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Character and word reading in Chinese: Why and how they should be considered uniquely vis-à-vis literacy development

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ABSTRACT

Two correlational studies from the same data set demonstrated the distinctiveness of character and word reading for Chinese reading development among 337 Hong Kong Chinese children in grades 1–3. Study 1 examined the cognitive-linguistic correlates of single-character reading and two-character word reading. Rapid automatized naming, morphological awareness and visual-orthographic skill independently explained variance in both character and word reading beyond age, grade, nonverbal IQ and vocabulary knowledge. Importantly, rapid automatized naming and morphological awareness additionally explained variance in word reading even after statistically controlling for character reading; there were no such unique correlates for character reading beyond word reading. Study 2 investigated the roles of character and word reading in reading comprehension. Both were individually significantly associated with reading comprehension even when a multifaceted measure of language comprehension was statistically controlled. Moreover, character reading and language comprehension significantly explained variance in reading comprehension through word reading; word reading and language comprehension uniquely contributed to reading comprehension in the model. Results suggest that character and word reading likely reflect slightly different processes in Chinese literacy: Theoretically, these results underscore the importance of models of reading that integrate unique features of Chinese. Practically, these results suggest that character and word reading may depend on different cognitive-linguistic processes which can be cultivated when teaching them, separately or together.

1. Introduction

For years, many studies of Chinese literacy development have interchangeably used character reading and word reading to measure children's reading skills (e.g., Cheng et al., 2017; McBride-Chang et al., 2003; Shu et al., 2006; Yeung et al., 2011). Character reading measures the ability to recognize a list of single Chinese characters (e.g., Shu et al., 2006); word reading tasks generally test the skills of recognizing two-character words (e.g., Yeung et al., 2011). Each of these has been accepted as representing word reading skill in many studies. In Chinese, the concept of "word" is difficult to define (McBride, 2016a), and some individual Chinese characters are words, though others are not (Shu et al., 2003).

However, recently, several studies have highlighted some similarities and also differences in character and word reading in Chinese-speaking young children (Li et al., 2017; Wang & McBride, 2016). Moreover, some studies have provided evidence of different approaches to processing of characters and words in Chinese (Liu et al., 2010; Yan et al., 2006). In other words, processing of characters and words can be distinguished across some empirical studies. In practice, characters and words are two basic concepts for children to learn at the early stage of formal literacy instruction in Chinese (e.g., McBride-Chang & Chen, 2003; Shu et al., 2003). However, there remain relatively few studies comparing Chinese characters and words among Chinese children. In order to understand the nature of Chinese reading theoretically and practically, it is essential to explore the interaction and distinctiveness of character and word reading in Chinese readers at both the character and word levels, as well as at a passage level. Such an exploration is particularly important since it considers in detail what the primary unit of reading is in Chinese. This is not a question in English or other Indo-

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European languages where a word is defined based on the white space on either side of the whole word, comprised of letters (McBride et al., under review). However, there is ongoing debate regarding the extent to which the basic unit of reading in Chinese is the character or the word. It is important to examine the character and the word levels as different yet mutually reinforcing in Chinese literacy learning. This may extend universal models of word recognition or reading comprehension to consider flexibility of the reading unit. Given that approximately 20% of the world' s population reads Chinese as a native language and others are trying to learn it as a second language (L2), this is a critical issue to move the field forward.

Our research addressed this question across two studies, using data from the same group of primary school children in Hong Kong. The children came from grades 1 to 3, i.e., the early stage of learning to read. Study 1 aimed to examine the unique cognitive-linguistic correlates of character and word reading; Study 2 investigated how character and word reading respectively contribute to reading comprehension within the framework of the Simple View of Reading (Hoover & Tunmer, 2018). This was among the first studies to consider character and word units separately in Chinese reading comprehension. Given that we focused both on word recognition and reading comprehension, i.e., different levels of print processing, we present the findings as two separate studies for clarity.

1.1. The basic concepts of the character and the word in Chinese

Before discussing the relationship between character and word reading in Chinese, we first introduce the two basic concepts of character and word. The character is the basic written unit of Chinese which one sees mostly dominantly and clearly in Chinese print. Unlike words in English, which are written from left to right, each character occupies a square and fixed amount of space on a page; characters contain different stroke numbers and structures. A Chinese character represents a syllable and, in most cases, a morpheme, or basic unit of meaning. In print, a word is more difficult to define in Chinese than in alphabetic languages (Li & McBride-Chang, 2014; McBride, 2016a). It can be made up of one or more characters. Even though some characters can function as an independent word alone (e.g. 水 /seoi2/ (written alphabetically using the Cantonese system in this example and hereafter), water), over 70% of all words in the Modern Chinese Frequency Dictionary (Institute of Language Teaching and Research [of China], 1986) are compound words formed from two or more characters. For clarity, the term "word" in this paper is used to refer to multiple-character words in Chinese Again, although single characters can also be words, in this article, we narrow the term "word" to refer only to multiple-character words. We refer to single characters, whether complete words or not, as "characters." Morphemes and compound structures are important in building the meanings of words in Chinese (Liu & McBride-Chang, 2010; McBride-Chang et al., 2003; Shu et al., 2006). Character recognition appears to depend particularly on the understanding of the orthographic composition of the writing unit and its meaning; word recognition requires not only the meanings of the morphemes (i.e., single characters) but also how they "legally" fit together in words. Chinese script is also unique in that there is no space demarcating words in print. This characteristic, together with the equal amount of space for each character, make it difficult to distinguish the boundaries of a word in Chinese text.

1.2. Unique correlates of character and word reading

Empirically, there have been various research studies demonstrating that phonological awareness, visual-orthographic skill, morphological awareness and RAN are closely associated with children's reading acquisition, irrespective of whether it is measured via character reading (Lei et al., 2011; Li et al., 2012; Lin et al., 2019; Liu & McBride-Chang, 2010; Pan et al., 2011; Shu et al., 2006; Wang et al., 2014), word reading (Liao et al., 2015; Tong et al., 2009; Yeung et al., 2011; 2013), or both (McBride-Chang et al., 2003; Tong et al., 2011; Wang & McBride, 2016). However, it is unclear whether each of these cognitive-linguistic skills are uniquely correlated with character reading or word reading.

The traditional way to read Chinese is via characters. The phonological information inherent in Chinese script is quite different from that in alphabetic languages. Alphabetic writing systems (e.g., Hebrew or English) use a small set of abstract elements to represent sound and thus create grapheme and phoneme connections of high or low transparency. However, in Chinese, each character represents a syllable, and there is no consistent written unit to reflect phonemic representation of the sounds of this syllable as alphabetic languages do. Given the relatively simple phonological structure of the Chinese language, the importance of phonological awareness may be relatively limited in reading of Chinese characters and words among Hong Kong primary school children; other cognitive-linguistic skills such as morphological awareness and vocabulary knowledge may better facilitate such reading (e.g., McBride-Chang et al., 2003; McBride-Chang & Ho, 2005; Tong et al., 2009; Yeung et al., 2011).

Visual-orthographic skill, which is associated with character reading, is likely related to word reading as well in Chinese-speaking children. Visual-orthographic skill refers to the sensitivity to orthographic regularities in print (Castles & Nation, 2006). In Chinese, this skill involves knowledge of character structures and the position regularities of radicals or stroke patterns (Ho et al., 2003a). Children gradually acquire visual-orthographic skill when they are exposed to print repeatedly. The visual-spatial layout of radicals or stroke patterns makes up different character structures (Law & Leung, 2000). In addition, in some cases, a slight change of a stroke creates several characters with totally different sounds and meanings (e.g., 太 /taai3/ too, 犬/hyun2/ dog, and 天 /tin1/ sky). Moreover, some characters are composed of identical radicals but in different positions (e.g., 晾 /long6/ sundry and 景 /ging2/ scenery). Therefore, it is essential for children to be aware of these orthographic regularities for reading characters accurately. In some studies of Chinese character recognition, visual-orthographic skill was a salient predictor in primary school children even when their phonological awareness, morphological awareness, and rapid automatized naming were statistically controlled (e.g., Li et al., 2012; Wang & McBride, 2016). Characters are the building blocks of words. Visual-orthographic skills, which are required for recognizing characters, are important for word reading in Chinese-speaking children (Tong et al., 2009; Yeung et al., 2011; 2013).

However, visual-orthographic skill may be more closely related to character reading rather than word reading because children may pay more attention to the internal structure of the character and the position of its components when recognizing single characters (McBride, 2016a; Wang & McBride, 2016). Empirically, when investigating Hong Kong fourth graders' sensitivities to character and word constructions in a judgment task at both levels, researchers have interpreted their findings as showing that children tend to use an analytic approach for character-level processing and focus more on processing orthographic information (Liu et al., 2010) for character recognition. In contrast, children demonstrate a more holistic tendency in word-level processing. Wang and McBride (2016) also found that visual-orthographic skill uniquely explained character reading even when word reading was statistically controlled in a group of third year kindergartners in Mainland China.

Morphological awareness might play a particularly important role in word reading. Morphological awareness is "awareness of and access to the meaning structure of language" (McBride, 2016b). Given some compounding characteristics of Chinese words, word reading may require more knowledge of lexical compounding and thus depend more on morphological awareness than does character reading. In some cases, morphological awareness helps children to recognize unfamiliar characters within orally familiar vocabulary. For example, young children may find it difficult to recognize the character 彩 (variety) when it is presented individually. However, when it appears in the word 彩色 (colorful), children are likely to read this word by using their knowledge of the more familiar morpheme 色 (color) since the vocabulary word 彩

色is orally familiar to them. Research has suggested that children perform significantly better in recognizing the same characters within a word than when each is presented alone (Li et al., 2017; Wang & McBride, 2016). Moreover, lexical compounding knowledge may also assist children in discriminating some words which are comprised of the same morphemes in different positions (e.g., 彩色 (colorful) and色彩 (colors); 帶領 (lead) and 領帶 (tie)).

