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Chinese character acquisition and visual skills in two Chinese scripts

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Abstract. Three different visual skills, along with Chinese character recognition, vocabulary, speeded naming, and syllable deletion skills were tested twice over one school year among 118 Hong Kong and 96 Xiangtan, China kindergartners. Results revealed that a task of Visual Spatial Relationships [Gardner, M. F. (1996). *Test of visual-perceptual skills* (*Non-motor*): *Revised manual*. Hydesville, CA: Psychological and Educational Publications] predicted unique variance in Chinese character recognition, controlling for other skills, at Time 1 among Hong Kong children and at Time 2 in Xiangtan children. The three visual skills were inconsistently affected by age and reading skill. Across testing times, visual skills of the Xiangtan children, who learn simplified script, were significantly higher than those of the Hong Kong children, learning traditional script. Results suggest a bidirectional association of visual skills with Chinese character acquisition across scripts.

Key words: Chinese, Chinese characters, Literacy, Reading, Script, Visual skills

Introduction

Learning to read typically involves the mapping of oral language onto visual symbols. Because some visual processing is usually required for reading, it is perhaps natural to wonder about the extent to which, and in what ways, visual skills interact with early reading acquisition. The importance of visual skills for reading was discussed in early research and has been explored in subsequent studies (see Willows, Kruk, & Corcos, 1993, for a review). The majority of this research has focused on the process of learning to read English. Relatively few studies have explored the importance of visual skills for learning to read Chinese, despite a long-standing assumption that visual skills are critical for Chinese character acquisition (Tzeng & Wang, 1983). Across orthographies, the developmental impact of individual differences in visual skills relative to reading abilities has been considered only rarely, and understanding of how visual skills might affect reading is limited. The present study on children's acquisition of visual skills in relation to beginning reading is intended to clarify the nature of this association in Chinese.

The extent to which visual skills and reading ability are associated in Chinese children is likely attributable to at least four factors. First, the age at which children's visual abilities and reading are assessed is critical in establishing an association between them. Second, the precise visual skills measured may be more or less important, relative to other reading-related abilities, for Chinese character recognition at a given level of development. Third, children's experience with reading may contribute to the association between character recognition and visual skills.

That is, among children of the same age, different children may have varying experiences with reading. For example, some children are taught to read earlier than others. Such experiences may affect the visual skills-reading process apart from age itself. Fourth, the script, traditional or simplified, may affect this association because of differences in visual features across Chinese orthographies.

The present study was an exploration of the association of three visual skills to Chinese character recognition in two groups of kindergarten children whose reading experiences and scripts differed from one another. We focused both on the importance of visual skills for Chinese character recognition and on how individual-level reading and group-level experiences are associated with subsequent visual skills in this 9-month longitudinal study. Below, we first review the importance of age, visual skills, experience with reading, and script in relation to character recognition.

Age

Age is likely to be important in examining visual skills in relation to Chinese character recognition because of previous work in both alphabetic orthographies (Ehri & Wilce, 1985) and Chinese (Ho & Bryant, 1997) demonstrating that young children may initially approach the task of reading from a logographic, holistic approach. That is, children sometimes appear to focus on salient visual features of print (e.g., the tail of the *q* in *quilt)* to recognize words. In alphabetic orthographies, this approach may imply a focus on a particular (usually the first) letter of a word to recognize it. Such visual salience may be sufficient to guarantee recognition provided that other words with similar visual features (e.g., *quiet)* are not also required to be learned simultaneously. However, with an increase in demands for visual distinctiveness, either new visual strategies must be implemented or different strategies (e.g., making use of letter-sound correspondences – Treiman & Rodriguez, 1999; Treiman, Sotak, & Bowman, 2001) gradually subsume the old ones. Such strategies are phonologically based in English and may be either phonologically or semantically (Chan & Nunes, 1998) based in Chinese.

As in English, Chinese characters are likely recognized according to visual distinctiveness in initial character recognition (Ho & Bryant, 1997). In fact, the importance of visual strategies for learning to read may be particularly salient in Chinese for two reasons. First, the amount of visual information contained within a Chinese character is greater than in an English word (e.g., Hoosain, 1991). Each character must be contained within a uniformly sized square shape. Thus, in contrast to English, where word length is a visual cue, only individual strokes of a character distinguish it visually; the space it occupies is constant.

Second, compared to English and other alphabetic orthographies, Chinese is less regular in its sound-print mapping. In compound Chinese characters, there is a phonetic component, which sometimes gives a clue to the sound of the character, and a semantic radical, which sometimes gives a clue to the character's meaning. However, children are rarely, if ever, explicitly taught to use these components to learn to read because they are quite irregular, and educators fear that they might serve to confuse children (Shu, Chen, Anderson, Wu, & Yue, 2003). Although researchers are converging on the idea that positive aspects of explicit teaching of these components outweigh the negative aspects on balance (Tsai & Nunes, 2003; Wu, Anderson, Li, Chen, & Meng, 2002) and that children are sensitive to these components (Chan & Wang, 2003; Ko & Wu, 2003), these components remain relatively unreliable cues to character reading. Furthermore, as in other orthographies, regularity is relatively low in Chinese characters learned by beginning readers and increases with grade level (Shu, Meng, & Lai, 2003).

Given that phonological cues may be relatively unavailable for initial character recognition, children might then be expected to focus on learning to read Chinese using whatever other information is salient to them. As children begin the process of literacy acquisition, visual characteristics of print are particularly salient. For example, both in English (Adi-Japha & Freeman, 2001) and Chinese (Chan & Louie, 1992), children show early recognition of print. By the age of three, children can distinguish print from pictorial representations (Gibson & Levin, 1975;

Gombert & Fayol, 1992). During this time, children's own script productions also reflect the visual features of their own script. For example, preschool Chinese children tend to represent script with short strokes and dots. In contrast, drawings tend to involve more circular motions (Chan & Louie, 1992).

