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Reading with meaning: the contributions of meaning-related variables at the word and subword levels to early Chinese reading comprehension

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Abstract This study examined the associations of three levels of meaning acquisition, i.e., whole word (vocabulary), morpheme (morphological awareness), and semantic radical (orthography-semantic awareness) to early Chinese reading comprehension among 164 Hong Kong Chinese primary school students, ages 7 and 8 years old, across 1 year. With time 1 word reading, phonological awareness and speeded naming controlled, morphological awareness was uniquely associated with concurrent and subsequent reading comprehension; orthography-semantic awareness uniquely explained concurrent reading comprehension at time 2. Together, the meaning acquisition variables explained between 2 and 6% unique variance in reading comprehension across time, underscoring the importance of acquisition of meaning for early reading comprehension among Chinese children.

Keywords Chinese children · Morphological awareness · Reading comprehension · Semantic radical awareness · Vocabulary

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Introduction

Reading comprehension consists of at least two separate components, decoding and linguistic comprehension (Gough & Tunmer, 1986; Hoover & Gough, 1990). Linguistic comprehension focuses on meaning in language, whereas decoding is typically measured using measures of word reading. Studies highlighting these two separate components of reading comprehension often refer to this as the Simple View of reading (Gough & Tumner, 1986; Hoover & Gough, 1990) and have applied this basic idea of language comprehension × decoding to the reading comprehension process in children learning to read alphabetic languages (Adlof, Catts, & Little, 2006; Catts, Adlof, & Weismer, 2006; Georgiou, Das, & Hayward, 2009; Tan, Wheldall, Madelaine, & Lee, 2007). However, this simple dichotomy of decoding and language comprehension may require some expansion to conform to the features of the Chinese script. This is because there are at least three different aspects of meaning conveyed at or below the word level in written Chinese text. The meaning-related variables examined in the present study were vocabulary knowledge at the word level, morphological awareness at the level of the morpheme, and subcharacter sensitivity to semantic radicals. Below, we first talk broadly about findings from previous studies on children's reading comprehension before highlighting the theoretical importance of these particular features of meaning for Chinese reading comprehension.

Debates about how best to measure reading comprehension are ongoing (Snow, 2002; Snow, Burns, & Griffin, 1998). Indeed, reading comprehension can look remarkably diverse as one compares nonfiction with fiction text comprehension or online (website) reading with book reading (e.g., Snow, 2002). Reading comprehension can also be compared across different units, such as the sentence, paragraph, and chapter levels. In the present study of 7- and 8-year-olds, we tested reading comprehension at the sentence level only. For this task, children were asked to select from among five choices the picture that best represented the sentence they were asked to read for each item. Although this way of measuring reading comprehension may be relatively limited in tapping the kind of global meaning-making required to process an entire story or narrative, it also allowed us to maximize variability across our measure relatively efficiently.

There are diverse findings from research on Chinese children's reading comprehension thus far. For example, Leong and colleagues (Leong, Hau, Tse, & Loh, 2007; Leong, Tse, Loh, & Hau, 2008) explored a variety of reading-related measures in relation to reading comprehension at the text level. They included measures of verbal working memory, Chinese pseudoword reading, rapid automatized naming, and phonological awareness and found that verbal working memory was uniquely associated with text comprehension, a replication and extension of work from alphabetic languages (e.g., Swanson, Howard, & Saez, 2006). Chan and Law (2003) also demonstrated the importance of metacognition in reading comprehension among sixth-grade Chinese children.

There have been at least three studies that have suggested that morphological awareness, defined here as awareness of and access to morphemes and their structure within words comprised of two or more morphemes, may be important not only for word recognition but also for reading comprehension in Chinese children. One group demonstrated that, together with vocabulary knowledge and rapid automatized number naming, morphological awareness was a unique concurrent correlate of text-level reading comprehension among fifth and sixth graders from Beijing (Shu, McBride-Chang, Wu, & Liu, 2006). Similarly, a 1-year longitudinal study demonstrated that morphological awareness could predict subsequent reading comprehension at the sentence level for Hong Kong Chinese children from ages five to six (Tong, McBride-Chang, Shu, & Wong, 2009). However, although these latter two studies demonstrated that morphological awareness was linked to reading comprehension in Chinese children, neither included a measure of Chinese word reading itself in any analyses explaining reading comprehension. A third study (Pasquarella, Chen, Lam, Luo, & Ramirez, 2011) did include such a measure. Interestingly, in that study of first, second, and fourth graders focused on biliteracy, they found that English, but not Chinese, compound awareness, was associated with reading comprehension in Chinese.

Given the importance of word reading for overall reading comprehension (Gough & Tunmer, 1986; Hoover & Gough, 1990), the inclusion of word reading is important particularly because Chinese word reading has been linked to morphological awareness in several previous studies of children (McBride-Chang, Shu, Zhou, Wat, & Wagner, 2003; McBride-Chang et al., 2005; Shu et al., 2006). Thus, it may be that morphological awareness is associated with reading comprehension primarily because it is related to Chinese word reading itself. Although Pasquarella et al. (2011) did not find this association in a correlational study of a mixed-grade sample of Chinese children, we wanted to test this association in a larger sample of children of the same age longitudinally because of the potential importance of the morphological awareness-word reading-reading comprehension connection in Chinese. That is, teasing apart the word reading aspect of reading comprehension from the broader aspects of meaning-building at the word and sub-word levels was one goal of the present study.

In this study, we included three separate skills that are fundamental to our conceptualization of meaning-building in Chinese, namely, vocabulary knowledge, morphological awareness, and semantic radical awareness. In a sense, these three constructs focus on meaning at three different levels that may be of utmost importance for reading comprehension, at least as we measured it at the sentence level. Vocabulary knowledge as conceptualized in this paper focuses on meaning at the whole word level, whereas morphological awareness focuses on meaning-building at the morpheme level within multi-morphemic words. Finally, semantic radical awareness focuses on meaning at the sub-character level.