Another strong correlate of character and word reading is rapid automatized naming, or RAN. RAN refers to accessing and retrieving phonological representations in long-term memory (Torgesen et al., 1997), but its contribution to reading is in some ways distinctive from phonological awareness. RAN probably involves not only phonological processing (Wagner & Torgesen, 1987), but also orthographic processing (Wolf et al., 2000) and other oral-written associations (Logan et al., 2011). RAN has been found to be significantly associated with both character and word reading in Chinese children (e.g., Li et al., 2012; Pan et al., 2011; Tong et al., 2009). It was hypothesized to be equally associated with character and word reading in the present study.

1.3. Character reading, word reading and language comprehension in relation to reading comprehension

To further compare character reading and word reading, their roles in reading comprehension were examined in the present study. It is widely agreed that reading comprehension is not one, but many things (Perfetti & Adlof, 2012). Reading comprehension necessitates various levels of cognitive and language processes that incorporate different kinds of knowledge to achieve accurate understanding of text (Ahmed et al., 2016; Cromley & Azevedo, 2007; Cromley et al., 2010; Ho et al., 2017; Kim, 2017; Kintsch & Rawson, 2005; Oakhill & Cain, 2012; Yeung et al., 2016). Even so, the Simple View of Reading separates the complexity of reading into two component parts, namely, decoding and language comprehension (Hoover & Gough, 1990; Hoover & Tunmer, 2018). According to this theory, reading comprehension can be characterized simply as the product of decoding and linguistic comprehension; a deficit in either decoding or linguistic comprehension results in reading comprehension failure (Hoover & Gough, 1990). Support for this theory has been widespread in research on Chinese reading comprehension in recent studies of Chinese primary school children (Ho et al., 2017; Joshi et al., 2012; Yeung et al., 2016). Yet in Chinese, the units of the character and the word as overlapping but distinct units might complicate this association somewhat. In Study 2 of this paper, we included both character reading and word reading together to represent decoding in explaining reading comprehension within the framework of the Simple View of Reading.

On the one hand, character reading may be uniquely associated with reading comprehension. After all, the character is the basic written unit in Chinese. Reading comprehension in Chinese involves decoding/identification of characters (Cheng et al., 2016; 2017). The importance of writing and recognition of characters is strongly emphasized in much of early literacy learning performance (Cheung & Ng, 2003; Shu et al., 2003). Characters in Chinese text have clear boundaries and convey meanings. These may lead young children to focus on characters at the beginning of learning to read sentences or discourse when they have less reading experience. Especially when there are some unfamiliar words in the text, children may rely on identification of the familiar characters to infer the meaning of the text. In some studies of reading comprehension in Chinese primary school children, character reading skills have been shown to be uniquely associated with reading comprehension (Cheng et al., 2016; 2017;; Ho et al., 2017).

On the other hand, word reading is also essential for reading comprehension (Chik et al., 2012; Yeung et al., 2011; 2016;; Zhang et al., 2012). Character reading and word reading are obviously highly correlated in Chinese young children (Ho et al., 2017; Wang & McBride, 2016), but consistently, children have been found to perform better in recognizing the same characters when they were within the context of a word than in isolation (Li et al., 2017; Wang & McBride, 2016). This finding implies that children may be able to extract the helpful contextual information in the words to assist in recognizing unfamiliar or low-frequency characters. Therefore, not only does word reading rely on character recognition, but it may be more than that: Accurate understanding of text may require not only recognizing the characters correctly, but also being aware of the morphemic structures of words to process word and text meanings. In addition, processing meanings at the word level may be more salient than processing them at the character level in reading Chinese text, even though word boundaries are not obvious. In fact, in most cases, only decoding at the word level will facilitate access to the correct meanings of the text because some characters carry more than one meaning. For example, in the sentence 藥的成分會影響睡眠 (The composition of the medicine can affect sleep quality), the character 分 is combined with 成before it to create the word 成分 (composition), even though 分 can also form the word 分會 (branch of a society or association) with the character 會 after it. From this perspective, word reading likely mediates the association between character reading and reading comprehension in Chinese.

In the Simple View of Reading, language comprehensions is "the ability to extract and construct literal and inferred meaning from linguistic discourse represented in speech" (Hoover & Tunmer, 2018, pp. 304). Earlier published work has showed that some language comprehension skills are important to reading comprehension in Chinese-speaking young children (e.g., Cheng et al., 2017; Chik et al., 2012; Ho et al., 2017; Shu et al., 2006; Tong et al., 2009; Yeung et al., 2016). Specifically, morphological awareness was repeatedly found to be essential for Chinese reading comprehension (e.g., Cheng et al., 2017; Ho et al., 2017; Tong et al., 2009). Vocabulary knowledge is another core language comprehension skill correlated with reading comprehension in Chinese (Chik et al., 2012; Zhang et al., 2012).

In addition, other syntactic skills are important for Chinese reading comprehension because of the features of Chinese syntax. For example, Chik et al. (2012) have identified unique contributions of morpho-syntactic skill and discourse skill for Chinese reading comprehension among typically developing children in grades 1–3 and dyslexic children in grades 4–5 in Hong Kong. It is indeed important for young readers to acquire accurate discourse skills in making inferences between sentences for understanding text accurately. In addition, unlike English, Chinese written language is considered as an impoverished system without inflectional or grammatical morphology such as case making or subject-verb agreement in English. Thus, instead of morphological transformations as employed in English (e.g., *watch- watched*; *apple- apples*), word compounding or morphosyntax is adopted to indicate tense, number, and degree in Chinese. For instance, nouns have no plural form and can be connected with some quantifiers to indicate their plurality, e.g., 一些 (some) and幾個 (several). To discriminate whether a noun represents plurality or not, the reader must look for more semantic or syntactic information in the text (e.g., 把這些蘋果放進籃子里。*put the apples into the basket.*). In addition, some function words (similar to prepositions in English) are generally used in combination with different verbs to indicate a different tense, e.g., *watched* is indicated by 看 (*watch*) 了(*-ed,* past tense) and *watching* by 看著 (-ing, continuous tense). Moreover, in English, a word usually changes its form depending on whether it is a verb or a noun, but this is not the case in Chinese. For example, 分析is used as a noun in the sentence: 這篇文章是關於消費品行業的分析報告 (*This article is an analysis report of the service industry*) and used as a verb in the sentence: 他分析了自己今年的工作表現 (*He analyzed his work performance this year*). Therefore, Chinese reading comprehension requires the reader to retrieve syntactic information from the given linguistic constituents and their semantic connections for accurate text comprehension (Ho et al., 2017; Li & Thompson, 1981). In a recent study of the Simple View of Reading in Hong Kong primary school children (Ho et al., 2017), these skills were all documented as significant indicators of language comprehension. These results echoed findings in studies of alphabetic languages (e.g., Joshi et al., 2012; Kim,

2017), demonstrating that morphological awareness, vocabulary knowledge, and syntactic skill are important componential skills of the construct of language comprehension. Similarly, this study constructed a latent variable of linguistic comprehension as indicated by children's morphological awareness, vocabulary knowledge, morpho-syntactic skill and discourse skill.

The Simple View of Reading demonstrates that reading comprehension is the product of decoding and linguistic comprehension (Hoover & Gough, 1990). There has been some debate about how decoding and linguistic comprehension are precisely associated across SVR models, both in alphabetic scripts (e.g., Conners, 2009; Joshi & Aaron, 2000; Kendeou et al., 2009; Kirby & Savage, 2008; Ouellette & Beers, 2010) and in Chinese (Yeung et al., 2016). Importantly, Yeung et al. (2016), in a three-year longitudinal study, highlighted the fact that linguistic comprehension and word reading appear to be more interdependent than previously hypothesized. In fact, they focused on the fact that semantic knowledge such as morphological awareness is potentially useful both in reading comprehension and in word recognition. Similar findings were also reported in studies of English (Vellutino et al., 2007) and Dutch (Verhoeven et al., 2018). No previous studies have considered the separate levels of character and word within this model, however. Given the two distinct levels of decoding in Chinese, i.e., characters and words, we tested the hypothesis that the associations of character reading and linguistic comprehension to reading comprehension might both be mediated by word reading in Chinese.

The present research focused on character and word reading in Chinese as overlapping but distinct units. We examined correlates of each of these units at the identification level (i.e., recognition of the character and word) in Study 1. Specifically, we measured children's nonverbal intelligence (IQ), vocabulary knowledge, phonological awareness, morphological awareness, visual-orthographic skill and RAN. All of these have been examined in some previous studies of Chinese character or word reading.

Given previous work, we made the following predictions: First, we expected that phonological awareness, RAN, and vocabulary knowledge would be associated equally with character and word reading. In contrast, given the clear visual-orthographic skills required for character recognition, we hypothesized that visual-orthographic skills might be more strongly linked to character as compared to word reading. Finally, given the importance of lexical compounding for word reading in Chinese, we expected that morphological awareness would be more strongly associated with word reading than with character reading.

In Study 2, we investigated the roles of character and word reading in relation to text comprehension level within the Simple View of Reading framework. Given the high overlap but distinct nature of characters and words in Chinese, we sought to test the uniqueness and overlap of these units for Chinese reading comprehension. We first tested whether character reading, a relatively pure decoding skill, was uniquely associated with reading comprehension. We then added word reading to the model in order to unpack the connections among character reading, word reading and reading comprehension. Word reading in Chinese likely draws upon both character recognition and linguistic comprehension skills (e.g., Yeung et al., 2016). Therefore, word reading was expected to mediate the effects of character reading and linguistic comprehension to reading comprehension in the model.