Initial Chinese character recognition in young children develops primarily through rote repetition. Indeed, rote repetition is the primary strategy encouraged by Chinese teachers for learning Chinese characters (Wu, Li, & Anderson, 1999). Similarly, in English, preschoolers learn to recognize letter names of the alphabet largely through paired associate learning. It may be that Chinese characters are learned similarly to alphabet letters by very young children using rote repetition. Initial character recognition in Hong Kong, for example, is highly correlated with English letter recognition, suggesting that children may learn to recognize both letters and characters using the same oral-visual pairing strategies (McBride-Chang & Ho, 2000). Both elementary characters and alphabet letters have relatively simple visual configurations and names.

The beginning reader, thus, has ample reason to exploit visual strategies in initial character acquisition. For beginning learners, visual cues to print are accessible. Furthermore, teachers generally encourage children to learn to read and write Chinese using visual cues. Given that visual skills are logically important in beginning readers, we next consider the nature and effects of these visual skills.

Visual skills

Past studies have tested the extent to which visual skills and Chinese character recognition are associated with mixed results. Some have found a positive relation of visual skills with reading without statistically controlling for other reading-related factors (e.g., Lee, Stigler, & Stevenson, 1986), while others have found no association (e.g., Ho, 1997; Hu & Catts, 1998; McBride-Chang & Ho, 2000). One well-known study (Huang & Hanley, 1995) found that a Visual Paired Associates test significantly predicted Chinese character recognition among children, ages 8.3 to 9.3 years in Taiwan. However, the theoretical and practical importance of visual skills for Chinese character recognition should be in their ability to predict unique variance in reading, beyond other skills already established to have some predictive utility. If visual skills can be demonstrated to predict unique variance in Chinese character recognition when other variables are controlled, these may be of particular interest to researchers. In a subsequent study in Taiwan, Huang and Hanley (1997) found that reading was not significantly predicted by Visual Paired Associates learning once IQ differences were statistically controlled.

Despite these relatively weak findings, subsequent research has demonstrated unique effects of visual skills on Chinese character recognition in Chinese children. A variety of visual skills have been used across studies. For example, in perhaps the strongest test of the unique prediction of visual skills, Ho and Bryant (1997) demonstrated that young children's performance on the Frostig Developmental Test of Visual Perception at age three significantly predicted their character recognition skills at ages four and five, even controlling for age, IQ, mothers' education, and children's performances on phonological sensitivity (partial homophone, rhyme, and tone detection) measures. Research has investigated specific kinds of visual skills in relation to Chinese reading acquisition. Ho and Bryant (1999) demonstrated that, among the Motor Coordination, Figure-ground, Constancy of Shape and Position in Space subtests, and a simplified version of the Spatial Relationships subtest of the Frostig Developmental Test of Visual Perception, the Constancy of Shape subtest in three year-old Hong Kong children predicted Chinese Character recognition 1 year later, once children's age, IQ, and their mothers' education level were statistically controlled. In another study, Siok and Fletcher (2001) showed that a test of visual sequential memory predicted Chinese character recognition in first and second grade Mainland Chinese respectively, controlling for IQ and children's age. Few studies have examined visual skills in relation to reading among older children, presumably because the transition from pure visual to orthographic skills in reading is important primarily for early literacy development. Researchers have concluded that visual skills may be most strongly predictive of reading ability in early character recognition and that it may be important to consider different dimensions of visual skills in relation to Chinese reading acquisition (Ho & Bryant, 1997; Siok & Fletcher, 2001). Nevertheless, there has been relatively little attention afforded to visual skills as theoretical or diagnostic predictors of early reading. Furthermore, theory guiding the importance of visual tasks for predicting reading has been relatively lacking.

Given the relatively few studies on visual skills in relation to reading development, there is little psychological theory to guide selection of visual tasks that may predict unique variance in early reading. We selected three tasks designed to tap various aspects of visual processing for the present study. These were chosen because they measure visual skills not previously tested in studies of beginning Chinese readers, but are presumably theoretically useful in learning to read for reasons detailed below. Because we were interested in investigating the contributions of specific kinds of visual skills to Chinese reading development, we explored these particular visual skills as a complement to previous findings. These tasks, all taken from a standardized battery (Gardner, 1996), were Visual Discrimination, Visual Closure, and Visual Spatial Relationships. We conceptualized Visual Discrimination as tapping recognition of a given stimulus, either a Chinese character or a line drawing, when exposed to several stimuli sharing several visual features in common. Visual Closure skill is the ability to recognize a whole stimulus, whether a Chinese character or another visual form, given a partial representation, involving incomplete features, of it. Finally, the ability to detect Visual Spatial Relationships taps perceptual skill in recognizing spatial orientation, such as left–right or bottom–top reversals. The tasks tapping these skills are further outlined below, to clarify the possible importance of these visual-cognitive abilities for early reading.

Visual Discrimination is defined as a ''subject's ability to match or determine exact characteristics of two forms when one of the forms is among similar forms'' (Gardner, 1996, p. 8). Because many Chinese characters are visually similar, e.g., 土 and 士; 未 and 末; 大,太 and 犬, this skill may be crucial in initially distinguishing print. Early character recognition depends strongly on children's ability to detect subtle line differences that change the meanings of symbols. This task is ideally suited to measuring such a skill outside the context of print itself.

Visual Closure may also be an important predictor of Chinese character recognition. This task measures individuals' abilities to match one of several incomplete line drawings to its target complete form (Gardner, 1996). This ability makes use of a Gestalt principle of Pragnanz, which encompasses visual organization and connectedness. Chinese character recognition requires a similar skill (Chen & Kao, 2002). Chinese characters that conform to a principle of closure are more easily recognized than those that do not (Chen & Kao, 2002). In the present study, we tested the extent to which individual variability in visual closure skills for symbols other than Chinese characters would predict differences in character recognition itself.

The final task, Visual Spatial-Relationships, measured children's abilities to distinguish directionality in line drawings. Children's early difficulties in distinguishing directionality in English letters are well documented (e.g., Fisher, Bornstein, & Gross, 1985). Most children at some point confuse letters that represent reversals of direction, such as *b* and *d* or *p* and *q*. This may reflect an innate tendency among human beings to treat left–right reversals as representing the same object (though in mirror image) (Bornstein, Gross, & Wolf, 1978). In fact, in adults, recognition of normal objects seems relatively insensitive to left–right handedness (Biederman & Cooper, 1991). Thus, requiring children to pay attention to the directionality of a letter may be in some sense unnatural. Similarly, in Chinese script, some Chinese characters are comprised of the same stroke patterns in different directions, indicating different semantic properties, e.g., 陪 and 部. For beginning learners of Chinese, such characters are easily visually confusable. In the present study, we included this task of visual perception as a possible predictor of character reading.