Figure 1 demonstrates meaning and the associations among these three levels. For example, 詩人 (si1 jan4) in Chinese (meaning poet) consists of two morphemes: 詩 (si1, meaning poem) and 人 (jan4, meaning person). Thus, the meaning of the whole word 詩人 can be understood as persons who write poems by making the inference from both morphemes considered together. Importantly, not only are these two morphemes themselves critical for establishing meaning, but their order is also important. For example, person-poem would have a very different meaning from poem-person, just as in English pancake has a very different meaning from a cake

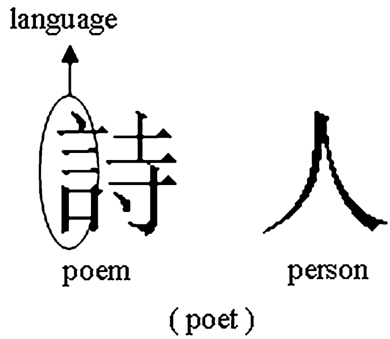


Fig. 1 An example for meaning and associations among word, morpheme, and sub-character levels

pan. Meanwhile, at the sub-character level, the semantic radical 言 (meaning language) of the first morpheme also implies that 詩 (si1) is something related to language.

These three levels of meaning are distinguishable from one another based on both the units of focus and also the ways in which they were measured. Vocabulary knowledge is related to children's understanding of whole words. The way in which we measured this variable required children to show broad knowledge of a given word, i.e., to be able to define or explain it. The majority (66% according to one estimate—Tan & Perfetti, 1999) of Chinese words are comprised of two or more morphemes. Thus, the morpheme level of measurement was focused only on knowledge of individual morphemes, or units of meaning, and the ways in which they could be legally structured within Chinese words made up of two morphemes. The poem-person/person-poem example above illustrates the importance of language knowledge for building words and, indeed, novel words or concepts, from an understanding of how one's language is structured. Both vocabulary knowledge and morpheme knowledge were measured at the level of oral language in the present study. Finally, the semantic radical is also different from the morpheme because it is only one part of a single character, i.e., it constitutes the sub-character level only. Semantic radicals do not give any clue as to the pronunciation of the character; they provide meaning information through orthographic or visual cues only. For example, the semantic radical of 河 (meaning river) is 氵, and it means water and has no pronunciation by itself. Crucially, the semantic radical aspect of meaning can, by definition, only be tested in relation to print.

A strong association between vocabulary and reading comprehension has been demonstrated in many previous studies of alphabetic languages (for a review, see Wagner, Muse, & Tannenbaum, 2004). It is likely that vocabulary knowledge and reading comprehension are bidirectionally associated. That is, early vocabulary knowledge helps children to read and understand text efficiently and in more depth. On the other hand, children whose reading comprehension is particularly good tend to use their comprehension skills to learn the meanings of new vocabulary words in text (e.g., Wagner et al., 2004).

Apart from vocabulary knowledge, morphological awareness has been recognized as a potentially important factor in Chinese character acquisition (McBride-Chang et al., 2003, 2005; Shu et al., 2006). We propose that morphological awareness may also be important for Chinese reading comprehension in at least the following two ways:

First, Chinese is relatively semantically transparent at the word and subword levels as compared to many alphabetic languages. By this, we mean that if a child understands the meaning of a given morpheme, he or she can grasp the meaning of other novel compound words that contain the morpheme more easily, as explained using the poet example in Fig. 1. As another example, knowing the morpheme 花 (faa1, meaning flower) in Chinese may help a child to understand the meaning of 菊花 (guk1 faa1, meaning *chrysanthemum*), or 百合花 (baak3 hap6 faa1, meaning *lily*), or 曇花 (taam4 faa1, meaning night-blooming cereus) when each appears in a passage. An analogy in English would be that children may still be able to infer that cheesecake is a specific kind of cake if they know the meaning of cake but not cheese. Thus, in a reading comprehension situation, although a child may not know the exact meaning of the word, he or she can roughly figure out that the passage is about a kind of flower; this can be helpful for activating background knowledge about the flower and maintaining consistency in reading. In contrast, without such morphological knowledge, the child will know nothing about the new word, blocking the construction or integration of ideas to comprehend the passage and possibly interrupting subsequent reading. Although there are also relatively semantically transparent compound words in alphabetic languages, e.g., workplace or sunflower, these occur less frequently in English as compared to Chinese (Shu & Anderson, 1997).

In addition, there are a large number of homophones in Chinese. In Mandarin, for example, each syllable corresponds to an average of approximately five homophones (Packard, 2000; Shu & Anderson, 1997). Typically, therefore, a phonological cue (accessing meaning through phonology) alone is unreliable when accessing the meaning of words or characters in text reading. In this situation, only good morphological awareness can help one to differentiate across meanings, facilitating understanding of the whole passage.

Beyond the morpheme, which generally corresponds to a single Chinese character, at the sub-character level of meaning is the semantic radical. In the present study, orthography-semantic awareness is identified as the awareness of and access to semantic information from visual cues, including position, within a single character. More than 80% of Chinese characters are composed of both a semantic and a phonetic radical (Shu, Chen, Anderson, Wu, & Xuan, 2003). The semantic radical provides semantic information about the character, whereas the phonetic radical offers hints to its pronunciation (Shu & Anderson, 1997; Shu et al., 2003). In 唱 (meaning sing) for example, the left part 口 means using mouth, and the right part 昌 provides the pronunciation /*coeng*/ for the character (McBride-Chang, 2004).