Study 1: Unique correlates of character reading and word reading

2. Method

2.1. Participants and procedures

Our sample of 337 Hong Kong Chinese children (166 boys) was drawn from a large longitudinal twin project (Wong, Ho, McBride, Chow, & Waye, 2017) focused on literacy and math development of Chinese twins in Hong Kong. We randomly selected on twin from each twin pair in order to ensure a random sample of children. The children were from grades 1 to 3 (185 in grade 1, 92 in grade 2 and 60 in grade 3), with a mean age of 87.34 months (SD = 10.42). They came from different types of schools (government-run, government-aided, private and international schools) all over Hong Kong. According to questionnaire data from parents, none of the children in this group had any known language, speech, behavioral or brain disorders. All children were typically developing twins with Cantonese as their mother language.

Written consent was obtained from their parents before test administration. Ethics approval was granted from the Survey and Behavioral Research Ethics Committee of the authors' institution. Children completed a systematic battery of literacy-related tasks in Chinese and English as part of their participation in our longitudinal project. Some of these tasks described below were included in analyses for both Study 1 and Study 2. All tasks were administered by trained research assistants in a given order that had been predetermined. The testing session lasted approximately 2 h. Five-minute breaks were given following every 30 min of testing.

2.2. Measures

Nonverbal IQ The Raven's Standard Progressive Matrices test was used to measure children's nonverbal IQ. Children were presented with a visual matrix with a missing part and were required to select the item that best fit the matrix from six or eight choices. We calculated the standard scores based on the local norm (Ho et al., 2017).

Rapid automatized naming We assessed rapid automatized naming with digits. The task consisted of eight rows of five digits (i.e., 2, 4, 6, 7, 9), which were arranged in different orders. During the procedure, children needed to name them as presented in a fixed sequence, as quickly as possible. The total time in seconds they used was recorded for each trial. This task was conducted twice and the final score was the averaged naming time.

Phonological awareness This task tapped both syllable and onset deletion (McBride-Chang & Ho, 2000; McBride-Chang & Kail, 2002). There were 19 syllable deletion items requiring children to take away one syllable from a given three-syllable real word or non-word (e.g., nyu2 soe1 daam5 without nyu2 would be soe1 daam5). There were also 22 onset deletion items including one-syllable, two-syllable, and three-syllable Cantonese words. Children were asked to take away the initial phoneme of these words and say what would be left. For example, tsa1 without the initial phoneme would be a1; koe1 kwo2 baai4 without the initial phoneme would be oe1 o2 aai4. The total possible score on this task was 41.

Visual-orthographic skill This was measured using a Chinese delayed copying task. The idea of developing the Chinese delayed copying task came from Anderson et al. (2002) and Pak, et al., (2005). In our task, after a 1000 ms fixation, a target word appeared on the screen for 2000 ms. Children were asked to write down each target word on a sheet of paper immediately after it disappeared on the screen. Those words were low-frequency Chinese characters consisting of between two to four logographemes. The logographeme is composed of a few strokes. For example, the Chinese character "峭" consists of three logographemes: "山", "刀", and "口". Our method of scoring these items was based on Lui et al. (2010). Two points were given if a given logographeme was reproduced completely in a correct way. One point was given if a minor error (e.g., missing stroke, extra stroke) was observed in the copied logographeme. One practice item and 15 experimental items were included in the task. Given that there were 2 to 4 logographemes in each word, the maximum possible score was 82. We considered this to be a reasonable proxy of orthographic knowledge because it capitalizes on children's knowledge of Chinese character structures and relies on recall, rather than recognition (e.g., Lam & McBride, 2018).

Vocabulary knowledge A vocabulary definition test was used as a proxy for vocabulary knowledge (e.g., McBride-Chang et al., 2008). In

the 26-item vocabulary definition task, the participants were presented with one Chinese word for each item and then asked to define each of them orally. Participants' responses were rated by two well-trained research assistants according to a complete scoring key created through pilot testing and a previous study (see McBride-Chang et al., 2008). The inter-rater reliability was 0.79. Participants were given a score of either 0, 1, or 2 for each item according to how close their response was to the correct answer. Testing was discontinued when the child obtained a score of zero across five consecutive items. The total possible score was 52.

Morphological awareness This task was adapted from McBride-Chang et al. (2003) to test children's ability to demonstrate lexical compounding. There were 2 practice items and 48 test items. For each item, children were first orally presented with one scenario and then were asked to construct new words according to the second scenario. One example was "日頭出嚟, 我地會叫佢做日出 /yat6 ceot1/; 咁月亮出嚟, 我哋會點叫佢啊? (The sun rising is called a sunrise. What would we call it if the moon rises?). This task was divided by grade level, and the administration began according to children's corresponding grade. One point was given to the child for each correctly answered item. Adjustments for lower scores beginning at grade level were made (i.e., participants had to answer questions from lower level grades if they consecutively obtained zero score in four items from their own corresponding level items). The maximum possible score for this task was 48.

Character reading This was assessed using a list of single characters (McBride-Chang et al., 2006). Eighty Chinese single characters in order of difficulty were presented to children. Children were asked to read these characters aloud one by one. One point was given for each character pronounced correctly (i.e., accurate syllable and tone). Testing was discontinued when the child failed to read 15 characters consecutively. The maximum possible score was 80.

Word reading This was assessed with the Chinese word reading subtest of the Hong Kong Test of Specific Learning Difficulties in Reading and Writing for Primary School Students-Second Edition (Ho et al., 2007). This is a widely used diagnostic test to assess children's reading abilities with local norms. One hundred-fifty Chinese two-character words were shown to children, and they needed to read them out in an order. One point was given to each correctly read word. Testing was discontinued when children encountered 15 consecutive failures. The maximum score was 150.

3. Results and discussion

Table 1 shows the descriptive statistics, reliability coefficients and skewness values of all measures in Study 1. All measures showed good reliabilities ($\alpha \geq 0.81$). Table 2 shows the partial correlations among all measures after statistically controlling for age, grade, and nonverbal IQ. Apart from the fact that visual-orthographic skill was not significant correlated with vocabulary knowledge ($r = 0.06$, $p = .27$), RAN ($r = -0.10$, $p = .08$) or phonological awareness ($r = -0.04$, $p = .43$), all other partial correlations were significant, with the magnitudes being equal to or larger than 0.13, $ps < 0.05$. Among the partial correlations, character reading was highly correlated with word reading, $r = 0.93$, $p < .001$.

Table 1
Descriptive statistics of all measures in Study 1 and 2.

	Mean	SD	Range	Skewness	α
Age	87.34	10.42	70–120	–	–
Nonverbal IQ	111.81	13.40	75–135	-0.11	0.87
Vocabulary knowledge	13.03	6.32	0–34	0.61	0.81
RAN	22.94	6.98	10.29–56.08	1.29	0.92
Phonological awareness	26.43	8.78	4–41	-0.06	0.95
Morphological awareness	20.57	5.96	0–35	-0.08	0.89
Visual-orthographic skill	36.42	17.18	7–74	0.30	0.93
Character reading	35.13	18.36	0–73	-0.01	0.97
Word reading	63.66	34.05	1–137	-0.05	0.99
Morpho-syntactic skill	13.53	10.18	0–45	0.72	0.86
Discourse skill	8.08	6.27	0–26	0.82	0.81
Reading comprehension	7.50	4.38	0–19.5	0.61	0.77

Note. $N = 337$.

In Table 3, hierarchical regression analyses were performed to explain character reading and word reading concurrently from age, grade, nonverbal IQ, and vocabulary entered in Step 1 and RAN, phonological awareness, morphological awareness, and visual-orthographic skill entered in Step 2. With age, grade, nonverbal IQ and vocabulary knowledge statistically controlled, the cognitive linguistic skills together explained an additional 12% of variance in character reading and word reading respectively. Specifically, RAN was negatively associated with character reading ($\beta = -0.26$, $t = -5.92$, $p < .01$) and word reading ($\beta = -0.26$, $t = -6.37$, $p < .01$), respectively. In addition, morphological awareness was positively associated with character reading ($\beta = 0.22$, $t = 4.23$, $p < .01$) and word reading ($\beta = 0.24$, $t = 4.82$, $p < .01$) respectively. Finally, visual-orthographic skill also accounted for significant variance in character reading ($\beta = 0.12$, $t = 3.01$, $p < .01$) and word reading ($\beta = 0.12$, $t = 3.23$, $p < .01$), respectively.

In order to examine most stringently the unique correlates of word and character reading given their substantial overlap, additional hierarchical regression analyses were performed to explain character reading with word reading statistically controlled. In Table 4, age, grade, nonverbal IQ, and vocabulary knowledge were entered in Step 1 as control variables. They accounted for 44% of the variance in character reading. Word reading was entered in Step 2 and explained an extra 47% of the variance in character reading. RAN, phonological awareness, morphological awareness, and visual-orthographic skill were entered in Step 3; no unique cognitive correlates emerged, suggesting that word reading accounted for all the variability of cognitive-linguistic skills related to character recognition. Table 4 also shows the results explaining word reading with character reading statistically controlled. Character reading accounted for an extra 42.6% of the variance in word reading when age, grade, nonverbal IQ and vocabulary knowledge were controlled. In Step 3, the cognitive linguistic skills together additionally explained 0.3% of variance in word reading after controlling for character reading. Specifically, the final beta weights for RAN ($\beta = -0.04$, $t = -2.27$, $p < .05$) and morphological awareness ($\beta = 0.05$, $t = 2.27$, $p < .05$) were significant.