To be of maximal theoretical interest, visual skills should predict unique variance in Chinese character recognition controlling for other abilities demonstrated to have strong associations with reading in previous studies. In Chinese, those constructs are phonological awareness (Ho & Bryant, 1997; Hu & Catts, 1998; McBride-Chang & Ho, 2000; McBride-Chang & Kai1, 2002) and naming speed (e.g., Ho & Lai, 1999; Hu & Catts, 1998; Shu, Meng, & Lai, 2003). Both phonological awareness and speeded naming tasks have been shown to predict unique variance in Chinese character recognition and to distinguish good from poor readers of Chinese. In the present study, we examined the predictive utility of visual skills for Chinese character recognition once vocabulary, phonological awareness, and speeded naming were all statistically controlled.

To summarize, we examined the associations of each of these three visual perceptual tasks separately in an attempt to discern whether one or more were uniquely associated with Chinese character recognition. We predicted that all three would be initially associated with Chinese character recognition because of the underlying cognitive skills tapped by the tasks, all involving two-dimensional line drawings, that may also be required for early character recognition. These visual skills could be linked specifically to both individual variability and group differences in character recognition.

Children's experience with reading

Both individual and group differences in Chinese reading ability are common in young children. Individual differences refer to differences within a given group of children, e.g., all the kindergartners tested in the present study were from one school in Xiangtan, China. Individual differences are reflected in correlational data in many studies of predictors of reading. For example, wide variability in reading skills among Chinese children has been linked to both variability in cognitive skills (Ho & Bryant, 1997; Hu & Carts, 1998; McBride-Chang & Ho, 2000) and home literacy experiences (Shu, Li, Anderson, Ku, & Yue, 2002). In contrast, group differences refer to those across samples. For example, in the present study, there were several group differences between the kindergartners from Xiangtan and Hong Kong, China in language, culture, and education. Group differences in literacy acquisition are largely attributable to educational practices across Chinese societies (e.g., Li, 2003; Li & Rao, 2000).

Differences in kindergarten educational practices across Chinese societies are large (Cheung & Ng, 2003). In particular, Hong Kong children tend to begin formal literacy instruction around the age of three, whereas children in Mainland China are not expected to begin formal reading instruction in Chinese character recognition until they begin primary school at the age of six (Li & Rao, 2000). In practice, however, parents and teachers do often encourage kindergarten children in China to learn to recognize some characters, though this instruction is much less formal or institutionalized than it is in Hong Kong (e.g., Ingulsrud & Allen, 1999).

China and Hong Kong differ in other aspects related to reading development as well. In China, regardless of the dialect spoken at home, children map spoken Mandarin onto Chinese characters, whereas Hong Kong children speak and read in Cantonese. In addition, an alphabetic coding system, Pinyin, is introduced to help children learn to read in China, whereas no coding system is used as an aid to character recognition in Hong Kong. In school, kindergartners in China learn only Mandarin, whereas Hong Kong kindergartners are expected to learn to speak both English and Mandarin, in addition to their native Cantonese. Most noteworthy for the present study, children from Hong Kong and China learn to read different scripts. Children in Hong Kong learn to read the traditional Chinese script, whereas those in China learn to read a simplified script. Some examples of the same characters presented in each of these scripts are given in Figure 1.

Script

The traditional and simplified scripts differ for historical reasons. Although Chinese individuals have simplified various characters in unsystematic ways for centuries (Seybolt & Chiang, 1979), it was not until the formation of the Republic of China in 1949 that the new government itself considered altering the writing system officially. As this was carried out, two basic emphases of the simplification processes were (a) simplify the structure by eliminating some characters and (b) decrease the number of strokes in characters that remain in use. The

Traditional	Simplified	English
結	结	Result
潔	洁	Clean
僅	仅	Only
儀	仪	Elegant
漢	汉	Chinese
濃	浓	Strong taste
膿	脓	Abscess
儂	侬	I
搶	抢	Rob
掄	抡	To Hit
槍	枪	Gun
橋	桥	Bridge
僑	侨	Overseas Chinese
喬	乔	A tall tree
齊	齐	Together
訴	诉	Complaint
拆	拆	Tear apart
折	折	Break branches
頭	头	Head
斗	斗	Dipper
豐	丰	Abundant
韋	韦	Leather
堅	坚	Tough
豎	竖	Straight down
還	还	Return
壞	坏	Bad
兒	儿	Son
幾	几	Several
東	东	East
車	车	Motor

Figure 1. Examples of Chinese characters in traditional and simplified script.

first list of simplifications in 1956 eliminated 29 characters and altered 486 of them. In 1964, a new list of 2238 simplified characters was announced (Teng & Jiang, 2000). Compared to traditional characters, simplified characters have approximately 22.5% fewer strokes (Gao & Kao, 2002).

During the simplification process, there was not consistent emphasis on preserving all phonetic and semantic information in the characters.

Rather, several different types of simplification were used: (a) simplification by phonetic borrowing, (b) simplification derived from cursive writing, (c) simplification by meaning, (d) simplification by removing elements, (e) simplification by rhyme, and (f) simplification by replacing a complex character element with a simpler one (Seybolt & Chiang, 1979). With these varied rules, there was some inconsistency in the simplification process. For example, identical components were simplified in some characters, but not in others, e.g., 觀 (to view) was simplified to 观 while the traditional and simplified characters of 罐 (a can) were the same. Also, identical components were simplified differently, e.g. 燈 (a lamp) was simplified to 灯 while 鄧 (a surname) was simplified to 邓. Furthermore, components were not always simplified in their derivative characters, e.g. 復 (to recover) was simplified to 复 but the component 復 in 覆 (to reply) was not simplified. Finally, many inappropriate simplifications have persisted, e.g. the simplified character of 導 (to lead) is 导 which was simplified with 巳 but not with the homophone 刀 (a knife). As a result of the simplification, thousands of characters and their components took on a quite different look (Harbaugh, 2003).