Orthography-semantic awareness refers to the direct access to meaning of a character only from the orthography or print rather than from its sound. Apart from our example in Fig. 1 of how language is related to poem within the first character of the word poet, another good example of this phenomenon is understanding that 唱 is easier to remember as such if one recognizes the mouth radical as a way to classify its meaning. The importance of orthography-semantic awareness for reading comprehension lies in its cues at the sub-character level, which is especially relevant for comprehending novel characters. For example, if a child knows that the logogram 犭 represents animals, when encountering a new and infrequent character 獾 (meaning badger) in a text, he or she might be able to guess its rough meaning and know that the text refers to a kind of animal. This may, in turn, facilitate the comprehension of the whole passage.

Although our primary focus in the present study was on the importance of different levels of meaning for reading comprehension, we also included phonological awareness and rapid automatized naming, both of which have been tested in relation to reading comprehension in previous studies of Chinese children (Shu et al., 2006; Tong et al., 2009). These have also been demonstrated to be important for reading comprehension in alphabetic language such as English (Johnston, & Kirby, 2006; Joshi, & Aaron, 2000; Kirby, Parrila, & Pfeiffer, 2003). As such, they were crucial statistical controls for a stringent test of how meaning acquisition variables would collectively explain variability in Chinese children's reading comprehension.

To summarize, the present research aimed to explore how the acquisition of meaning, assessed at three levels, from the word level as measured by vocabulary knowledge, to the morpheme level, as assessed using a task of morphological awareness, to the sub-character level, using a newly developed task of orthography-semantic awareness, was concurrently and longitudinally associated with Chinese children's reading comprehension at the sentence level. We put these three components together in a single block after controlling Chinese character recognition, phonological awareness and rapid automatized naming. Through such analyses, we could investigate the unique contributions of the acquisition of meaning at the word and sub-word levels including the morpheme level and sub-character level awareness, to Chinese children's early reading comprehension.

We focused on sentence-level reading comprehension for three main reasons. First, although the children in our study were relatively sophisticated in reading skills, they were still relatively young. We worried that tapping text-level reading comprehension might be too broad for our purposes. Children who can master sentence-level comprehension may still not show the metalinguistic abilities necessary, such as extensive synthesis of materials across paragraphs, to carry out text-level comprehension. Thus, we started with a more limited level of reading comprehension. Second, the reading materials children of these ages encounter in school tend to be mostly at the sentence or short paragraph levels. Therefore, for the purposes of (pedagogic) ecological validity we reasoned that reading comprehension measured at the sentence level would be relatively familiar to children and maximize their efficiency on the test. Finally, comprehension at the sentence level forms the foundation of higher level reading comprehension. Thus, once we understand processes of sentence-level reading comprehension, this may help us to understand even higher-level comprehension.

Method

Participants

A total of 164 Hong Kong Chinese children (69 boys and 95 girls) participated in this study. The first testing time was between September and December 2007 and the second was between June and August 2008. All children were native Cantonese speakers, and their mean age was 88.42 months (SD = 3.94) at Time 1 and 97.16 (SD = 3.51) at Time 2. The children were originally recruited from five Maternal and Child Health Centers located in four regions (Hong Kong, Kowloon, New Territories East, and New Territories West) across Hong Kong in the summer of 2001 for a norming study of the Cantonese Communicative Development Inventory (CCDI; Tardif, Fletcher, Zhang, & Liang, 2008). According to parental reports, they were typically developing, without any family history of hearing impairment or congenital malformations.

Procedure

Invitation letters were sent to the parents requesting their children's participation. After the consent forms were obtained from the parents of all participants, appointments were arranged for student testing at home. Each child was tested individually by a trained psychology major in a single testing session that lasted for about 1–1.5 h. All measures described below were administered at both Time 1 and 2.

Measures

Reading comprehension

This task contained 30 test items and one demonstration item. Each item gave a short written description of an everyday scenario, e.g., "*媽媽將書本交給妹妹, 然後妹妹將書本放進書包*" (Mom gives sister a book and then she puts it in her school bag) and children were asked to select one of the five pictures that best matched the meaning of the sentence (see the "Appendix"). The five pictures available for children to choose from were all designed to be more or less related to the description, so that children needed to fully comprehend the whole sentence in order to get the correct answer. The four foils were designed such that they differed from the target minimally in one or two pieces of information. The maximum possible score for this task was 30. A similar task was used in a recent study (Tong et al., 2009).

Chinese character recognition

The reading and writing subtest of the Hong Kong Test of Specific Learning Difficulties (HKT-SpLD; Ho, Chan, Tsang & Lee, 2000) was used to access character recognition of children. The test consisted of 150 two-character words, e.g.,

畢業 (baT1 jip6, meaning graduation), and children were required to read aloud the characters one by one. The testing ended when the child was unable to give a correct answer for 15 consecutive items, and the maximum possible score was 150.

Rapid digit naming

In this task, children were presented with 25 numbers randomly arranged on a sheet (five rows of five digits). Each row consisted of the same five single digit numbers presented in different orders. Children were instructed to name all 25 numbers aloud as quickly as possible, beginning with the first number in the first row and ending with the last number of the last row. Errors were few and were not recorded. Total naming times were measured by the interviewers using a stop-watch, and two trials were administered to obtain an average time for each child. The test–retest reliability between the two trials was .83 and .87 for times 1 and 2, respectively. A similar task has been used in previous work on this age group (e.g., McBride-Chang & Kail, 2002).

Phonological awareness

The phonological awareness task, intended to emulate the Comprehensive Test of Phonological Processing (CTOPP; Wagner, Torgesen, & Rashotte, 1999) progressed from syllable to onset phoneme deletion in different forms, from the easiest to the most difficult. The test has a ceiling and a basal level set according to grade level and has been used successfully to distinguish Hong Kong Chinese children with and without dyslexia in previous work (Chung, McBride-Chang, Wong, Cheung, Penney, & Ho, 2008). The maximum possible score for the whole phonological awareness task was 51.