To sum up, the results showed that, for Hong Kong primary school children, Chinese character and word reading were highly correlated. This was in line with previous findings for younger Chinese-speaking children in Mainland China (Wang & McBride, 2016). However, the correlations of word and character recognition with other cognitive linguistic skills were somewhat different. Even though vocabulary knowledge, RAN, morphological awareness and visual-orthographic skill were uniquely associated with character and word reading, respectively, RAN and morphological awareness significantly contributed to word reading even after statistically controlling character reading. There were no such unique correlates for character reading when word reading was statistically controlled.

Visual-orthographic skill was found to be equally important for Chinese character and word reading. This study used delayed copying of unfamiliar characters to measure children's abilities to make use of their visual-orthographic knowledge (Anderson et al., 2013; Wang et al., 2014). The results were consistent with previous findings in Hong Kong primary school children showing that, developmentally, children acquire knowledge of character structure, position, and function of components from Grade 1 (Ho et al., 2003b). Sensitivity to the orthographic components of Chinese characters facilitated children's character and word reading (Ho et al., 2003a; Yeung et al., 2011).

RAN was also found to explain character reading and word reading respectively beyond other cognitive-linguistic skills. This RAN-reading relationship has been consistently demonstrated in many Chinese studies (e.g., McBride-Chang et al., 2011; Liao et al., 2008; Pan et al., 2011). Our study extended the existing findings to show that RAN was

Table 2
Correlations among all measures in Study 1.

	1	2	3	4	5	6	7
1 Vocabulary knowledge	–	−0.35	0.32	0.55	0.25	0.53	0.55
2 Rapid automatized naming	−0.13	–	−0.39	−0.38	−0.24	−0.54	−0.56
3 Phonological awareness	0.18	−0.29	–	0.52	0.10	0.36	0.37
4 Morphological awareness	0.38	-0.19	0.41	–	0.34	0.57	0.60
5 Visual-orthographic skill	0.06	−0.10	−0.04	0.18	–	0.39	0.41
6 Character reading	0.28	−0.37	0.20	0.37	0.23	–	0.95
7 Word reading	0.28	−0.39	0.21	0.40	0.24	0.93	–

Note. $N = 337$. The magnitudes of correlations larger than or equal to 0.13 were significant at $\alpha < 0.05$ level. The lower triangle shows the correlation among all measures after controlling for age, grade and nonverbal IQ, and the upper triangle shows the correlation among raw scores of all measures.

Table 3
Hierarchical regression models explaining Chinese character reading and word reading.

Step/Measure	Character reading					Word reading				
	R^2	$\triangle R^2$	*B* (*SE*)	β	*t*	R^2	$\triangle R^2$	*B* (*SE*)	β	*t*
1.Age	0.44	0.44**	0.29 (0.12)	0.16	2.33*	0.50	0.50**	0.66 (0.21)	0.20	3.12**
Grade			2.64 (1.57)	0.11	1.68			5.86 (2.71)	0.13	2.16*
IQ			0.15 (0.06)	0.11	2.69**			0.26 (0.10)	0.10	2.62**
VK			0.40 (0.14)	0.14	2.80**			0.66 (0.24)	0.12	2.71**
2.RAN	0.56	0.12**	−0.68 (0.11)	−0.26	−5.92**	0.62	0.12**	−1.25 (0.20)	−0.26	−6.37**
PA			−0.01 (0.10)	−0.00	−0.07			−0.03 (0.17)	−0.01	−0.18
MA			0.68 (0.16)	0.22	4.23**			1.35 (0.28)	0.24	4.82**
V-O skill			0.13 (0.04)	0.12	3.01**			0.24 (0.08)	0.12	3.23**

Note. * $p < .05$. ** $p < .01$. $N = 337$. VK = Vocabulary knowledge; RAN = Rapid automatized naming; PA = Phonological awareness; MA = Morphological awareness; V-O skill = Visual-orthographic skill.

Table 4
Hierarchical regressions explaining character reading and word reading with word reading and character reading controlled respectively.

Step/ Measure	Character reading					Word reading				
	R^2	$\triangle R^2$	*B* (*SE*)	β	*t*	R^2	$\triangle R^2$	*B* (*SE*)	β	*t*
1.Age	0.44	0.44**	−0.06 (0.06)	−0.03	−1.04	0.495	0.495**	0.22 (0.10)	0.07	2.32*
Grade			−0.40 (0.71)	−0.02	−0.57			1.78 (1.21)	0.04	1.46
IQ			0.02 (0.03)	0.01	0.77			0.02 (0.04)	0.01	0.46
VK			0.05 (0.06)	0.02	0.84			0.05 (0.11)	0.01	0.44
2.Word/Character reading	0.91	0.47**	0.52 (0.01)	0.96	36.42**	0.921	0.426**	1.54 (0.04)	0.83	36.42**
3.RAN	0.91	0.00	−0.03 (0.05)	−0.01	−0.46	0.924	0.003*	−0.21 (0.09)	−0.04	−2.27*
PA			0.01 (0.04)	0.00	0.19			−0.02 (0.07)	−0.01	−0.25
MA			−0.02 (0.08)	−0.01	−0.20			0.29 (0.13)	0.05	2.27*
V-O skill			0.01 (0.02)	0.01	0.28			0.04 (0.03)	0.02	1.16

Note. * $p < .05$. ** $p < .01$. $N = 337$. VK = Vocabulary knowledge; RAN = Rapid automatized naming; PA = Phonological awareness; MA = Morphological awareness; V-O skill = Visual-orthographic skill.

uniquely associated with word reading even with character reading statistically controlled. To some extent, this finding supports one theory of the RAN-reading relationship, namely that their associations may be mediated by orthographic knowledge (Wolf et al., 2000). Because our measure of words comprised only those items made up of more than one character, they were, thus, more complicated than the character measure. Accurate word reading requires that each character within the word be activated in sufficiently close temporal proximity, which may depend particularly on RAN. From another perspective, RAN is critical in the arbitrary relationship between the symbol and its name (Manis et al., 1999). The RAN-reading relationship is likely to be stronger when reading tasks involve more arbitrary orthography-to-phonology mappings (Liao et al., 2008).

Another unique correlate of word reading was morphological awareness. This clearly supported our hypothesis. In addition to character recognition, morphological awareness can facilitate children's word reading. With increasing morphological awareness in the form of lexical compounding, children may be better at inferring the meaning of the entire word (Li & McBride-Chang, 2014). In addition, morphological awareness may facilitate the reading of some unfamiliar words given the use of word contextual information (Li et al., 2017; Wang & McBride, 2016).

These results suggest that character reading and word reading, though highly overlapping, are somewhat different. Since word reading in Chinese is contextualized, it likely depends on not only character recognition but also on some oral language knowledge. The differences found between character reading and word reading encouraged us to investigate whether the two have different contributions in explaining reading comprehension in Study 2. Participants in Study 1 had additionally been tested on other language comprehension skills and reading comprehension when they participated in our project. Therefore, Study 2 focused on the same participants as those in Study 1. Study 2 examined whether children's character reading and word reading would be uniquely associated with reading comprehension when their multifaceted language comprehension skills were statistically controlled. Moreover, we investigated the extent to which word reading might mediate either the relations between character reading and reading comprehension, or the association between language comprehension and reading comprehension, or both.

Study 2: The roles of character and word reading in reading comprehension

4. Method

4.1. Participants and procedures

Participants and procedures were the same as those in Study 1. For those tasks used in Study 2, morpho-syntactic skill, discourse skill, and reading comprehension were administered individually. The nonverbal IQ, morphological awareness, vocabulary knowledge, character reading, and word reading skills were the same as those used in Study 1.

4.2. Measures

Morpho-syntactic skill. The morpho-syntactic task was adopted from Chik et al. (2012) to measure children's ability in detecting and correcting errors in Chinese sentences. During the task, children were first orally presented with a sentence that included an incorrect word. The administrator then asked them to point out the incorrectly used word in the sentence and to replace it with a correct one. For example, in the sentence "植樹可以美麗環境 (Planting may beautiful the environment)", "美麗 (beautiful)" should be replaced with "美化 (beautify)". There were two practice items and 18 experimental items. For each item, one point was allotted for identifying the incorrectly used word, and two points were given for an accurate word replacement. Thus, the total possible score was 54.

Discourse skill. The discourse task, similar to the one used by Chik et al. (2012), was developed to measure children's skills in connecting between sentences and integrating them to form a meaningful discourse. In this task, children were first orally presented with three to six sentences. They were then required to organize those sentences into a discourse in a meaningful way. To ease children's cognitive workload, those sentences were placed in a text format in front of each child. Those sentences could be orally repeated when needed. The topics of the discourses included narrative, procedural, or factual information. One practice and 11 experimental items were included. Specifically, three three-sentence items (Items 1–3), three four-sentence items (Items 4–6), three five-sentence items (Items 7–9), and two six-sentence items (Items 10–11) were included in the experimental trials. These items were arranged in the order of increasing difficulty. Partial credit was awarded if the order of sentences in the item was partially correct. Scoring for Item 1–3 is 0/1, for Items 4–6 is 0/1/2, for item 7–9 is 0/1/2/3, and for items 10–11 is 0/1/2/3/4. The maximum possible score was 26.

Reading comprehension. Our reading comprehension task consisted of one narrative passage and two expository passages. Those passages are two commonly used genres in Chinese textbooks for Hong Kong primary school students (Leung & Lee, 2002). Each passage contained 99 to 216 Chinese characters. The narrative passage was followed by four multiple-choice questions and one open-ended question. The second expository passage was followed by four multiple-choice questions and three open-ended questions. The third expository passage was followed by four multiple-choice questions and four open-ended questions. Those questions were mainly designed to assess children's abilities in retrieval of information, inference making, interpreting, and evaluating contextual information. One point was given for a correct answer to each of the 12 multiple-choice questions. For the open questions, one point was allocated to a correct answer for four of the questions, and two points were given for correct answers to four relatively difficult questions. Scores from all the questions were summed into a composite reading comprehension score. The maximum possible score was 24. This measure has been used successfully to test children's reading comprehension in primary school (Ho et al., 2017).