Do these differences in appearance affect the learnability of characters in the simplified or traditional script? This question has gone largely unanswered. For example, Guan (1979), citing a pure reduction in strokes in the simplified characters without standardization of principles for doing so, stated simply, "The simplified characters are more difficult to learn and to understand than the original characters" (p. 162, Guan, as cited in Seybolt & Chiang, 1979). Kummer (2001) argues that the simplified shapes of characters offer little balance between the legibility and distinctiveness of the stroke patterns, so that simplified characters may be visually more difficult to differentiate from one another than are traditional characters. However, it is perhaps equally plausible that traditional characters are more difficult to learn to read because of the large number of strokes across characters. These features could conceivably lead children to "stroke overload." In this case, children might find it more difficult to attend to the character because of its large number of features. An analogy to this in English might be that children may find it easier to learn to read shorter words such as *cat* or *dog* before longer ones such as *butterfly* in part because their letter components are easier to manage cognitively. Despite these speculations, little empirical research on the extent to which simplified or traditional characters differ in the ease with which they can be recognized exists to date, perhaps in large part for historical and political reasons.

Cognitively, some general processing principles may affect the ease with which Chinese characters are recognized. These include overlapping features and visual–spatial properties. First, children's print learning may be affected by features. For example, children may be more likely to confuse *M* and *N, F* and *E,* or *C* and *G* initially because they share most features in common. Similarly, children learning to recognize Chinese characters may focus globally on the character's overall appearance. Those characters that differ by one or two features may be more likely to be confused than are those that differ by several features (e.g., Tversky, 1977). Visual–spatial properties are also crucial for quick and accurate character recognition (Chen & Kao, 2002). Characters appear to be processed in a relatively holistic fashion in children with limited literacy experience. For example, Miller (2002) demonstrated that, although they could not read Chinese, children aged 4–5 years in Beijing were proficient at distinguishing Chinese characters that had been spatially transformed (reversed) from those that had not been, as compared to a group of American children without experience with Chinese. Miller concluded, "Children show an awareness of the visual structure of their writing system before formal reading instruction. This understanding is limited to the orthography they see around them" (p. 25). Chen and Kao (2002) conducted two experiments on the visual–spatial properties and the orthographic processing of Chinese characters of 50 fourth-grade school children. They found that the visual–spatial properties of Chinese characters provide a perceptual basis for the orthographic processing. Furthermore, the more visual–spatial properties the characters have, the greater the facilitating effect of orthographic processing of the characters (Chen & Kao, 2002).

To date, few studies have examined script differences in relation to expert or developing reading (Gao & Kao, 2002). Among children, at least one study (Chan & Wang, 2003) found no differences in reading or spelling skills attributable to script among children aged five to nine in Hong Kong and Beijing. However, this lack of difference is not surprising given that the cues children apply in learning to read are phonetic components and semantic radicals in compound characters, both of which have been largely preserved in simplified script, though with fewer strokes. Explicit attention to visual skills was not a focus of this study. In contrast, Chen and Yuen (1991) did find some differences in visual processing in their study of children aged 7 to 9.3. Specifically, children from China were more likely to make visual errors in character recognition than were children from Hong Kong. This difference in error patterns was attributed to differences in script across groups. Chen and Yuen (1991) argued that because the number of strokes is fewer in the simplified script, distinguishing among characters may be more difficult in beginning reading. With this background, the extent to which traditional and simplified scripts are correlated with visual skill was one focus of the present study. This was accomplished by comparing the Hong Kong group, using traditional script, to the Xiangtan group, using simplified script.

The present study

We sought to investigate the extent to which visual skills and reading were bidirectionally associated in young children across two Chinese scripts at Times 1 and 2 across the school year. Such a bidirectional association has been suggested by Hoosain (1991). That is, in addition to the idea that visual skills might predict early reading, learning to read may actually facilitate visual skills because the attention to visual detail necessary for beginning reading may strengthen visual abilities. McBride-Chang and Zhong (2003) found some evidence that reading skill predicted visual skill levels in a short-term longitudinal study of Hong Kong kindergartners. We tested this further in the present study, in which we hypothesized that visual skills would be predicted by age, individual differences in reading skill, and group, at both Times 1 and 2. Next, to test the unique variance in Chinese character recognition predicted by visual skills, we used regression equations systematically controlling all other measured variables in the study. These included children's ages, vocabulary knowledge, phonological awareness, and speeded naming skill.

Method

Participants

Participants were 118 Cantonese-speaking Hong Kong kindergartners with a mean age of 5.3 years (54 girls; 47 boys) and 96 Mandarin-speaking Xiangtan kindergartners with a mean age of 4.9 years (23 girls; 72 boys) when they were initially tested. In Hong Kong, traditional Chinese characters are used in educational and everyday life settings, and the mainstream approach to early Chinese reading instruction relies on rote memorization. In Xiangtan simplified Chinese characters are used and Pinyin, a phonological coding system, is taught during early Chinese lessons. Character pronunciations are always taught with Pinyin.

Measures

Vocabulary

The Stanford-Binet Intelligence Scale vocabulary subtest (Thorndike, Hagen, & Sattler, 1986) was administered to measure vocabulary knowledge of the children at Time 1 only. This was translated and adapted for Chinese children for the present study. The maximum raw score possible on the task administered was 20.

Chinese word reading

The Chinese Word Reading task (Ho & Bryant, 1997) was used at both Times 1 and 2 to measure reading of Chinese characters. The task consisted of 27 single Chinese characters and 34 two-character words, increasing in difficulty. The maximum score of the task was 61. The traditional Chinese script version was used in Hong Kong, whereas the simplified Chinese script version was used in Xiangtan.

Phonological awareness

The Chinese Syllable Deletion task (McBride-Chang & Ho, 2000; McBride-Chang & Kail, 2002), consisting of 25 two- and three-syllable phrases, was administered at Time 1. The phrases were orally presented by the experimenter and children were asked to delete a single syllable (e.g., in Cantonese, *dai6 mun4 hau2* without *mun4* would be *dai6 hau2)*. In Hong Kong, this task was administered in Cantonese, whereas the same task was administered in Mandarin in Xiangtan.