Vocabulary definitions

Our first level of meaning to be tested was at the word level. We opted to test vocabulary knowledge using a test involving children's oral definitions. In the present study, a total of 53 words were adopted from Hong Kong Chinese children's books (Zhuang, 2000) according to the words' frequencies and difficulty levels. A marking scheme based on the Stanford-Binet Intelligence Scale vocabulary subtest (Thorndike, Hagen, & Sattler, 1986) was used to assign scores of 0, 1, or 2, depending upon the quality of children's answers. The scoring scheme for each item had been previously determined based on definitions from a Chinese dictionary (Lau, 1999). For example, a standard two-point answer for the word 警察 (meaning police) is "a person who catches thieves/bad guys, with guns and handcuffs." A one-point answer might be something like "a person who shoots with guns" or "a person who catches people". A score of zero was allotted for answers such as "those with uniforms." The total maximum score a child could get was 106, and testing stopped when the children scored a 0 across five consecutive questions. The same task was used in previous work on Chinese children (e.g., McBride-Chang, Tardif, Cho, Shu, Fletcher, Stokes et al., 2008).

Morphological awareness

Our second measure of meaning, morphological awareness, included two subtasks, which were morphological construction and homophone production. In the first subtask, there were 27 items in total which were grouped into five sets with an increasing level of difficulty (from kindergarten to fourth grade levels). The number of items in each set varied from 5 to 7. For each item, children were orally presented a scenario and visually shown a picture which described a concept/compound word and then they were asked to form a novel compound word to name a new picture using the morphemes that they had grasped. For example, children were first shown a piece of white paper and told *"呢度有張紙, 佢係白色嘅, 我哋就會叫佢做白紙"* (There is a piece of paper and it is white. So we call it "white paper"), and then they were presented with a piece of red paper and asked "*咁而家呢度有張紙, 佢係紅色嘅, 我哋會點叫佢呀?*" (Now there is a piece of paper and it is red. What should we call it?). The answer is *紅紙* (red paper). This task was also designed to have both a ceiling and a basal set. The testing started with the first items in the set designated for the children's grade level. If the children could produce fewer than 2 (1 or 0) wrong answers in this set, they then progressed to the items in the next more difficult set. According to our ceiling rule, the test stopped when the child made 4 or more errors in a set. Otherwise, if children answered incorrectly for 2 or more items in the originally designated set, they then went down to the items in the easier set, and this testing stopped when they made fewer than 2 errors (1 or 0) in this level according to our basal rule. Before the formal testing, two practice trials were administered to make sure that children were familiar with the procedure. There was no time limit for this task, and the maximum possible score was 27. This task was shown to be useful in distinguishing Hong Kong Chinese children with and without dyslexia in previous research (Chung et al., 2008).

In the homophone production subtask, 14 two-morpheme words were used in total. For each trial, one word was orally presented with one of the constituent morpheme/characters designated as the target morpheme. Children were then asked to generate as many real words that were comprised of this target morpheme within 20 s as they could. For example, for the item *書* (syu1, meaning book) in the word *書包* (syu1 baau1, meaning school bag),children were first asked to generate as many words that included the target *書* (syu1) as they could in 20 s. Among the correct answers could be *書桌* (syu1 coek3, meaning desk) and *書架* (syu1 gaa3, meaning bookshelf). An example of this in English would be that, given the target sun in the word sunshine, another word that shares the same morpheme is sunburn. After that, children were given another 20 s to produce real words that included the morphemes which were the homophones of the target morpheme. Thus, for the example of *書* (syu1, meaning book) in*書包* (syu1 baau1, meaning school bag), children were required to recall as many words that included the homophone of *書* (syu1, meaning book) as possible in another 20 s. Among the correct answers for this section could be *舒服* (syu1 fuk6, meaning comfortable) or*舒暢* (syu1 coeng3, meaning happy or entirely free from worry) because both contain the morpheme *舒* (syu1), which has the exact pronunciation as that of *書* (syu1), but has a different meanings. For an analogy of this in English, an example might be again to target the sun in sunshine, such that a correct answer for a homophone of sun would be the son in grandson because both morphemes sound the same but have different meanings and written representations.

Two practice trials were also included before formal testing. The task stopped if children could not answer correctly in five consecutive trials. Each word generated in the task was allotted one point, and therefore no limit was set for the maximum score. A similar type of task was used by Shu et al. (2006) for Mandarin-speaking fifth and sixth graders.

Orthography-semantic awareness

Our final measure of meaning, at the sub-character level, was the orthography-semantic awareness task. In this newly developed task, children were given one picture and four nonsense characters. Each picture of the 36 items referred to an object that could be represented by a one-character Chinese real word made up of both a semantic and a phonetic radical in either of the following ways: left–right, e.g., 河 (meaning river), or top-bottom, e.g., 窗 (meaning window). Each of the four nonsense characters contained either the semantic or phonetic radical so that two of them shared the same radical. However, this radical was in a different position in each case. For example, for the picture of flower 花, the four non-sense characters given were [illegible], [illegible], [illegible] and [illegible]. Here, [illegible] was the correct answer, since it resembled the same semantic radical 艹 which was placed in the upper position in the same way as the target real word. The children were asked to pick the answer that best represented the meaning of the picture. The correct answer was the nonsense character with the semantic radical in the same position as that of the target real word. Thus, this task tested children's knowledge of both semantic radicals and their position within a given character. This task was used successfully in previous work on children's orthographic skills (Tong & McBride-Chang 2010).

