasks were conducted in Cantonese.

*Raven's Standard Progressive Matrices* The participants' nonverbal intelligence was assessed by the Raven's Standard Progressive Matrices. This is a standardized test with five sets of 12 items each. Each item consisted of a target matrix with a missing piece.

**Table 1** Characteristics of the three groups of participants

Characteristic or task	Dyslexics ( <i>n</i> =101) M (SD)	CA controls ( <i>n</i> =101) M (SD)	RL controls ( <i>n</i> =101) M (SD)	<i>F</i> (2, 300)	Post hoc
Age (in months)	117.26 (11.14)	116.85 (10.52)	92.73 (13.92)	139.50*	D = CA, D > RL
IQ	101.74 (11.01)	101.53 (10.63)	103.49 (11.01)	.98	D = CA = RL
Chinese word reading	85.50 (29.95)	125.11 (12.10)	86.51 (28.03)	84.47*	D < CA, D = RL

*CA controls* children matched on chronological age, *RL controls* children matched on reading level

\**p*<0.05

Children were required to pick, from six to eight alternatives, the best piece to complete the target matrix. The short form of the test, made up of the first three sets of the full form, was administered to participants of less than 8.5 years old and the full form to 8.5 years and older children in the present study. Scoring procedures were based on the local norm established by the Education Department of The Hong Kong Government in 1986.

*Chinese word reading* The Chinese Word Reading subtest of the HKT-SpLD (Ho et al., 2000) was used to assess the children's Chinese word reading performance. This is a standardized test with local norms. The children were asked to read aloud 150 Chinese two-character words in the order of graded difficulty. The test was discontinued when the child failed to read 15 words consecutively. One point was given to each correctly read word.

*Sentence reading comprehension* In this task, there were two parts, each with one practice and 15 test sentences. Part 1 consisted of cloze sentences in which a noun, a verb or an adjective was missing. The children were asked to choose, from four choices, the word that best completed each sentence. In each sentence of Part 2, the children were required to select, from four options, the word that best replaced an unfamiliar word highlighted. One point was given for each correct answer.

*Passage reading comprehension* In this task, the children were asked to read in silence a total of five narrative or expository passages. The passage lengths varied between 67 and 130 Chinese characters. To ensure that the texts are readable to all participants, words used were familiar to children in early grades according to The Hong Kong Corpus of Primary School Chinese by Leung and Lee (2002). For each passage, children were asked to answer questions in either the multiple choice or open-ended format. Two practice items were given to the participants before the testing ones. One point was awarded for each correct answer to the multiple-choice questions and at maximum, two points for the open-ended questions which contained one or two main ideas. The full mark of this task was 24.

*Verbal working memory* This task was adapted from Leong and Ho (2008) to assess children's verbal working memory capacity, by requiring them to hold increasing verbal information in memory (the memory component) while doing comprehension (the processing component). In this task, five items consisting of one to five prerecorded sentences, all unrelated in meaning, were played to individual participants one by one. The participants were asked to first listen to the sentence(s), then answer a comprehension question about those sentence(s) and finally, repeat the last word in each sentence aloud. Three practice items were given to each participant before formal testing. One point was given to each correctly recalled word yielding a maximum score of 11 points.

*Oral vocabulary* In this task, each child was presented a set of eight two-character Chinese words familiar to primary school children. The child was asked to use the target word to construct a sentence that could elaborate the meaning of the word. The children had two practice trials before the testing trials. Their answers were audio-recorded and scored on a two-point scale: one point for correct usage of the word and another for proper elaboration of the meaning of the word in the sentence.

*Word semantics* There were one practice and 12 items of multiple-choice format in this task. The words used were all two-character Chinese words familiar to primary school children. In each item, the children first heard the target word and were asked to choose,

among three options, the one that was semantically identical or very similar to the target word (e.g., 美麗 *beautiful* and 漂亮 *pretty*). There were, two distracters in the options: semantic distracter, which had a meaning close to the target word in scope, but differed in the context of usage (e.g., 美麗 *beautiful* and 優雅 *elegant*); and morphemic distracter, which shared the same morpheme (i.e., same character) with the target word, but being different in both meaning scope and usage (e.g., 美麗 *beautiful* and 美味 *delicious*). One point was given for each correct answer.

*Word order* This task was used to measure children's knowledge of some basic Chinese sentence structure rules (e.g., subject–verb–object, subject–verb–verb, and special sentence types, such as using “ba [把]”, etc.) and the use of connectives in complex sentences (see two examples below). There were a total of 15 items and the children were asked to arrange four to six sentence fragments into a syntactically correct sentence. One point was given to each correctly ordered sentence.