Speeded naming

Speeded Picture-Naming was administered at Time 1. Children were presented with three rows of five pictures each (apple, butterfly, airplane, sun, and watermelon), presented in different orders in each row, on a single sheet of paper. In both Cantonese and Mandarin, all of these pictures are two-syllables each. After initially identifying all five pictures orally one by one, slowly, children were required to name all three rows of pictures as quickly as possible, and their response times were recorded. They completed this task twice, and the average of these two times was their speeded score. On this task, a lower score was preferable because it indicated a faster time.

Visual skills

The Visual Closure, Visual Discrimination, and Visual Spatial Relationships subtests from Gardner's (1996) Test of Visual-Perceptual Skills (n-m) Revised were administered at both Times 1 and 2 to test various visual processing skills of the children. All three tasks consist of one practice item and 16 test items.

Visual Closure tests one's ability to select a form that is the same as the completed target form from among four incomplete forms. Each target item is a complete, black-and-white line drawing. The four choices are incomplete, comprised of unconnected line segments. Children must choose the item that would be the same as the target completed form if the discrete lines were all connected. This test is terminated when the child fails three out of four consecutive items.

The Visual Discrimination subtest tests the ability to match exact characteristics of a target form with one of five choices. Both the target and the five choices are printed in black and-white as line drawings or geometric forms. Children's task is to select the choice that is identical to the target. When the child fails four out of five consecutive items, the task is terminated.

Visual Spatial Relationships assesses the ability to discriminate a single form or part of a single form presented in a direction different from that of the other four forms of identical configuration. Each trial consists of five black-and-white line drawings. Of these, one is oriented differently from the other four. The child must distinguish this form from the others. The ceiling on this task is four out of five items incorrect.

Procedure

All participants were individually tested twice within an interval of 9 months by trained undergraduate psychology majors during school hours at schools. They were initially tested on the Stanford Vocabulary, the Chinese Word Reading, the Chinese Syllable Deletion, the Speeded Naming of Picture, and the Visual Closure, Visual Discrimination and Visual Spatial Relationships subtests in September, and subsequently tested on the Chinese Word Reading, and the Visual Closure, Visual Discrimination and Visual Spatial Relationships subtests in June.

Results

Means and standard deviations of all variables included in the study are shown in Table 1.

Table 1. Means and standard deviations for all times 1 and 2 measures.

Measures	Hong Kong		Xiangtan	
	Mean	*SD*	Mean	*SD*
Age in years	5.32	0.36	4.93	0.48
Stanford vocabulary (Time 1)	13.14	3.74	13.14	2.93
Chinese word reading (Time 1)	45.17	9.38	20.54	16.34
Chinese word reading (Time 2)	54.73	7.36	33.00	15.43
Chinese syllable deletion (Time 1)	19.66	4.44	19.81	6.17
Chinese syllable deletion (Time 2)	22.97	2.81	22.95	3.37
Speeded naming of pictures (Time 1)	33.90	11.04	37.95	10.33
Speeded naming of pictures (Time 2)	29.01	8.42	34.05	7.44
Visual closure (Time 1)	5.38	3.01	7.98	3.76
Visual closure (Time 2)	7.31	3.59	10.96	3.43
Visual discrimination (Time 1	7.90	3.76	10.62	4.41
Visual discrimination (Time 2	10.87	3.22	12.94	2.40
Visual spatial relationships (Time 1)	9.84	3.81	9.67	4.36
Visual spatial relationships (Time 2)	12.17	3.32	12.41	3.02

$^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.
Note. $N = 101$ for Hong Kong; $N = 95$ for Xiangtan.

Table 2. Descriptive statistics and *F*-tests controlling for age and time 1 Chinese word reading of time 1 visual skill measures.

Measures	Hong Kong		Xiangtan		Group	Age	CWR1	R^2
	Mean	*SD*	Mean	*SD*	*F*(1,193)	*F*(1,193)	*F*(1,193)	
Visual closure (Time 1)	5.38	3.01	7.98	3.76	28.77***	0.38	3.84	0.15
Visual discrimination (Time 1)	7.90	3.76	10.62	4.41	29.63***	6.50*	3.17	0.15
Visual spatial relationships (Time 1)	9.84	3.81	9.67	4.36	10.67**	1.91	20.07***	0.11

$^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.
Note. $N = 101$ for Hong Kong; $N = 95$ for Xiangtan.

To test the extent to which visual skills at both time periods were affected by age, individual differences in reading ability, and group, separate univariate analyses of variance were conducted across groups. As indicated in Table 2, the most consistent predictor of visual skills was group. With both age and reading knowledge statistically controlled, Xiangtan subjects scored significantly higher than their Hong Kong counterparts on all visual skill measures, $F(1, 193) = 28.77$, $P < 0.01$ for the Visual Closure, $F(l, 193) = 29.63$, $P < 0.01$ for the Visual Discrimination, and $F(1, 193) = 10.67$, $P < 0.01$ for the Visual Spatial Relationships. Only for the Visual Spatial Relationships task was reading skill a significant covariate, suggesting that Chinese character recognition was more strongly associated with this measure than the others at Time 1. Age was only significantly associated with the Visual Discrimination task.

To examine group differences in visual skills at Time 2, separate univariate analyses of variance on all Time 2 visual skill measures with age, corresponding Time 1 visual skill measure, and Times 1 and 2 Chinese Word Reading as covariates were conducted. As indicated in Table 3, Xiangtan subjects scored significantly higher than their Hong Kong counterparts on all Time 2 visual skill measures. Across different skills, age, previous skill on that visual measure, and Chinese character recognition were inconsistently associated with visual skill.

Predicting concurrent reading ability

Associations among all variables across both testing times are displayed in Table 4. Across both groups, syllable deletion, our measure of phonological awareness, was significantly associated with character recognition at Time 1. However, although both speeded naming and vocabulary were significantly associated with Chinese character recognition in the group from Xiangtan, they were not in the Hong Kong group. In contrast, correlations of the three visual skills with character recognition were remarkably similar across groups.