Results

Table 1 shows the means, standard deviations, ranges, and reliabilities across all variables. The reliability of the rapid automatized naming task was test–retest reliability and the others represented measures of internal consistency reliability. All reliabilities were above .75.

Correlations among all measures for times 1 and 2 are shown in Table 2. Time 2 reading comprehension was significantly correlated with all measures at both testing times. Children's performance on reading comprehension from Time 1 to Time 2 was correlated .67 and word reading performance was correlated .93 across the same time period. Associations of other variables with word reading and reading comprehension tended to be moderate across tasks.

To explore the longitudinal effect of meaning acquisition on reading comprehension, we carried out a hierarchical regression, in which age, Time 1, Chinese word reading and phonological processing skills were all included in step one and

Table 1 Means, standard deviations, range, and reliability for all variables

Variables	Mean (SD)		Range		Reliability	
	T1	T2	T1	T2	T1	T2
Age	88.4 (3.9)	97.2 (3.5)	80–97	89–105	–	–
Reading comprehension	17.4 (5.2)	20.5 (4.9)	3–27	9–28	.79	.77
Chinese character recognition	82.9 (28.3)	100.6 (24.0)	3–137	6–149	.98	.98
Rapid digit naming	12.1 (3.6)	10.2 (3.1)	6–28	5–24	.83	.87
Phonological awareness	32.4 (9.5)	36.4 (9.8)	13–51	8–51	.95	.93
Morphological awareness	30.8 (15.5)	41.6 (21.8)	1–72	14–115	.94	.93
Vocabulary definitions	36.2 (11.9)	39.4 (14.9)	7–72	8–86	.86	.91
Orthography-semantic	17.9 (5.5)	21.9 (5.4)	7–33	9–33	.78	.79

the three meaning variables were added in step 2. The rationale for carrying out this regression in two steps was that in step 1, we controlled for all reading-related variables relevant to reading comprehension apart from the meaning-related variables themselves. In step 2, we then included the meaning-related variables as a block to determine the extent to which this block explained unique variance in reading comprehension in this group. Results of these analyses are shown in Table 3. The inclusion of phonological processing skills, age, and Chinese word reading at Time 1 explained 36% of the variance in Time 2 reading comprehension. In step 2, the three meaning variables explained an additional 5% of the variance in reading comprehension. The final beta weights for this analysis show that Time 1 morphological awareness and Chinese character recognition were the only unique predictors of subsequent reading comprehension with all variables considered together. In a separate analysis, we found that, with Time 1 reading comprehension further statistically controlled, the combined effect of meaning in step 2 was no longer significant; however, the final beta weight of morphological awareness was marginally significant ($t = 1.81$, $p < .10$) as shown in the same table.

We then turned to analyses of the concurrent relations between reading comprehension and meaning acquisition at both Time 1 and Time 2 using hierarchical regressions.

As shown in Table 4, with Time 1 age, phonological measures and word reading controlled, the combined effect of the meaning measures contributed 4% unique variance to the equation; here, morphological awareness, phonological awareness and word reading were the only significant correlates.

Table 5 showed the concurrent prediction of reading comprehension at Time 2. Here, the combination of Time 2 meaning variables, vocabulary, morphological awareness, and orthography-semantic awareness accounted for a unique 6% of the variance in Time 2 reading comprehension, once age, Chinese word reading, and phonological processing skills were statistically controlled. The final beta weights for this analysis demonstrated that the orthography-semantic awareness variable, along with Chinese character recognition, was a unique significant correlate of reading comprehension ($t = 3.04$, $p < .01$) and no other variables approached significance.

Table 2 Correlations among all variables

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Reading comprehension (T2)	1												
2. Vocabulary definitions (T1)	.42	1											
3. Morphological awareness (T1)	.48	.45	1										
4.Orthography-semantic awareness (T1)	.22	.27	.31	1									
5. Chinese character recognition (T1)	.60	.45	.42	.28	1								
6. Rapid automatized naming (T1)	−.34	−.15	−.31	−.18	−.41	1							
7. Phonological awareness (T1)	.35	.32	.22	.22	.34	−.30	1						
8. Reading comprehension (T1)	.67	.47	.54	.31	.62	−.35	.49	1					
9. Vocabulary definitions (T2)	.40	.42	.31	.11	.38	−.18	.19	.35	1				
10. Morphological awareness (T2)	.32	.29	.48	.14	.34	−.32	.41	.31	.47	1			
11.Orthography-semantic awareness (T2)	.49	.30	.43	.46	.47	−.26	.25	.42	.43	.31	1		
12. Chinese character recognition (T2)	.56	.45	.41	.22	.93	−.40	.32	.58	.44	.38	.47	1	
13. Rapid automatized naming (T2)	−.31	−.15	−.32	−.09	−.42	.78	−.30	−.34	−.17	−.27	−.22	−.42	1
14. Phonological awareness (T2)	.29	.18	.43	.16	.23	−.27	.60	.32	.26	.53	.26	.28	−.29

Correlations of .16 or above are significant at $\alpha = .05$; correlation of .22 or above are significant at $\alpha = .01$; correlations of .28 or above are significant at $\alpha = .001$. T1 = Time 1, T2 = Time 2

Also in Table 5, even with Time 1 reading comprehension further controlled, the combined effect of meaning uniquely contributed 3% variance, ΔF (3, 151) = 3.53, $p < .05$) with the whole model explaining 53% of the variance. In that analysis, the final beta weight for orthography-semantic awareness remained significant ($t = 2.69$, $p < .01$).