Example 1: (1) 弟弟 younger brother/(2) 足球 football/(3) 正在玩 is playing

Answer: (1) (3) (2)

Example 2: (1) 把 Ba [I could have]/(2) 可以看電視了 watch television/(3) 功課做好 done my homework/(4) 我就 I could/(5) 只要 only if。

Answer: (5) (1) (3) (4) (2)

*Morphosyntax* This task aimed at measuring children's skills in detecting and correcting morphosyntactic errors in Chinese sentences. There were two parts in this task, both with one to two practice trials. Part 1 consisted of four items, each with a certain basic part of speech (subject, verb, or object) being missed out in a sentence (e.g., 中秋節, 我們一家到公園裏賞月、吃月餅和燈籠。 In Mid-Autumn festival, our family went to a park to admire the full moon, eat moon cakes and lanterns.). Children were asked to insert an arrow at the place where they thought a word was missing in the sentence and then provide the correct missing word (i.e., In Mid-Autumn festival, our family went to a park to admire the full moon, eat moon cakes and [^ play] lanterns.). There were eight items in Part 2, each with a sentence that contained an error in word compound (e.g., 王老師很青年 Miss Wong is very youth.). The children were asked to circle the error (i.e., 青年 youth) and provide a correct word (i.e., 年青 young). The maximum score of each item in both parts was three points: one point for correct identification of the error only, two points for correct identification and syntactically proper (but semantically inappropriate) correction, and three points for completely correct answers.

*Discourse skills* This task intended to measure children's skills in drawing inferences between sentences that together form a coherent and meaningful discourse. In each of the 10 items, the children were asked to arrange three to five sentences into a coherent and meaningful discourse, which was either a narration of events or an elaboration of procedures or facts (see Example 3 below). Two practice items were given to the participants before formal testing. One point, two points, and three points were given for correctly ordered three-sentence, four-sentence, and five-sentence items, respectively. The maximum score of this task was 20 points.

Example 3: 1. 然後, 拿起杯子。 Then, pick up [the] glass [of water].  
2. 最後加上蓋子。 Finally, cover [it] with a lid.  
3. 首先, 把水倒進杯子裏。 First, pour water into [a] glass.

Answer: (3) (1) (2)

## Results

### Group comparisons

Table 2 presents the means, standard deviations, reliability (in terms of Cronbach's alpha coefficients), and the results of MANOVA for various measures in this study. In general, the reliability coefficients were acceptable ranging from 0.56 to 0.88. The results of MANOVA and separate ANOVAs showed that the main effects of group were significant for all the measures in this study (all  $F$ 's > 20.3, all  $p$ 's < 0.001). The post hoc comparisons with Tukey's test further showed that the Dyslexia group performed significantly less well than the CA control group but similarly with the RL group in all the measures except oral vocabulary. Dyslexic children outperformed younger average readers in oral vocabulary.

### Partial correlation analyses

In order to show the interrelationships among different variables in children at different developmental stages, correlation coefficients among various measures controlling for the effect of age and IQ were computed for the dyslexic children in the senior grades (Grades 4 to 5), and typically developing children in the junior grades (Grades 1 to 3) and senior grades (Grades 4 to 5). The results are shown in Table 3. A composite score of Chinese reading comprehension was computed by taking the average  $z$  scores of the sentence and passage comprehension tasks, given that performance of these two measures was strongly correlated ( $r=0.71$ ).

**Table 2** Results of MANOVA on various measures among the dyslexia (D), reading level control (RL) and chronological age control (CA) groups

Measure (max. score)	Reliability coefficient	Dyslexics ( $n=$ 101)	CA controls ( $n=$ 101)	RL controls ( $n=$ 101)	$F(2, 299)$	Post hoc
		M (SD)	M (SD)	M (SD)		
Sentence comprehension (30)	0.88	12.54 (5.72)	20.93 (4.33)	11.89 (5.74)	91.24***	D < CA, D = RL
Passage comprehension (24)	0.82	11.76 (4.74)	17.61 (2.62)	11.66 (4.71)	68.29***	D < CA, D = RL
Oral vocabulary (16)	0.56	7.31 (3.00)	8.36 (2.67)	5.75 (3.07)	20.34***	D < CA, D > RL
Word semantics (12)	0.75	6.58 (2.57)	9.49 (1.99)	6.12 (2.62)	57.80***	D < CA, D = RL
Word order (15)	0.80	9.85 (2.98)	12.94 (1.51)	9.32 (3.33)	52.22***	D < CA, D = RL
Morphosyntax (36)	0.75	18.04 (7.06)	25.97 (5.27)	16.51 (6.88)	62.59***	D < CA, D = RL
Discourse skills (20)	0.69	8.64 (3.73)	13.07 (3.17)	8.03 (3.69)	60.88***	D < CA, D = RL
Verbal working memory (14)	0.59	6.17 (2.40)	7.73 (2.13)	5.45 (2.62)	24.12***	D < CA, D = RL