Interestingly, Table 4 demonstrates that stabilities of visual skills from Time 1 to Time 2 were quite variable. For example, for both the Hong Kong ($r = 0.30$) and Xiangtan ($r = 0.06$) children, the association of Visual Closure across testing times was fairly low. Similarly, for both groups ($r = 0.45$, Hong Kong; $r = 0.50$, Xiangtan), the associations from Times 1 to 2 on the Visual Spatial Relationships task were relatively high. Of the three tasks, only the Visual Spatial Relationships task was significantly associated with reading at Time 1. Across the three visual tasks, the magnitude of the association of the Visual Spatial Relationships task with reading was also highest (though nonsignificant) for the Hong Kong group and relatively strong for the Xiangtan group at Time 2. Given its relatively high test–retest reliability and its strong association with reading across groups, only the Visual Spatial

Table 3. Descriptive statistics and *F*-tests controlling for age, corresponding visual skill measures at time 1, and times 1 and 2 Chinese word reading of time 2 visual skill measures.

Measures	Hong Kong		Xiangtan		Group	Age	Visual skill (Time 1)	CWR1	CWR2	R^2
	Mean	SD	Mean	SD	*F*(1,193)	*F*(1,193)	F(1,193)	*F*(1,193)	*F*(1,193)	
Visual closure (Time 2)	7.31	3.59	10.96	3.43	43.27***	9.35**	3.67	0.73	6.29*	0.30
Visual discrimination (Time 2)	10.87	3.22	12.94	2.40	22.53***	1.5	19.54***	1.12	1.62	0.26
Visual spatial relationships (Time 2)	12.17	3.32	12.41	3.02	4.80*	1.46	39.19***	0.02	3.08	0.23

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.
Note. $N = 101$ for Hong Kong; $N = 95$ for Xiangtan.

Table 4. Intercorrelations among different measures.

	Age	Stanford vocabulary	Chinese syllable deletion (Time 1)	Speeded naming of picture (Time 1)	Visual closure (Time 1)	Visual discrimination (Time 1)	Visual spatial relationships (Time 1)	Visual closure (Time 2)	Visual discrimination (Time 2)	Visual spatial relationships (Time 2)	Chinese word reading (Time 1)	Chinese word reading (Time 2)
Age in years	–	0.34***	0.16	−0.20*	0.11	0.28**	0.28**	0.38***	0.12	0.22*	0.10	−0.08
Stanford vocabulary	0.16	–	0.20*	−0.09	0.12	0.27**	0.29**	0.26**	0.22*	0.31**	0.09	0.00
Chinese syllable deletion (Time 1)	0.20	0.41***	–	−0.34**	0.12	0.40***	0.40***	0.26*	0.21*	0.43***	0.37***	0.20
Speeded naming (Time 1) −0.	−0.18	−0.28**	−0.33**	–	−0.12	−0.22*	−0.18	−0.29*	−0.15	−0.21*	−0.12	−0.11
Visual closure (Time 1)	0.04	0.36***	0.25*	−0.12	–	0.31**	0.21*	0.30**	0.24*	0.23*	0.14	0.13
Visual discrimination (Time 1)	0.15	0.43***	0.31**	−0.17	0.41***	–	0.43***	0.24*	0.38***	0.40***	0.19	0.10
Visual spatial relationships (Time 1)	0.05	0.50***	0.37***	−0.30**	0.45***	0.47***	–	0.34**	0.33**	0.45***	0.35***	0.17
Visual closure (Time 2)	0.11	0.06	0.08	0.01	0.06	0.29**	0.33**	–	0.35***	0.35***	0.23*	0.12
Visual discrimination (Time 2)	0.24*	0.19	0.18	−0.20	0.16	0.34**	0.31**	0.57***	–	0.44***	0.17	0.05
Visual spatial relationships (Time 2)	0.09	0.04	0.13	−0.11	0.25*	0.24*	0.50***	0.61***	0.63***	–	0.27**	0.19

Chinese word reading (Time 1)	0.18	0.29**	0.45***	−0.32**	0.16	0.14	0.32**	0.07	0.31**	0.24*	–	0.67***
Chinese word reading (Time 2)	0.15	0.21*	0.38***	−0.31**	0.15	0.17	0.35***	0.29**	0.40***	0.35**	0.67***	–

$*P < 0.05$, $**P < 0.01$, $***P < 0.001$.

Note. Correlations above the diagonal represent associations among the Hong Kong subjects; correlations below the diagonal represent associations among the Xiangtan subjects. $N = 101$ for Hong Kong; $N = 95$ for Xiangtan.

Relationships task was retained in subsequent regression analyses predicting reading.

Hierarchical regression equations predicting Time 1 Chinese Word Reading are presented separately for the Hong Kong and Xiangtan groups in Table 5. In these equations, the Visual Spatial Relationships task was entered following all other variables included so as to investigate the extent to which children's skill in visual spatial relationships uniquely predicted reading. The variables were entered in order of hypothesized contribution to reading. Age was entered first because it is a strong predictor of cognitive development. The Stanford Vocabulary was entered at the second step to control for any contribution of verbal

Table 5. Hierarchical regression equation predicting concurrent Chinese word reading (CWR1).

Step	Hong kong		Xiangtan	
	R^2 Change	Cumulative R^2	R^2 Change	Cumulative R^2
1. Age in years	0.01	0.01	0.03^{+}	0.03
2. Visual spatial relationships (Time 1)	0.11**	0.12	0.10**	0.13
1. Age in years	0.01	0.01	0.03^{+}	0.03
2. Stanford vocabulary	0.00	0.01	0.07**	0.10
3. Visual spatial relationships (Time 1)	0.11**	0.12	0.04*	0.15
1. Age in years	0.01	0.01	0.03+	0.03
2. Stanford vocabulary	0.00	0.01	0.07**	0.10
3. Chinese syllable deletion (Time 1)	0.13***	0.14	0.12***	0.23
4. Visual spatial relationships (Time 1)	0.05*	0.19	0.02^{+}	0.25
1. Age in years	0.01	0.01	0.03^{+}	0.03
2. Stanford vocabulary	0.00	0.01	0.07**	0.10
3. Chinese syllable deletion (Time 1)	0.13***	0.14	0.12***	0.23
4. Speeded naming of pictures (Time 1)	0.00	0.14	0.02^{+}	0.25
5. Visual spatial relationships (Time 1)	0.05*	0.19	0.01	0.26

$^{+}P < 0.10$, $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$

Note. $N = 101$ for Hong Kong; $N = 95$ for Xiangtan.