Overall, these analyses suggest that our meaning level variables as a group broadly uniquely explained reading comprehension beyond word recognition and phonological processing skills. In addition, morphological awareness emerged as a unique predictor of reading comprehension concurrently and longitudinally from Time 1 to Time 2, and the orthography-semantic awareness task was a unique correlate of reading comprehension at Time 2. One puzzle, however, was the lack of unique association of vocabulary knowledge, our broadest-level meaning variable,

Table 3 Hierarchical regression explaining Time 2 reading comprehension from Time 1 vocabulary, morphological awareness, and orthography-semantic awareness with/without Time 1 reading comprehension statistically controlled

Step	Variables	Reading comprehension (T2)				Reading comprehension (T2)			
		β	t	R^2	ΔR^2	β	t	R^2	ΔR^2
1.	Age (T1)	−.04	−.60	.36	.36***	−.05	−.80	.48	.48***
	Chinese character recognition (T1)	.41	5.17***			.26	3.37**		
	Rapid automatized naming (T1)	−.03	−.47			−.04	−.57		
	Phonological awareness(T1)	.05	.71			−.03	−.34		
	Reading comprehension (T1)					.40	4.77***		
2.	Vocabulary (T1)	.11	1.45	.41	.05**	.06	.91	.50	.02
	Morphological awareness (T1)	.22	2.69**			.14	1.81†		
	Orthography-semantic awareness (T1)	.01	.18			−.01	−.22		

† $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$

Table 4 Hierarchical regression explaining Time 1 reading comprehension concurrently from Time 1 vocabulary, morphological awareness, and orthography-semantic awareness with Time 1 Chinese character recognition controlled

Step	Variables	Reading comprehension (T1)			
		β	t	R^2	ΔR^2
1.	Age (T1)	−.01	.18	.45	0.45***
	Rapid automatized naming (T1)	−.03	−.43		
	Phonological awareness (T1)	.19	2.82**		
	Chinese character recognition (T1)	.38	5.31***		
2.	Vocabulary (T1)	.13	1.86†	.49	0.04**
	Morphological awareness (T1)	.20	2.64**		
	Orthography-semantic awareness (T1)	.06	0.93		

* $p < .05$; ** $p < .01$; *** $p < .001$

for any of these analyses. One possible explanation for this finding is that vocabulary was fairly strongly associated with both morphological awareness and word reading itself across analyses. We wondered, therefore, whether vocabulary knowledge would emerge as a unique correlate of reading comprehension when word reading was not included in the regression analyses. As shown in Table 6, without word reading included in the analyses, the total variance explained from Time 1 to Time 2 for reading comprehension was 31%. In that analysis, the only individual tasks that emerged with unique standardized beta weights were morphological awareness and vocabulary knowledge itself. For the concurrent analysis, Table 7 shows the results of similar analyses for explaining variance in Time 1 reading comprehension. Here, when Time 1 word reading was not statistically controlled, the three meaning variables together explained 14% unique variance in Time 1 reading comprehension; both vocabulary and morphological awareness were significant correlates in the

Table 5 Hierarchical regression explaining Time 2 reading comprehension from Time 2 vocabulary, morphological awareness, and orthography-semantic awareness with/without Time 1 reading comprehension further controlled

Step	Variables	Reading comprehension (T2)				Reading comprehension (T2)			
		β	t	R^2	ΔR^2	β	t	R^2	ΔR^2
1.	Age (T2)	.02	.36	.34	.34***	−.01	−.12	.50	.50***
	Chinese character recognition (T2)	.34	4.14***			.15	1.95†		
	Rapid automatized naming (T2)	−.07	−1.00			−.06	−.95		
	Phonological awareness(T2)	.12	1.51			.03	.47		
	Reading comprehension (T1)					.44	5.94***		
2.	Vocabulary (T2)	.11	1.38	.40	.06**	.07	1.05	.53	.03*
	Morphological awareness (T2)	−.02	−.18			.01	.10		
	Orthography-semantic awareness (T2)	.23	3.04**			.18	2.69**		

† $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$

Table 6 Hierarchical regression explaining Time 2 reading comprehension from Time 1 vocabulary, morphological awareness, and orthography-semantic awareness without Time 1 Chinese character recognition controlled

Step	Variables	Reading comprehension (T2)			
		β	t	R^2	ΔR^2
1.	Age (T1)	−.02	−.27	.17	.17***
	Rapid automatized naming (T1)	−.14	−1.19†		
	Phonological awareness (T1)	.08	1.01		
2.	Vocabulary (T1)	.24	3.13**	.31	.14***
	Morphological awareness (T1)	.27	3.02**		
	Orthography-semantic awareness (T1)	.05	.68		

† $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$

regression analyses. In a further analysis as shown in Table 8, explaining Time 2 reading comprehension from Time 2 variables only, 33% of the variance in reading comprehension could be explained, with the only unique correlates being speeded naming, vocabulary knowledge, and orthography-semantic awareness. Thus, without word reading statistically controlled in the analyses, vocabulary knowledge did emerge as a unique predictor of reading comprehension, underscoring both the importance of vocabulary knowledge for reading comprehension overall and its strong overlap with Chinese word reading.