5. Results and discussion

The descriptive statistics, reliability coefficients, and skewness values of all measures used in Study 2 are also shown in Table 1. All the measures showed good reliabilities ($\alpha \geq 0.77$). Table 5 shows the partial correlations among all measures after statistically controlling for age, grade, and nonverbal IQ in the lower triangle. All the partial correlations were positive and significant, with the magnitudes being equal to or larger than 0.27, $ps < 0.01$. Among the partial correlations, character reading ($r = 0.56$, $p < .01$) and word reading ($r = 0.59$, $p < .01$) were moderately associated with reading comprehension.

Table 5
Correlations among all measures in Study 2.

	1	2	3	4	5	6	7
1 Vocabulary knowledge	–	0.55	0.62	0.55	0.53	0.55	0.55
2 Morphological awareness	0.38	–	0.59	0.59	0.57	0.60	0.56
3 Morpho-syntactic skill	0.40	0.41	–	0.64	0.73	0.76	0.71
4 Discourse skill	0.27	0.35	0.35	–	0.65	0.68	0.68
5 Character reading	0.28	0.37	0.56	0.38	–	0.95	0.74
6 Word reading	0.28	0.40	0.58	0.39	0.93	–	0.77
7 Reading comprehension	0.30	0.34	0.51	0.41	0.56	0.59	–

Note. $N = 337$. The correlations were all significant at $\alpha < 0.01$ level. The lower triangle shows the correlation among all measures after controlling for age, grade and nonverbal IQ, and the upper triangle shows the correlation among raw scores of all measures.

A set of Structural Equation Modeling (SEM) analyses were performed using language comprehension, character reading, and word reading to predict reading comprehension. We regressed the raw scores of each measure on children's age, grade and nonverbal IQ, and used the standardized residual scores in the subsequent analyses. Mplus 7.4 (Muthén & Muthén, 2012) was used to perform the SEM analyses. A latent variable was created for language comprehension which was assessed by vocabulary knowledge, morphological awareness, morpho-syntactic skill and discourse skill. In Model 1 (Fig. 1), a SEM model without word reading was run to examine the regressions of language comprehension and character reading to reading comprehension. Model 1 did not fit well to the data: $\chi^2(9, N = 337) = 159.29$, $p = .00$, CFI = 0.71, RMSEA = 0.22 and SRMR = 0.17. Both language comprehension ($\beta = 0.45$, $SE = 0.07$, $p < .01$) and character reading ($\beta = 0.39$, $SE = 0.06$, $p < .01$) were positively associated with reading comprehension (see Fig 1).

In Model 2 (Fig. 2), language comprehension, character reading, and word reading were entered to explain reading comprehension. Language comprehension ($\beta = 0.40$, $SE = 0.07$, $p < .01$) and word reading ($\beta = 0.40$, $SE = 0.12$, $p < .01$) were significantly associated with reading comprehension. The final Beta weight for character reading was not significant ($\beta = 0.04$, $SE = 0.12$, $p = .71$). However, the overall fit of Model 2 was not good: $\chi^2(13, N = 337) = 180.76$, $p = .00$, CFI = 0.69, RMSEA = 0.20 and SRMR = 0.21.

Further, Model 2A (Fig. 3) was created based on the results of Model 2 by dropping the nonsignificant direct path from character reading to reading comprehension and examining the mediation effects of word reading from character reading and language comprehension to reading comprehension. Model 2A was a nested model of Model 2. It fitted well to the data: $\chi^2(12, N = 337) = 23.82$, $p = .02$, CFI = 0.99, RMSEA = 0.05 and SRMR = 0.03. Model 2A fitted better to the data than Model 2: $\Delta\chi^2(1, N = 337) = 156.93$, $p < .01$).

In Model 2A, word reading significantly explained reading comprehension ($\beta = 0.23$, $SE = 0.08$, $p < .01$). Both character reading and language comprehension had indirect effects through word reading on reading comprehension. For character reading, a full mediation effect of word reading was demonstrated ($\beta = 0.18$, $SE = 0.07$, $p < .01$). Language comprehension also significantly predicted reading comprehension partially via word reading ($\beta = 0.04$, $SE = 0.01$, $p < .01$) and its direct effect was also significant ($\beta = 0.50$, $SE = 0.08$, $p < .01$). These results suggest that word reading partially mediated the effect of language comprehension on reading comprehension. Overall, the model explained 47.1% ($p < .01$) of the variance in reading comprehension.

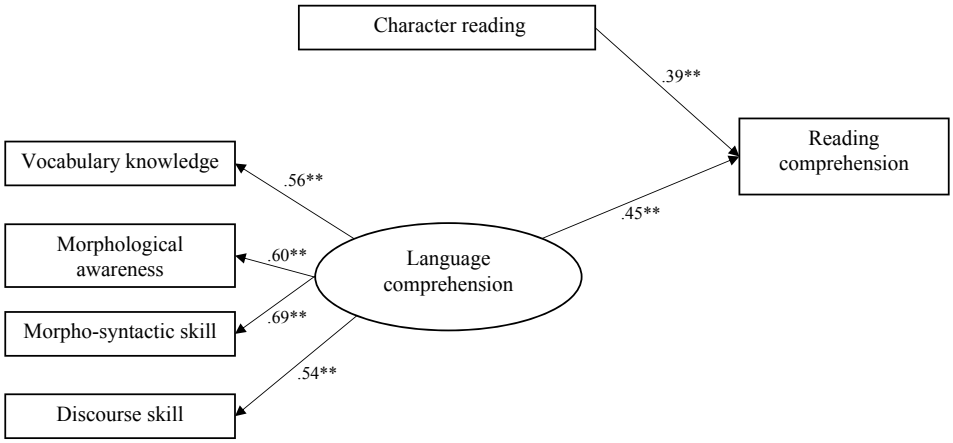

Fig. 1. Model 1 of reading comprehension in Chinese with standardized coefficient estimates. *Note.* $^{**}p < .01$.

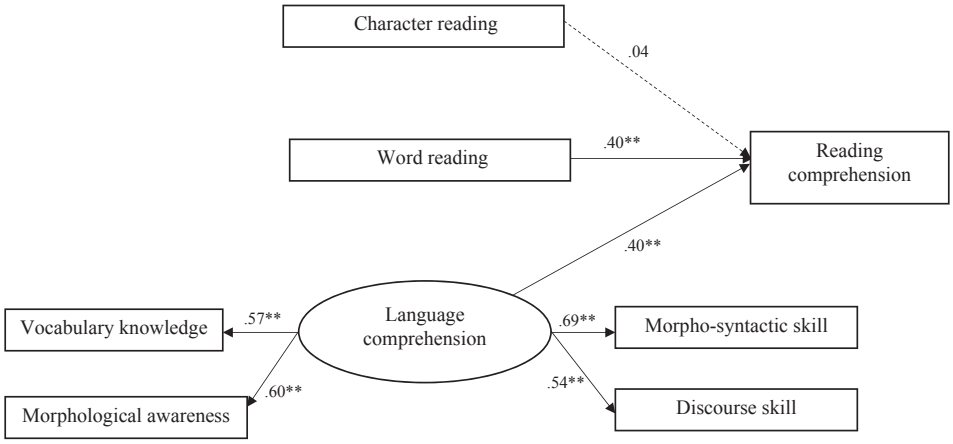

Fig. 2. Model 2 of reading comprehension in Chinese with standardized coefficient estimates. *Note.* $^{**}p < .01$. Dashed lines represent nonsignificant paths.

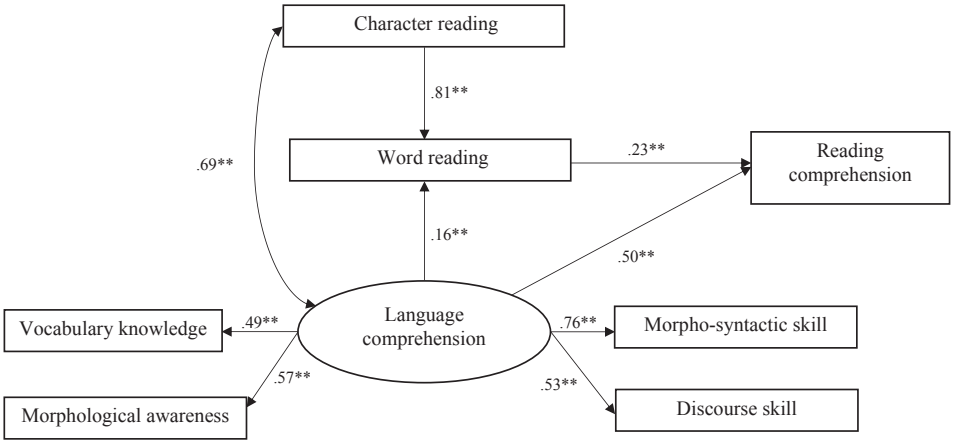

Fig. 3. Model 2A of reading comprehension in Chinese with standardized coefficient estimates. *Note.* $^{**}p < .01$.

These results have demonstrated different roles of character reading and word reading in explaining reading comprehension. That is, character reading was significantly associated with reading comprehension when language comprehension was statistically controlled. However, when word reading was also included in the same model, the association between character reading and reading comprehension was not significant. Further, the SEM analyses results suggested that word reading fully mediates the association between character reading and reading comprehension while partially mediating the effect of linguistic comprehension on reading comprehension.