CA controls children matched on chronological age, RL controls children matched on reading level

\*\*\* $p < 0.001$

**Table 3** Partial correlation coefficients among various measures after controlling for the effect of differences in age and IQ for different groups of children in this study

Variable	1	2	3	4	5	6	7
Dyslexic children in senior grades (G4 to G5) ( $n=59$ )							
1 Chinese word reading	–						
2 Reading comprehension (composite score)	0.60**	–					
3 Oral vocabulary	0.34*	0.44**	–				
4 Word semantics	0.45**	0.63**	0.35**	–			
5 Word order	0.53**	0.58**	0.44**	0.51**	–		
6 Morphosyntax	0.34**	0.56**	0.32*	0.47**	0.38**	–	
7 Discourse skills	0.59**	0.73**	0.17	0.42**	0.56**	0.53**	–
8 Verbal working memory	0.05	0.25	0.19	0.17	0.16	0.14	0.09
Typically developing children in junior grades (G1 to G3) ( $n=119$ )							
1 Chinese word reading	–						
2 Reading comprehension (composite score)	0.53**	–					
3 Oral vocabulary	0.26**	0.42**	–				
4 Word semantics	0.33**	0.52**	0.30**	–			
5 Word order	0.50**	0.52**	0.16	0.33**	–		
6 Morphosyntax	0.38**	0.55**	0.37**	0.46**	0.47**	–	
7 Discourse skills	0.45**	0.64**	0.13	0.42**	0.59**	0.58**	–
8 Verbal working memory	0.27**	0.36**	0.26**	0.21*	0.28**	0.24*	0.33**
Typically developing children in senior grades (G4 to G5) ( $n=83$ )							
1 Chinese word reading	–						
2 Reading comprehension (composite score)	0.37**	–					
3 Oral vocabulary	0.21	0.21	–				
4 Word semantics	0.30**	0.20	0.14	–			
5 Word order	0.26*	0.34**	0.34**	0.25*	–		
6 Morphosyntax	0.28*	0.53**	0.19	0.19	0.37**	–	
7 Discourse skills	0.37**	0.49**	0.18	0.19	0.31**	0.28*	–
8 Verbal working memory	0.15	0.21	0.16	0.23*	0.25*	0.21	0.23*

\* $p < 0.05$ ; \*\* $p < 0.01$ 

As shown in Table 3, the correlation coefficients of the scores demonstrated strong relationships of Chinese reading comprehension with both the word-level (oral vocabulary and word semantics) and text-level skills (word order, morphosyntax, and discourse skills), but not with verbal working memory among the dyslexic children. Slightly different patterns were observed among the typically developing children in the junior and senior grades. In the typically developing children of junior grades, significant correlations were found not only between Chinese reading comprehension and word- and text-level skills, but also between Chinese reading comprehension and verbal working memory. However, in typically developing children of senior grades, significant relationships were only found between Chinese reading comprehension and text-level reading-related skills (word order, morphosyntax, and discourse skills).

## Multiple regression analyses

To identify the significant predictors of reading comprehension for Chinese dyslexic children and typically developing children at different developmental stages, three sets of multiple regression analyses were conducted for three groups of participants: dyslexic readers in the senior grades, typically developing children in the junior grades and senior grades. In each set of analysis, age, IQ, and Chinese word reading were entered in the equation first as control variables. Verbal working memory and various word-level and text-level reading-related skills were entered as the final step predictors. Table 4 summarizes the results of these regression analyses.

Among the dyslexic children, their age, IQ, and Chinese word reading scores accounted for 46.5% of variance of their Chinese reading comprehension score, while their verbal working memory and the reading-related skills together explained for an additional variance of 30.8%,  $F(6,49)=11.05$ ,  $p<0.001$ . Among the six final step predictors, oral vocabulary, word semantics, and discourse skills had significant unique contributions to Chinese reading comprehension (all  $\beta_s>0.16$ , all  $p_s<0.05$ ).