Discussion

A primary goal of the present study was to examine the role of meaning acquisition for reading comprehension for young Chinese children. In the present study,

Table 7 Hierarchical regression explaining Time 1 reading comprehension from Time 1 vocabulary, morphological awareness, and orthography-semantic awareness without Time 1 Chinese character recognition controlled

Step	Variables	Reading comprehension (T1)			
		β	t	R^2	ΔR^2
1.	Age (T1)	.03	.49	.28	0.28***
	Rapid automatized naming (T1)	−.12	−1.79		
	Phonological awareness (T1)	.22	2.96**		
2.	Vocabulary (T1)	.25	3.49**	.42	0.14***
	Morphological awareness (T1)	.24	2.97**		
	Orthography-semantic awareness (T1)	.09	1.39		

* $p < .05$; ** $p < .01$; *** $p < .001$

Table 8 Hierarchical regression explaining Time 2 reading comprehension from Time 2 vocabulary, morphological awareness, and orthography-semantic awareness without Time 2 Chinese character recognition controlled

Step	Variables	Reading comprehension (T2)			
		β	t	R^2	ΔR^2
1.	Age (T2)	.04	.54	.15	.15***
	Rapid automatized naming (T2)	−.17	−2.35*		
	Phonological awareness (T2)	.09	1.14		
2.	Vocabulary (T2)	.18	2.30*	.33	.18***
	Morphological awareness (T2)	.04	.42		
	Orthography-semantic awareness (T2)	.33	4.37***		

* $p < .05$; ** $p < .01$; *** $p < .001$

Chinese word reading was consistently strongly associated with reading comprehension across analyses of both longitudinal and concurrent correlates of reading comprehension. These results are consistent with the importance of word recognition skills for reading comprehension as identified early on for alphabetic orthographies (Gough & Tunmer, 1986; Hoover & Gough, 1990). Beyond word reading, we additionally viewed meaning-building as occurring on at least three different more focused levels, i.e., the whole word level as vocabulary knowledge, the morpheme level as morphological awareness, and the sub-character level, as semantic-orthography awareness. Results of the present study highlight the important role of meaning acquisition for sentence-level reading comprehension of Chinese children. Across analyses, our a priori meaning-building variables explained unique variance in reading comprehension, both longitudinally and concurrently. Importantly, this pattern emerged even with the autoregressive effects of reading comprehension controlled. The present study built upon previous research highlighting the role of morphological awareness to literacy development (Shu et al., 2006; Tong et al., 2009) at the lexical level and has extended the recognized importance of meaning-building from beyond the word level to the sub-character level (e.g., Shu & Anderson, 1997) to show its link to reading comprehension as well.

In comparison with alphabetic languages, Chinese is relatively semantically transparent, at both the lexical and sub-character levels. At the lexical level, Chinese vocabulary words are typically comprised of two or more morphemes that are combined via lexical compounding. Previous research has demonstrated that vocabulary knowledge and morphological awareness are bidirectionally predictive of one another among young Chinese and Korean children (McBride-Chang et al., 2008). We propose that this bidirectional relationship also serves to facilitate the acquisition of meaning that directly benefits reading comprehension.

Correlations of vocabulary knowledge with reading comprehension across testing times were above .35, both concurrently and longitudinally, suggesting a bidirectional association of vocabulary knowledge and reading comprehension, as in previous work (e.g., Wagner et al., 2004). Further analyses in the present study showed that vocabulary was uniquely associated with reading comprehension both longitudinally and concurrently only when word reading was not controlled. Collectively, the present study underscores the relatively high associations among vocabulary and both word reading and reading comprehension.

Previous work (Shu et al., 2006; Tong et al., 2009) has already demonstrated the importance of morphological awareness for reading comprehension in Chinese children. The present study has replicated this finding and extends it by demonstrating its importance longitudinally. Indeed, morphological awareness was a unique longitudinal correlate of reading comprehension even with word reading and the autoregressive effects of reading comprehension statistically controlled.

At the sub-character level, semantic cues can advance the understanding of single characters, which represent morphemes, and this appears to be helpful for comprehending text. Readers actively construct their understanding of text, underscoring the importance of both top-down and bottom-up processing. It is not uncommon for young children to encounter novel words or characters as they read sentences or passages. Under these circumstances, children who can guess the meanings of new words either according to known morphemes and rules of morpheme combination (morphological awareness) or the meaning of novel single characters from visual cues and orthographic rules (orthographic-semantic awareness), are at a distinct advantage. They are then further able to relate background knowledge, context, or their existing schema to the current information presented in order to assimilate it, although admittedly the meaning they derive might be relatively sketchy. However, without cues to meaning, readers will not progress far in a text before becoming discouraged by a lack of context. In alphabetic languages, as compared to Chinese, the link from print to meaning is more often through the phonological route, and phonological awareness is highly emphasized in reading comprehension (Lonigan, 2004). However, the importance of orthography-semantic awareness for Chinese reading comprehension highlights the potential for a unique path from print directly to meaning via semantic radicals.

Another finding of potential interest in the present study is that morphological awareness and orthography-semantic awareness were each uniquely associated with reading comprehension at different testing times. Do these differential associations at different testing times represent a real developmental change across time? In the present study, the unique effect of morphological awareness was demonstrated at age 7 only, whereas the unique effect of orthography-semantic awareness was demonstrated at age 8 only. If such differences are replicated in future research, these associations may have important developmental implications, suggesting that Chinese children may first focus on word-level effects, shifting to character or sub-character level processing for meaning as time goes by (e.g., Chen, Song, Lau, Wong, & Tam, 2003; Tong & McBride-Chang, 2010).

In one prominent conceptualization of reading comprehension, reading comprehension involves both decoding skills, which are typically measured via word recognition, and linguistic comprehension, which comprises some global understanding of oral language (Gough & Tunmer, 1986; Hoover & Gough, 1990). That is, meaning via print would not be considered as part of linguistic comprehension. In discussing meaning-building throughout this paper, we have argued for three levels, word, morpheme, and subcharacter levels. The first two, word and morpheme, are clearly based in oral language. However, by definition, the third can be measured via print only. Here, we distinguish this from word decoding because deriving meaning is so fundamental to subcharacter processing at the level of the semantic radical (e.g., Shu & Anderson, 1997). Because most models of reading acquisition have been developed based on alphabetic languages, it is thus difficult to defend without question where semantic radical awareness fits within a so-called Simple View of reading, which distinguishes only the decoding aspect of word recognition and the oral language component (Gough & Tunmer, 1986; Hoover & Gough, 1990); subcharacter processing seems to fall somewhere in between these two. In addition, the present studies showed that character reading and vocabulary shared substantial variance to explain reading comprehension even for children at a relatively young age. This finding is inconsistent with the traditional claim of the Simple View that decoding and oral language are two separate components. Therefore, this contemporary perspective may need to be adjusted somewhat to fit with the reality of Chinese reading comprehension development.