It is important to note that these findings have extended existing studies of the Simple View of Reading in Chinese (Ho et al., 2017; Yeung et al., 2016) to suggest that this idea may be a bit more complicated in Chinese. That is, there may be three core component skills in Chinese reading comprehension. Specifically, character reading is important for recognizing characters in print accurately to gain access to their

meanings. An incorrect identification of a character (e.g., mistakenly identifying 書 (book) as 畫 (painting)) can result in very divergent understanding of a sentence's meaning (e.g., compare 他喜歡看書 (he likes reading books) and 他喜歡看畫 (he likes looking at paintings)). Language comprehension, including lexical-level to discourse-level skills, is also essential to construct meanings in reading comprehension as shown in many previous studies across languages. In Chinese, however, word reading may be an intermediary process, a third important skill that combines the decoding ability associated with pure character recognition together with some language comprehension skills to contribute to reading comprehension. These findings are potentially illuminating for either Chinese learners and instructors or researchers who are interested in Chinese reading comprehension to keep in mind: The character and the word may play different roles in Chinese reading comprehension.

6. General discussion

In this paper, two studies representing different analyses of our data on the reading of Hong Kong primary school children suggested that character reading and word reading reflect somewhat different processes in Chinese literacy. Study 1 demonstrated that despite character reading and word reading being highly associated, their unique correlates suggest a somewhat different pattern between them. Study 2 further showed that character reading and word reading play different roles in contributing to Chinese reading comprehension. Admittedly, such findings are complicated given the very strong association between character and word reading. However, this distinction between character and word recognition may be both theoretically and practically useful. Theoretically, researchers are interested in the basic unit of reading universally and across specific scripts. Practically, differences between the two may imply different approaches to teaching and learning them.

Character reading and word reading reinforce one another in young Chinese children's literacy development. Those who know more characters are able to recognize more words. Conversely, better word reading skills may benefit children because they make use of lexical compounding skills and vocabulary knowledge to learn new characters. Despite the interaction between character and word reading, then, these processes are not equivalent in understanding Chinese literacy development, especially for young children. This idea is not new (Chen et al., 2003; Li et al., 2017; Wang & McBride, 2016), but it is worth considering the implications. Our results again highlight the fact that Chinese word reading likely depends strongly on morphological awareness (McBride-Chang et al., 2003; Tong et al., 2009), and this is different from requirements for character reading (McBride, 2016a). That is, word reading not only requires knowing a sufficient number of characters (morphemes) but also involves understanding of how these characters can be used to make up words in Chinese.

This difference between character reading and word reading also resulted in their different contributions to reading comprehension in the results of Study 2. Our findings have demonstrated that decoding should be considered at both the character and word level within the framework of the Simple View of Reading in Chinese. Chinese is unique since characters are not like letters, suffixes, or prefixes in English words. Chinese characters have independent pronunciations and convey complete meanings; most of them can be independent words. Children who are better in character recognition perform better in reading comprehension (Cheng et al., 2017).

However, our results have also suggested that word reading fully mediated the association between character reading and reading comprehension in the present study. This was not totally in line with our hypothesis that character reading should make an additional contribution to reading comprehension in addition to its indirect association with reading comprehension via word reading. It was expected that visual-orthographic skill in the form of radical or sub-lexical processing of characters (e.g., Ho et al., 2003a; Shu & Anderson, 1997) might not be required as precisely in word reading as compared to character recognition, since children may use a holistic form of processing at the word level (Liu et al., 2010). Yet this was not supported in Study 1, and the unique role of character reading in reading comprehension beyond word reading was not demonstrated in Study 2, perhaps because the primary school children tested in the present study already had extensive literacy learning experience. They may tend to process words as meaning units in reading longer text and rely less on the sub-lexical processing in characters. It is possible that character reading would be uniquely associated with reading comprehension in younger Chinese children or people who learn Chinese as a second language when they are at the beginning stages of learning characters and words together instead.

Another notable finding is that word reading appeared partly to mediate children's reading comprehension and language comprehension. Some language comprehension skills such as morphological awareness or morpho-syntactic skill likely contribute to reading comprehension through word reading (Kim et al., 2020). Indeed, word reading contributes to reading comprehension inasmuch as it yields accurate inferences about words' meanings that can be integrated into mental models of texts' meanings (Kintsch, 1988; Perfetti & Stafura, 2014). The influence of language comprehension skills in reading comprehension via word reading may be universal across languages because similar findings have been documented in studies of English (Vellutino et al., 2007) and Dutch (Verhoeven et al., 2018). To some extent, our evidence supports the Reading Systems Framework that says that word knowledge is the center of the reading comprehension model, integrating decoding and oral language comprehension during the word-to-text integration processes (Perfetti & Stafura, 2014).

6.1. Limitations and future directions

Findings in this study should be understood with at least three limitations in mind. First, the results came from Hong Kong lower grade primary schoolers, who receive literacy training as early as age 3.5 years old. Thus, one should be careful when generalizing the results to other Chinese societies where children may begin their formal literacy training later, including most students in Mainland China, Taiwan, and Singapore. In addition, this sample consisted of children from twin pairs. Future studies should test this model with data from children who are not twins. Different learning experiences in various micro- or macro-environment could influence the relations between character reading and word reading. Future studies should also explore whether similar patterns of character reading and word reading being associated with reading comprehension emerge in younger and older children across Chinese societies. Another limitation is that we measured the variables with single tasks due to our limited time and resources. Even though the reliabilities of the tasks were good or excellent in these two studies, latent constructs as representations would be preferable so as to minimize the measurement errors.

6.2. Theoretical and practical implications

Understanding how and whether character reading and word reading can be distinguished among Chinese developing learners is essential for future research and practice. Existing models of Chinese reading acquisition (e.g., Yang et al., 2009) have often assumed that characters are the basic units of literacy in Chinese. Thus, most studies, particularly in mainland China, tend to use tasks of character recognition to measure children's reading skills (e.g., Li et al., 2012; Shu et al., 2006). Studies in other societies such as Hong Kong mostly tap word recognition with word, rather than character, lists (e.g., Tong et al., 2009; Yeung et al., 2011). In the present research studies, we have emphasized the fact that character and word reading are not necessarily the same process, especially for young children. Future cross-cultural comparative studies (e.g., investigating the similarities and differences of word reading predictors across Hong Kong and Beijing

kindergarteners) should use the same measures to test children's reading skills to compare them based on exactly the same skills. In addition, morphological awareness should be particularly helpful in developing word reading skill. Training morphological skills explicitly could be effective in teaching Chinese words (e.g., McBride, 2016a).

Taken together, these findings demonstrate somewhat more complex relations of decoding, language comprehension, and reading comprehension in Chinese than was originally proposed in the Simple View of Reading (Hoover & Gough, 1990). We agree that the complexity of reading comprehension can be conceptualized as comprising two parts: decoding and language comprehension. This idea has also been well supported in other studies of reading comprehension in Chinese (Ho et al., 2017; Yeung et al., 2016). Yet we also support the notion from Hoover and Tunmer (2018, p. 311) that "there is much more to understand about reading than what is represented in the Simple View of Reading." Our findings highlight the fact that decoding in Chinese may involve both character and word levels, two levels which have no clear analogy to alphabetic languages. Models of literacy development tend to place all languages and orthographies on a continuum (e.g., Seymour et al., 2003), but in some circumstances, such continua may not totally fit in Chinese. Understanding Chinese reading development is not only a matter of applying models of alphabetic literacy development and tweaking them (McBride, 2016a). Research in Chinese contributes to achieving the ultimate understanding of universalities and specificities across languages in reading development.

Practically, clarification of the relations between character reading and word reading and, further, between them and reading comprehension will be valuable for teachers, parents, and educators to focus precisely on key predictors in the literacy curriculum and day-to-day interactions to cultivate young children's as well as second language learners' Chinese reading abilities effectively. Based on our results and suggestions from previous work (e.g., Yeung et al., 2016), teachers of Chinese literacy may consider using slightly different strategies in teaching characters and words. For example, they can highlight word structure and compounding rules when teaching new words. In addition, parents and teachers can instruct children to recognize different word units in the text and to focus on the connections across sentences, to facilitate their reading comprehension.

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References

Ahmed, Y., Francis, D. J., York, M., Fletcher, J. M., Barnes, M., & Kulesz, P. (2016). Validation of the direct and inferential mediation (DIME) model of reading comprehension in grades 7 through 12. *Contemporary Educational Psychology, 44–45*, 68–82. https://doi.org/10.1016/j.cedpsych.2016.02.002.

Anderson, R. C., Ku, Y.-M., Li, W., Wu, X., & Hao, M. (2002). *Learning to see the patterns in Chinese characters*. Champaign, IL: Center for the Study of Reading, University of Illinois.

Anderson, R. C., Ku, Y.-M., Li, W., Chen, X., Wu, X., & Shu, H. (2013). Learning to see the patterns in Chinese characters. *Scientific Studies of Reading, 17*(1), 41–56. https://doi.org/10.1080/10888438.2012.689789Mcb.

Castles, A., & Nation, K. (2006). How does orthographic learning happen? In S. Andrews (Ed.), *From inkmarks to ideas: Challenges and controversies about word recognition and reading*. Hove, East Sussex: Psychology Press.

Chen, H.-C., Song, H., Lau, W. Y., Wong, K. F. E., & Tang, S. L. (2003). Developmental characteristics of eye movements in reading Chinese. In C. McBride- Chang, & H.-.-C. Chen (Eds.), *Reading development in Chinese children* (pp. 157–169). Westport, CT: Prae- ger Press. https://doi.org/10.4324/9780203841211.