Among the typically developing children of the junior grades, age, IQ and Chinese word reading scores explained 63.3% of the variance of their Chinese reading comprehension. An additional contribution of 16.3% was made by their verbal working memory and the two levels reading-related skills,  $F(6,109)=14.60$ ,  $p<0.001$ . Similar to the results for dyslexic children in senior grades, oral vocabulary, word semantics, and discourse skills remained to be significant predictors of Chinese reading comprehension in the final step (all  $\beta_s>0.15$ , all  $p_s<0.05$ ).

In typically developing children of senior grades, verbal working memory and the reading-related skills together accounted for an additional 25.5% of variance of Chinese reading comprehension ( $F(6,73)=6.15$ ,  $p<0.001$ ), beyond that by their age, IQ and Chinese word reading scores. Unlike the results for the other two groups, only the unique contributions of discourse skills ( $\beta=0.30$ ,  $p<0.01$ ) and morphosyntax ( $\beta=0.39$ ,  $p<0.001$ ) remained to be significant for predicting Chinese reading comprehension.

**Table 4** Multiple regression equations predicting Chinese reading comprehension from various measures after control of age, IQ, and Chinese word reading

Final step predictor	Dyslexics in Grades 4 to 5 ( $n=59$ )			Typically developing children in Grades 1 to 3 ( $n=119$ )			Typically developing children in Grades 4 to 5 ( $n=83$ )		
	B	SE B	$\beta$	B	SE B	$\beta$	B	SE B	$\beta$
Verbal working memory	0.03	0.02	0.11	0.02	0.02	0.05	0.00	0.02	0.02
Oral vocabulary	0.05	0.02	0.17*	0.05	0.02	0.19**	0.01	0.02	0.03
Discourse skills	0.10	0.02	0.49***	0.08	0.02	0.34***	0.04	0.01	0.30**
Word semantics	0.08	0.03	0.25**	0.05	0.02	0.16*	0.00	0.02	0.01
Morphosyntax	0.01	0.01	0.08	0.01	0.01	0.06	0.03	0.01	0.39***
Word order	0.00	0.03	0.01	0.02	0.02	0.08	0.01	0.03	0.05

\*\*\* $p<0.001$ ; \*\* $p<0.01$ ; \* $p<0.05$

## Discussion

To reiterate, the present study attempts to enrich the current reading literature by examining the contributions of a range of cognitive and word- and text-level reading-related skills to Chinese reading comprehension. In particular, it aims to identify important predictors for typically developing and dyslexic Chinese children at different developmental stages. In what follows, we discuss the significance and implications of the key findings of the present study.

### Significant predictors of reading comprehension in Chinese

In the present study, two sets of multiple regression analyses were performed to identify important skills for predicting reading comprehension in Chinese typically developing children of junior and senior grades. The results show both similarities and differences in what appeared to be important predictors for reading comprehension in these two groups of children. Among all the final step predictors, discourse skills was the sole factor that had significant unique contributions to reading comprehension in both groups of children.

The significance of discourse skills for Chinese reading comprehension of typically developing children at different developmental stages may be related to the high relevance of children's story or narrative understanding to their development of reading comprehension (Perfetti, Landi, & Oakhill 2005). Specifically, understanding about narrative structure of written texts pertains to children's mastery of structural coherence (event structure) and linguistic cohesion (the use of cohesive devices to show the semantic and logical relations between clauses and sentences) of story organization. For example, less skilled comprehenders were less able than skilled ones in producing appropriate causal connectives or referential ties in narrating a given picture sequence (Yuill & Oakhill, 1991); and in putting up a well-structured story when given a title (Cain & Oakhill, 1996).

Thus, children's performance in the discourse skills task may reflect their sensitivity of text coherence, and knowledge about cohesive devices and discourse markers. As in the discourse skills task, the children were required to arrange the shuffled sentences into a coherent discourse. In doing so, they had to pay attention to the cohesive devices, such as causal connectives and some particular story features, such as time and sequence markers. How sensitive children are in detecting those devices and features then forms a good index of their ability in reading to comprehend the meaning and logic of a given text.