IQ. Chinese Syllable Deletion was entered at the third step, followed by Speeded Naming of Pictures, as phonological processing tasks.

As demonstrated in Table 5, the Visual Spatial Relationships task predicted 11 and 4% of total variance in concurrent Chinese Word Reading when both age and the Stanford Vocabulary were entered in the equation for the Hong Kong and Xiangtan groups, respectively. With all measured variables included in the equation, Chinese Syllable deletion significantly contributed the greatest variance in concurrent Chinese Word Reading in both groups, 13% and 12 % of total variance in concurrent Chinese Word Reading for Hong Kong children and Xiangtan children, respectively. Though Chinese Syllable Deletion contributed a relatively large proportion of total variance, the Visual Spatial Relationships task still significantly predicted 5% of total variance in concurrent Chinese Word Reading for the Hong Kong group. However, the same task was not uniquely predictive of Chinese character recognition in the Xiangtan group once other variables were controlled, perhaps because of limited variability in the reading measure for this group.

Predicting subsequent reading ability

To test the effects of Time 1 Visual Spatial Relationships on reading at Time 2, hierarchical regression equations predicting Time 2 Chinese Word Reading from Time 1 measures were performed for Hong Kong and Xiangtan groups separately. In these equations, the variables were entered in the same order of the previous hierarchical regression equations predicting Time 1 Chinese Word with one exception: In the final equation, Time 1 Chinese Word Reading was included to control for its autoregressive effects on Time 2 Chinese Word Reading. We used the Visual Spatial Relationships task to predict Chinese character recognition in both groups because it had the strongest association with character recognition across groups.

As shown in Table 6, controlling for age and vocabulary, Chinese Syllable Deletion significantly contributed 4 and 10% of total variance in subsequent Chinese Word Reading among Hong Kong children and Xiangtan children, respectively. Even when all cognitive variables were entered into the equation, Time 1 Visual Spatial Relationships still significantly predicted 4% of total variance in subsequent Chinese Word Reading for Xiangtan subjects. It also predicted 2% of the variance for Xiangtan subjects when Time 1 Chinese Word Reading was entered, though this difference was nonsignificant ($P < 0.10$). In contrast, once all cognitive variables and Time Chinese Word Reading were statistically

Table 6. Hierarchical regression equation predicting Time 2 Chinese word reading (CWR2).

Step	Hong Kong		Xiangtan	
	R^2 change	Cumulative R^2	R^2 change	Cumulative R^2
1. Age in years	0.01	0.01	0.02	0.02
2. Visual spatial relationships (Time 1)	0.04*	0.05	0.12**	0.14
1. Age in years	0.01	0.01	0.02	0.02
2. Stanford vocabulary	0.00	0.01	0.03$^+$	0.06
3. Visual spatial relationships (Time 1)	0.04*	0.05	0.09**	0.14
1. Age in years	0.01	0.01	0.02	0.02
2. Stanford vocabulary	0.00	0.01	0.03$^+$	0.06
3. Chinese syllable deletion (Time 1)	0.04*	0.05	0.10**	0.15
4. Visual spatial relationships (Time 1)	0.02	0.07	0.06**	0.21
1. Age in years	0.01	0.01	0.02	0.02
2. Stanford vocabulary	0.00	0.01	0.03$^+$	0.06
3. Chinese syllable deletion (Time 1)	0.04*	0.05	0.10**	0.15
4. Speeded naming of pictures (Time 1)	0.00	0.06	0.03$^+$	0.18
5. Visual spatial relationships (Time 1)	0.02	0.07	0.04*	0.23
1. Age in years	0.01	0.01	0.02	0.02
2. Stanford vocabulary	0.00	0.01	0.03$^+$	0.06
3. Chinese syllable deletion (Time 1)	0.04*	0.05	0.10**	0.15
4. Speeded naming of pictures (Time 1)	0.00	0.06	0.03$^+$	0.18
5. Chinese word reading (Time 1)	0.43***	0.48	0.28***	0.46
6. Visual spatial relationships (Time 1)	0.00	0.48	0.02$^+$	0.48

$^+P < 0.10$ $^*P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.
Note. $N = 101$ for Hong Kong; $N = 95$ for Xiangtan.

controlled among the Hong Kong children, Visual Spatial Relations was no longer predictive of subsequent Chinese Word Reading.

Discussion

In the present study, we examined three visual skills in relation to character recognition in beginning readers in Xiangtan and Hong Kong, China. We obtained three primary results. First, different tasks of visual skill had different associations with Chinese character recognition. The task of Visual Spatial Relationships appeared to be particularly strongly associated with reading. Second, children's reading experience, age, and visual skills were sometimes predictive of subsequent visual skills. Third, there were clear group differences in the levels and associations of visual skills across children from Hong Kong and Xiangtan, China, perhaps attributable, in part, to the timing of their reading instruction and to the script they were taught. We consider each of these, in turn, below.

Of the three tasks of visual skills included in the present study, Visual–Spatial Relations had the strongest association with Chinese character recognition across both samples and both testing times, statistically controlling for age. In addition, this task had the greatest stability over the 9-month testing period. This result is of practical significance. Given that there was no theoretical rationale for expecting one task of visual skills to be more clearly associated with Chinese reading than the others, we have, within practical limits, established the superiority of the Visual Spatial task over those of Closure and Discrimination for predicting beginning reading. This task is important not just because it was significantly associated with Chinese character recognition across time, but because it was uniquely predictive of reading once other reading-related tasks were statistically controlled. At Time 1, this task predicted unique variance in Chinese character recognition even after controlling for the effects of age, vocabulary knowledge, phonological awareness, and speeded naming in the Hong Kong students. At Time 2, among the Xiangtan students, a similar pattern of unique variance predicted by this visual skill emerged. In fact, even when Chinese character recognition at Time 1 was statistically controlled, the Visual Spatial Relationships task contributed an additional 2% of the variance in the equation. Although this contribution was not statistically significant, it nevertheless suggests that this task may be particularly important in predicting early Chinese character recognition.