Cheng, Y., Zhang, J., Li, H., Wu, X., Liu, H., Dong, Q., Li, L., Nguyen, T., P., Zheng, M., Zhao, Y., & Sun, P. (2017). Growth of compounding awareness predicts reading comprehension in young Chinese students: A longitudinal Study from Grade 1 to Grade 2. Reading Research Quarterly, 52(1), 91–104. https://doi.org/10.1002/rrq.155.

Cheng, Y., Zhang, J., Wu, X., Liu, H., & Li, H. (2016). Cross-lagged relationships between morphological awareness and reading comprehension among Chinese children. *Frontiers in Psychology, 7*(SEP), 1379. https://doi.org/10.3389/fpsyg.2016.01379.

Cheung, H., & Ng, K. H. (2003). Chinese reading development in some major Chinese societies: An introduction. In C. McBride-Chang, & H.-. C. Chen (Eds.), *Reading development in Chinese children* (pp. 3–17). Westport, CT: Greenwood.

Chik, P. P., Ho, C. S., Yeung, P., Chan, D. W., Chung, K. K., Luan, H., … Lau, W. S. (2012). Syntactic skills in sentence reading comprehension among Chinese elementary school children. *Reading and Writing, 25*(3), 679–699. https://doi.org/10.1007/s11145-010-9293-4.

Cromley, J. G., & Azevedo, R. (2007). Testing and refining the direct and inferential mediation model of reading comprehension. *Journal of Educational Psychology, 99*, 311–325. https://doi.org/10.1037/0022-0663.99.2.311.

Cromley, J. G., Snyder-Hogan, L., & Luciw-Dubas, U. A. (2010). Reading comprehension of scientific text: A domain- specific test of the direct and inferential mediation model of reading comprehension. *Journal of Educational Psychology, 102*, 687–700. https://doi.org/10.1037/a0019452.

Wong, S. W. L., Ho, C. S. H., McBride, C., Chow, B. W. Y., & Waye, M. M. Y. (2017). Less is more in Hong Kong: Investigation of biscriptal and trilingual development among Chinese Twins in a (Relatively) Small City. *Twin Research and Human Genetics, 20*(1), 66–71. https://doi.org/10.1017/thg.2016.90.

Conners, F. A. (2009). Attentional control and the Simple View of reading. *Reading and Writing, 22*, 591–613. https://doi.org/10.1007/s11145-008-9126-x.

Ho, C. S. H., Chan, D. W. O., Chung, K. K. H., Tsang, S. M., Lee, S. H., & Cheng, R. W. Y. (2007). *The Hong Kong test of specific learning difficulties in reading and writing for primary school students- [HKT-P (II)]*. Hong Kong: Hong Kong Specific Learning Difficulties Research Team.

Ho, C. S. H., Ng, T. T., & Ng, W. K. (2003b). A "radical" approach to reading development in Chinese: the role of semantic radicals and phonetic radicals. *Journal of Literacy Research, 35*(3), 849–878.

Ho, C. S.-H., Yau, P. W.-Y., & Au, A. (2003a). Development of orthographic knowledge and its relationship with reading and spelling among Chinese kindergarten and primary school children. In C. McBride-Chang, & H.-. C. Chen (Eds.), *Reading development in Chinese children* (pp. 51–71). Westport, CT: Praeger.

Ho, C. S. H., Zheng, M., McBride, C., Hsu, L. S. J., Waye, M. M. Y., & Kwok, J. C. Y. (2017). Examining an extended simple view of reading in Chinese: The role of naming efficiency for reading comprehension. *Contemporary Educational Psychology, 51*(September), 293–302.

Hoover, W. A., & Gough, P. B. (1990). The Simple View of Reading. *Reading and Writing: An Interdisciplinary Journal, 2*, 127–160. https://doi.org/10.1002/art.38914.

Hoover, W. A., & Tunmer, W. E. (2018). The Simple View of Reading: Three assessments of its adequacy. *Remedial and Special Education, 39*(5), 304–312. https://doi.org/10.1177/0741932518773154.

Institute of Language Teaching and Research [of China]. (1986). A frequency dictionary of modern Chinese. Beijing, China: Beijing Language Institute Press.

Joshi, R. M., & Aaron, P. G. (2000). The component model of reading: Simple View of Reading made a little more complex. *Reading Psychology, 21*, 85–97.

Joshi, R. M., Tao, S., Aaron, P. G., & Quiroz, B. (2012). Cognitive component of componential model of reading applied to different orthographies. *Journal of Learning Disabilities, 45*(5), 480–486. https://doi.org/10.1177/0022219411432690.

Kendeou, P., van den Broek, P., White, M. J., & Lynch, J. S. (2009). Predicting reading comprehension in early elementary school: The independent contributions of oral language and decoding skills. *Journal of Educational Psychology, 101*(4), 765–778. https://doi.org/10.1037/a0015956.

Kim, Y. G., Guo, Q., Liu, Y., Peng, Y., & Yang, L. (2020). Multiple pathways by which compounding morphological awareness is related to reading comprehension: Evidence from Chinese second graders. *Reading Research Quarterly, 55*(2), 193–212. https://doi.org/10.1002/rrq.262.

Kim, Y. S. G. (2017). Why the Simple View of Reading is not simplistic: Unpacking component skills of reading using a direct and indirect effect model of reading (DIER). *Scientific Studies of Reading, 21*(4), 310–333. https://doi.org/10.1080/10888438.2017.1291643.

Kintsch, W. (1988). The use of knowledge in discourse processing: A construction-integration model. *Psychological Review, 95*, 163–182.

Kintsch, W., & Rawson, K. A. (2005). Comprehension. In M. J. Snowling, & C. Hulme (Eds.), *The science of reading: A handbook* (pp. 209–226). Oxford: Black- well.

Kirby, J. R., & Savage, R. S. (2008). Can the simple view deal with the complexities of reading? *Literacy, 42*(2), 75–82. https://doi.org/10.1111/j.1741-4369.2008.00487.x.

Lam, S. S.-Y., & McBride, C. (2018). Learning to write: The role of handwriting for Chinese spelling in kindergarten children. *Journal of Educational Psychology, 110*(7), 917–930. https://doi.org/10.1037/edu0000253.

Law, S. P., & Leung, M. T. (2000). Structural representations of characters in Chinese writing: Evidence from a case of acquired dysgraphia. *Psychologia, 43*, 67–83.

Lei, L., Pan, J., Liu, H., McBride-Chang, C., Li, H., Zhang, Y., … Shu, H. (2011). Developmental trajectories of reading development and impairment from ages 3 to 8 years in Chinese children. *Journal of Child Psychology and Psychiatry, 52*(2), 212–220. https://doi.org/10.1111/j.1469-7610.2010.02311.x.

Leung, M. T., & Lee, A. (2002). The Hong Kong corpus of primary school Chinese. Paper presented in 9th meeting of the international clinical phonetics and linguistics association, Hong Kong.

Li, T., & McBride-Chang, C. (2014). How character reading can be different from word reading in Chinese and why it matters for Chinese reading development. In X. Chen, Q. Wang, & Y. C. Luo (Eds.), *Reading development and difficulties in monolingual and bilingual Chinese children*. New York: Springer.

Li, H., Shu, H., McBride-Chang, C., Liu, H., & Peng, H. (2012). Chinese children's character recognition: Visuo-orthographic, phonological processing and morphological skills. *Journal of Research in Reading, 35*(3), 287–307. https://doi.org/10.1111/j.1467-9817.2010.01460.x.