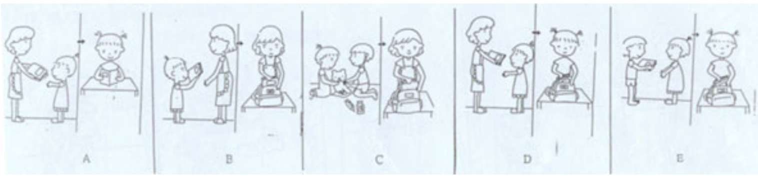
The present study had at least two limitations. The first was that we measured reading comprehension at the sentence level only. Although there were good developmental and design reasons for doing this, it is possible that had we measured reading comprehension at the paragraph or text level, our results may have been somewhat different. After all, metacognition, inference-making, and many other skills apart from specific meaning-building at the word or sub-word levels likely contribute to overall reading comprehension (e.g., Snow, 2002). Future work might examine correlates of reading comprehension at different levels, e.g., sentence, paragraph, and full text, simultaneously. At the same time, however, this focus on reading comprehension at the sentence level may best highlight the importance of meaning-related variables for Chinese reading comprehension. At the broadest level of an entire text, it is more likely that the top-down skills such as metacognition might subsume the importance of word-, morpheme-, or subcharacter-level analyses. Yet, without attention to these smaller units in the development of reading comprehension, broad-based reading comprehension development is impossible. This was a major reason for our decision to measure reading comprehension at the sentence level and, indeed, for teachers to teach reading comprehension this way for children of these ages of 7–8 years old as in the present study.

Thus, a second limitation of the present study is that our conclusions must be limited by the tasks included. Measurement error and other potential irregularities resulting from particular tests must be taken into account when considering issues such as the extent to which morphological awareness as defined as lexical compounding skills (including homophone sensitivity) might perhaps be more important for earlier reading comprehension, whereas sub-character-level processing may emerge as uniquely important for reading comprehension later. The fact that the vocabulary knowledge measure was never independently associated with reading comprehension should also be considered here. There might be at least two possible reasons for the relatively low contribution of vocabulary knowledge to reading comprehension. One is that morphological awareness might explain some shared variance that vocabulary and reading comprehension might incorporate since both of them were shown bidirectionally associated with one another developmentally (McBride-Chang, et al., 2008). The other reason might be that the vocabulary measure included in the present study narrowly focused on expressive aspects of vocabulary knowledge as well as vocabulary depth, rather than other aspects as tapped by receptive and vocabulary breadth measures. Therefore, without a large battery of measures tapping meaning building at three different levels, i.e., word, morpheme, and sub-character levels, the conclusions we draw from these data must be somewhat limited. Moreover, other aspects of reading comprehension, including inference-making, metacognitive strategies, background knowledge, and syntactic skills (Cornoldi & Oakhill, 1996) are also crucial for reading comprehension and should be included in future work in this area.

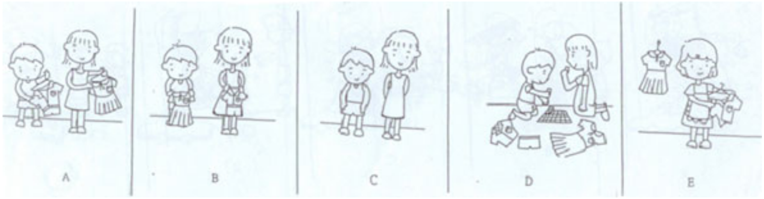
Despite these limitations, however, the present study has increased the knowledge base on reading comprehension in Chinese children. One replication/extension of our work in relation to previous findings was that we demonstrated that Chinese word recognition was important for reading comprehension, underscoring the importance of word decoding for reading comprehension (Gough & Tunmer, 1986; Hoover & Gough, 1990). In the present study, this was found in relatively young children using sentence-level reading comprehension. Most interestingly, however, we have proposed a model of meaning-building, occurring at the word, morpheme, and sub-character levels, and demonstrated that meaning-building as a whole explains unique variance in sentence-level reading comprehension both longitudinally and concurrently, with other variables previously linked to reading comprehension statistically controlled. This work might provide an impetus for future researchers to examine the role of other cognitive variables in explaining reading comprehension. It is likely that most of these variables should be associated with reading comprehension across orthographies. However, it is also possible that a few of these variables, such as orthography-semantic awareness in the present study, may be script-specific.

Appendix: Examples for reading comprehension task

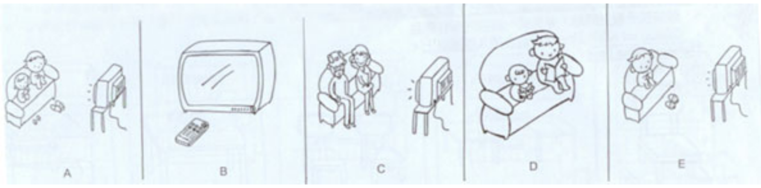
1. 媽媽將書本交給妹妹,然後妹妹將書本放進書包。 (Mom gives sister a book and then she puts it in her school bag) Correct answer: D



2. 姐姐和弟弟把各自的校服掛起。 (The sister and brother are hanging up their own school uniforms) Correct answer: A



3. 爸媽不在家的時候,我們才看電視。 (We only watch TV when our parents are not home) Correct answer: A



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