Mastery of this kind of discourse skills may be of particular importance for understanding Chinese texts. As mentioned earlier, the Chinese writing system is characterized by the extensive use of connectives (Liu, 1999) and allows omissions of subject nouns/phrases across succeeding sentences (Chao, 1968; Li & Thompson 1981). Therefore, discourse skills that encompass readers' understanding of what specific linguistic devices (such as pairs of connectives) mean and skills to follow the semantic traces between sentences are crucial to make sense of Chinese texts.

Differences were, however, noted in predictors other than discourse skills that had unique significant contributions to the typically developing children of junior and senior grades in the present study. The word-level reading-related skills of oral vocabulary and word semantics remained to be strongly predictive of reading comprehension for the Chinese typically developing children at junior grades, after controlling for their age, IQ, and Chinese word reading scores. But they were no longer predictive for reading comprehension of their counterparts at senior grades. Instead, reading comprehension of the senior graders was largely accounted by the text-level reading-related skill of morphosyntax.

These findings support the existing literature on alphabetic languages that word semantic skills (as measured as word meaning elaboration in the oral vocabulary task and as synonym judgment) is an important factor differentiating children's performances on reading comprehension in early grades (e.g., Roth et al., 2002; Snow, Tabors, Nicholson, & Kurland 1995) and between good and poor comprehenders (e.g., Nation et al., 2004). Developmentally, beginning readers are in the stage of vocabulary building and rely much on word semantic cues to comprehend the meaning of given texts. In comparison, older children may have moved away from looking for clues at word level, to paying more attention to advanced features in morphosyntax in reading comprehension.

Unlike those in Leong et al. (2008) study, one unexpected finding of the present study was that verbal working memory did not appear to be a strong predictor for Chinese reading comprehension in any group of our children. One possibility may be due to the fact that in their studies, Leong and his colleagues have controlled for Chinese pseudo word reading, instead of real word reading as we did in the present study. The use of real word reading as a control measure in the present study may have absorbed some of the contribution of verbal working memory to children's reading comprehension, since both may engage the reader in similar processes of recalling word pronunciations and meaning. For example, in the word reading test, the children were required to recognize a bank of two-character words in print, recall their pronunciations, and then read aloud each of them. In the verbal working memory test, they were also required to recognize and reproduce some two-syllable words, but this time, from acoustically presented groups of sentences. The role of pseudo word reading in Chinese reading comprehension has yet to be explored (Leong et al., 2008).

### Reading comprehension in Chinese dyslexic children

Another set of multiple regression analyses was conducted to examine the important predictors of reading comprehension in Chinese dyslexic children of senior grades. Discourse skills were found to be a strong predictor for reading comprehension of these children, as it was for typically developing children. The two word-level reading-related skills, i.e., oral vocabulary and word semantics, also had significant unique contributions to reading comprehension of the Chinese dyslexic children, similar to the predictors for the younger, typically developing children. But unlike the case for typically developing children in the senior grades, no significant unique contribution of morphosyntax, one of the text-level reading-related skills, was found for the dyslexic children.

Together with the group comparison results (see Table 2), the above finding suggests that Chinese dyslexic children at Grades 4 and 5 perform less well in reading comprehension than expected of their age and they may still rely more on word-level reading-related skills than text-level reading-related skills for reading comprehension like what younger children do. Unlike same-age typically developing children, dyslexic children do not rely that much on morphosyntax skills for text comprehension. In understanding a passage, Chinese dyslexic children tend to rely on meaning of individual words as cues rather than semantic and syntactic interrelationships among words or sentences.

The finding that Chinese dyslexic children are performing like younger typically developing children may suggest a relatively slow rate of word decoding in these children to support their development of higher level and integrative skills required for text comprehension in senior grades. It is expected that Chinese dyslexic children may use more advanced text-level skills, like morphosyntax skill, when they have gained more reading experience later. This suggestion calls for validation in future research.

## Conclusions

The present study aimed at identifying the predictors of reading comprehension in Chinese typically developing and dyslexic children. Developmentally, children of junior elementary grades rely heavily on word-level reading-related skills, namely oral vocabulary and word semantics, for text comprehension. They have also acquired some discourse skills for understanding the general organization and schema of passages. Children of senior elementary grades rely more on advanced text-level reading-related skills, like morpho-syntax, than word-level skills for text comprehension. Discourse and morphosyntax skills are particularly important for Chinese with the unique features of non-inflectional and topic-prominent writing system which necessitates the mastery of text coherence and use of cohesive devices.

The reading comprehension pattern of Chinese dyslexic children is more like younger typically developing children than those of the same age, and this suggests a possible delay of Chinese dyslexic children in developing appropriate reading-comprehension-related skills.

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