Li, C. N., & Thompson, S. A. (1981). *Mandarin Chinese: A functional reference grammar*. California: University of California Press.
Li, T., Wang, Y., Tong, X., & McBride, C. (2017). A developmental study of Chinese children's word and character reading. *Journal of Psycholinguistic Research, 46*(1), 141–155. https://doi.org/10.1007/s10936-016-9429-z.
Liao, C. H., Georgiou, G. K., & Parrila, R. (2008). Rapid naming speed and Chinese character recognition. *Reading and Writing, 21*(3), 231–253. https://doi.org/10.1007/s11145-007-9071-0.
Liao, C. H., Deng, C., Hamilton, J., Lee, C. S. C., Wei, W., & Georgiou, G. K. (2015). The role of rapid naming in reading development and dyslexia in Chinese. *Journal of Experimental Child Psychology, 130*, 106–122. https://doi.org/10.1016/j.jecp.2014.10.002.
Lin, D., Sun, H., & McBride, C. (2019). Morphological awareness predicts the growth rate of Chinese character reading. *Developmental Science, 22*(4). https://doi.org/10.1111/desc.12793.
Liu, P. D., & McBride-Chang, C. (2010). What is morphological awareness? Tapping lexical compounding awareness in Chinese third graders. *Journal of Educational Psychology, 102*(1), 62–73. https://doi.org/10.1037/a0016933.
Liu, P. D., Chung, K. K. H., McBride-Chang, C., & Tong, X. (2010). Holistic versus analytic processing: Evidence for a different approach to processing of Chinese at the word and character levels in Chinese children. *Journal of Experimental Child Psychology, 107*(4), 466–478. https://doi.org/10.1016/j.jecp.2010.06.006.
Logan, J. A. R., Schatschneider, C., & Wagner, R. K. (2011). Rapid serial naming and reading ability: The role of lexical access. *Reading and Writing, 24*(1), 1–25. https://doi.org/10.1007/s11145-009-9199-1.
Lui, H.-M., Leung, M.-T., Law, S.-P., & Fung, R. S.-Y. (2010). A database for investigating the logographeme as a basic unit of writing Chinese. *International Journal of Speech-Language Pathology, 12*(1), 8–18. https://doi.org/10.3109/17549500903203082.
Manis, F. R., Seidenberg, M. S., & Doi, L. M. (1999). See Dick RAN: Rapid naming and the longitudinal prediction of reading subskills in first and second graders. *Scientific Studies of Reading, 3*, 129–157. https://doi.org/10.1207/s1532799xssr0302_3.
McBride-Chang, C., & Chen, H.-. C. (Eds.). (2003). *Reading development in Chinese children*. London: Praeger.
McBride, C. (2016b). *Children's literacy development* (2nd ed.). New York, NY: Routledge.
McBride, C. A. (2016a). Is Chinese special? Four aspects of Chinese literacy acquisition that might distinguish learning Chinese from learning alphabetic orthographies. *Educational Psychology Review, 28*(3), 523–549. https://doi.org/10.1007/s10648-015-9318-2.
McBride-Chang, C., & Ho, S. H. C. (2005). Predictors of Beginning Reading in Chinese and English: A 2-Year Longitudinal Study of Chinese Kindergartners. *Scientific Studies of Reading, 9*(2), 117–144. https://doi.org/10.1207/s1532799xssr0902_2.
McBride-Chang, C., & Ho, C. S. H. (2000). Developmental issues in Chinese children's character acquisition. *Journal of Educational Psychology, 92*(1), 50–55.
McBride-Chang, C., & Kail, R. V. (2002). Cross-cultural similarities in the predictors of reading acquisition. *Child Development, 73*(5), 1392–1407.
McBride-Chang, C., Cheung, H., Chow, B. Y., Chow, C. L., & Choi, L. (2006). Metalinguistic skills and vocabulary knowledge in Chinese (L1) and English (L2). *Reading and Writing, 19*(7), 695–716.
McBride-Chang, C., Lam, F., Lam, C., Chan, B., Fong, C. Y.-C., Wong, T. T.-Y., & Wong, S. W.-L. (2011). Early predictors of dyslexia in Chinese children: Familial history of dyslexia, language delay, and cognitive profiles. *Journal of Child Psychology and Psychiatry, 52*, 204–211. https://doi.org/10.1111/j.1469-7610.2010.02299.x.
McBride, C., Pan, J. D. & Mohseni, F. (Under review). Reading and writing words: A cross-linguistic perspective. Scientific Studies of Reading.
McBride-Chang, C., Shu, H., Zhou, A., Wat, C. P., & Wagner, R. K. (2003). Morphological Awareness Uniquely Predicts Young Children's Chinese Character Recognition. *Journal of Educational Psychology, 95*(4), 743–751. https://doi.org/10.1037/0022-0663.95.4.743.
McBride-Chang, C., Tardif, T., Cho, J. R., Shu, H. U. A., Fletcher, P., Stokes, S. F., Wong, A., & Leung, K. (2008). What's in a word? Morphological awareness and vocabulary knowledge in three languages. *Applied Psycholinguistics, 29*(3), 437–462.
Muthén, L. K., & Muthén, B. O. (2012). *Mplus user's guide* (7th ed.). Los Angeles, CA: Muthén & Muthén.
Oakhill, J. V., & Cain, K. (2012). The precursors of reading ability in young readers: Evidence from a four-year longitudinal study. *Scientific Studies of Reading, 16*(2), 91–121. https://doi.org/10.1080/10888438.2010.529219.
Ouellette, G., & Beers, A. (2010). A not-so-simple view of reading: How oral vocabulary and visual-word recognition complicate the story. *Reading and Writing, 23*(2), 189–208. https://doi.org/10.1007/s11145-008-9159-1.
Pan, J., McBride-Chang, C., Shu, H., Liu, H., Zhang, Y., & Li, H. (2011). What is in the naming? A 5-year longitudinal study of early rapid naming and phonological sensitivity in relation to subsequent reading skills in both native Chinese and English as a second language. *Journal of Educational Psychology, 103*(4), 897–908. https://doi.org/10.1037/a0024344.
Pak, A. K. H., Cheng-Lai, A., Tso, I. F., Shu, H., Li, W., & Anderson, R. C. (2005). Visual chunking skills of Hong Kong children. *Reading and Writing, 18*(5), 437–454. https://doi.org/10.1007/s11145-005-6575-3.
Perfetti, C. A., & Adlof, S. M. (2012). Reading comprehension: A conceptual framework from word meaning to text meaning. In J. P. Sabatini, E. R. Albro, & T. O'Reilly (Eds.), *Measuring up: Advances in how to assess reading ability* (pp. 3–20). Lanham, MD: Rowman & Littlefield Education.
Perfetti, C., & Stafura, J. (2014). Word knowledge in a theory of reading comprehension. *Scientific Studies of Reading, 18*(1), 22–37. https://doi.org/10.1080/10888438.2013.827687.
Seymour, P. H. K., Aro, M., & Erskine, J. M. (2003). Foundation literacy acquisition in European orthographies. *British Journal of Psychology, 94*, 143–174.
Shu, H., & Anderson, R. C. (1997). Role of radical awareness in the character and word acquisition of Chinese Children. *Reading Research Quarterly, 32*(1), 78–89. https://doi.org/10.1598/RRQ.32.1.5.
Shu, H., Chen, X., Anderson, R. C., Wu, N., & Xuan, Y. (2003). Properties of School Chinese: Implications for Learning to Read. *Child Development, 74*(1), 27–47.
Shu, H., McBride-Chang, C., Wu, S., & Liu, H. (2006). Understanding Chinese developmental dyslexia: Morphological awareness as a core cognitive construct. *Journal of Educational Psychology, 98*(1), 122–133. https://doi.org/10.1037/0022-0663.98.1.122.
Tong, X., McBride-Chang, C., Shu, H., & Wong, A. M.-Y. (2009). Morphological Awareness, Orthographic Knowledge, and Spelling Errors: Keys to Understanding Early Chinese Literacy Acquisition. *Scientific Studies of Reading, 13*(5), 426–452. https://doi.org/10.1080/10888430903162910.
Tong, X., Mcbride-Chang, C., Wong, A. M. Y., Shu, H., Reitsma, P., & Rispens, J. (2011). Longitudinal predictors of very early chinese literacy acquisition. *Journal of Research in Reading, 34*(3), 315–332. https://doi.org/10.1111/j.1467-9817.2009.01426.x.
Torgesen, J. K., Wagner, R. K., Rashotte, C. A., Burgess, S., & Hecht, S. (1997). Contributions of phonological awareness and rapid automatic naming ability to the growth of word-reading skills in second-to fifth- grade children. *Scientific Studies of Reading, 1*, 161–185. https://doi.org/10.1207/s1532799xssr0102_4.
Vellutino, F. R., Tunmer, W. E., Jaccard, J. J., & Chen, R. (2007). Components of reading ability: Multivariate evidence for a convergent skills model of reading development. *Scientific Studies of Reading, 11*(1), 3–32. https://doi.org/10.1207/s1532799xssr1101_2.
Verhoeven, L., Voeten, M., & Vermeer, A. (2018). Beyond the simple view of early first and second language reading: The impact of lexical quality. *Journal of Neurolinguistics, March*. https://doi.org/10.1016/j.jneuroling.2018.03.002.
Wagner, R. K., & Torgesen, J. K. (1987). The nature of phonological processing and its causal role in the acquisition of reading skills. *Psychological Bulletin, 101*, 192–212. https://doi.org/10.1037/0033-2909.101.2.192.
Wang, Y., & McBride, C. (2016). Character reading and word reading in Chinese: Unique correlates for Chinese kindergarteners. *Applied Psycholinguistics, 37*(2), 371–386. https://doi.org/10.1017/S014271641500003X.
Wang, Y., McBride-Chang, C., & Chan, S. F. (2014). Correlates of Chinese kindergarteners' word reading and writing: The unique role of copying skills? *Reading and Writing, 27*, 1281–1302. https://doi.org/10.1007/s11145-013-9486-8.
Wolf, M., Bowers, P. G., & Biddle, K. (2000). Naming-speed processes, timing, and reading: A conceptual review. *Journal of Learning Disabilities, 33*, 387–407. https://doi.org/10.1177/002221940003300409.
Yan, G., Tian, H., Bai, X., & Rayner, K. (2006). The effect of word and character frequency on the eye movements of Chinese readers. *British Journal of Psychology, 97*(2), 259–268. https://doi.org/10.1348/000712605X70066.
Yang, J., McCandliss, B. D., Shu, H., & Zevin, J. D. (2009). Simulating language-specific and language-general effects in a statistical learning model of Chinese reading. *Journal of Memory and Language, 61*, 237–258.
Yeung, P. S., Ho, C. S. H., Chan, D. W. O., & Chung, K. K. H. (2016). A componential model of reading in Chinese. *Learning and Individual Differences, 45*, 11–24. https://doi.org/10.1016/j.lindif.2015.11.007.
Yeung, P., Ho, C. S., Chik, P. P., Lo, L., Luan, H., Chan, D. W., & Chung, K. K. (2011). Reading and spelling Chinese among beginning readers: What skills make a DIFFERENCE? *Scientific Studies of Reading, 15*(4), 285–313. https://doi.org/10.1080/10888438.2010.482149.
Yeung, P., Ho, C. S., Wong, Y., Chan, D. W., Chung, K. K., Kong, H., & Yan, S. (2013). Longitudinal predictors of Chinese word reading and spelling among elementary grade students. *Applied Psycholinguistics, 34*(6), 1245–1277. https://doi.org/10.1017/S0142716412000239.
Zhang, J., McBride-Chang, C., Tong, X., Wong, A. M. Y., Shu, H., & Fong, C. Y. C. (2012). Reading with meaning: The contributions of meaning-related variables at the word and subword levels to early Chinese reading comprehension. *Reading and Writing, 25*(9), 2183–2203. https://doi.org/10.1007/s11145-011-9353-4.