Perhaps the importance of this task is attributable to the similarities between what it requires of children and what is demanded in initial character recognition. In this task, children had to select the item that was different from among alternatives. To distinguish the different item, they had to look carefully at features of each item, form a visual representation of each item that captured the spatial relations among features, and then compare among figures to determine the one that had a different spatial orientation. Similarly, in learning to read, children using a visual strategy must notice the salient visual feature(s) and the spatial relationships with which those features are conjoined, that distinguish one character from another. The other visual skills tasks rely more heavily on memory, where participants are required to judge where in the set a target shape (or part of the target shape) is found. These tasks require not so much discrimination among alternatives as identity judgments between a perceived stimulus and a memory representation.

One likely explanation for the fact that the task of Visual Spatial Relationships uniquely predicted variance in Time 1 only in Hong Kong and in Time 2 only in Xiangtan is that the importance of this measure for predicting reading acquisition depends on children's reading experience. Visual skills appear to be most important for reading development among beginning readers (Ho & Bryant, 1997). As children acquire more strategies for character recognition, they may be less likely to rely on visual ones, which tax memory skills to the extent that they become inefficient once a large number of characters must be learned. However, they may be invaluable in very early character recognition because they rely on basic perceptual skills available to all normally developing children. Given the clear differences in educational practices, language, and script between the two cultures included in the study, the consistency with which the Visual Spatial task was associated with Chinese character recognition across the groups was striking. A recent study on dyslexia in Hong Kong (Ho, Chan, Tsang, & Lee, 2002) also found that the task of Visual Spatial Relationships was particularly sensitive in revealing differences between 8-year-old dyslexic and normal readers. These results suggest that, regardless of age, the Visual Spatial Relationships task is a good predictor of reading skill in inexperienced Chinese readers, because dyslexic students typically have much less reading experience than do normal readers.

Differences in visual skill levels in the Xiangtan and Hong Kong groups found in the present study are of interest for two reasons. First, it did not appear that these differences were simply a product of overall cognitive ability. In addition, the Hong Kong group was slightly older.

Nevertheless, controlling for age, they did not differ from the Xiangtan group in the vocabulary or phonological processing measures, although they had better reading scores because they had had more formal reading instruction. Yet the Xiangtan group was clearly stronger in all of the visual skills tested, suggesting their relative strength in visual processing. Indeed, the clear group differences in phonological processing and reading relative to visual skills were not expected a *priori*. However, the difference in visual skills is particularly striking across time. That is, a second reason that these visual skill differences are of interest in the present study is that they persisted at Time 2, even controlling for visual skill differences at Time 1. Thus, not only did the children from Xiangtan begin with higher levels of visual skills as compared to their Hong Kong counterparts, their visual skills showed more improvement across time.

One explanation for this difference comes from script differences across the two places. If children are exposed to a simplified script literacy environment, they might make greater use of visual skills in learning about this environment. If children exposed to the simplified script are prone more to visual errors because the characters written in this script have fewer features and are, therefore, more difficult to distinguish, they may gradually acquire more reliance on visual cues to discriminate print (Chen & Yuen, 1991). The traditional script, because it contains more visual features, may be easier to discriminate initially (Seybolt & Chiang, 1979; Kummer, 2001). In addition, the phonetics and semantic radicals in this script may be more regular than in the simplified one, promoting sound- or meaning-based strategy use earlier than in the simplified script.

The idea that visual skills may be determined, in part, by script, requires a greater understanding of emergent literacy. Although it is clear that children in many cultures become aware of the visual components of their script early, it is unclear how and how much they focus on features of print at these ages. Most previous research on early concepts of print has focused on concepts of writing rather than on print recognition. Nevertheless, it is clear that the script to which children are exposed influences their global notions of print (Miller, 2002). Thus, although individual variability in reading skill is plausibly associated with visual skills (e.g., Hoosain, 1991), group-level differences, particularly in script, may also affect elementary visual skills. These ideas may be interesting to pursue in future research.

Critiques and future directions

There are a number of critiques that might be offered of this study. First, because the primary focus of this research is on visual skills, which have been examined relatively rarely in previous studies of literacy acquisition, we have focussed relatively little of our discussion of results in the present study on other well-known predictors of reading development. For example, phonological awareness appeared to be a particularly important correlate of Chinese reading acquisition in the present study. This was in line with findings of past research, such as Hu and Catts (1998), and McBride-Chang and Ho (2000), and further underscores the importance of phonological awareness for learning to read nonalphabetic languages such as Chinese. On the other hand, although we included several tasks previously demonstrated to predict unique variance in Chinese character recognition, such as vocabulary, phonological awareness, and naming speed (e.g., Ho & Bryant, 1997; Huang & Hanley, 1995; McBride-Chang & Ho, 2000), the variance in Chinese character recognition predicted by these skills collectively was relatively small, ranging from 6 to 25%. This suggests that there are other reading-related processes not tapped in the present study that may be stronger predictors of initial reading development. Our focus on visual skills in the present study is meant to underscore our interests in the interactions of visual skills with early Chinese character recognition, though we fully recognize that other cognitive abilities, such as phonological processing or morphological skills, are clearly central correlates of reading with development.

Second, our conclusions about visual skills in relation to beginning Chinese character recognition are based on data from measures with relatively small numbers of items (16 items in each task). Previous research studies investigating the associations of specific visual skills on Chinese reading acquisition, such as that carried out by Ho and Bryant (1999), who included visual skill tasks with number of items ranging from 8 to 20 or Siok and Fletcher (2001), who included visual skill tasks with 16 items, were similar in methodology and results. Nevertheless, future research might incorporate different tasks tapping the same specific visual ability constructs, such as understanding of visual–spatial relationships, to draw clearer conclusions.

Third, related to the previous point, a clearer concept of how visual skills develop and which ones are particularly important for reading is needed. Theory related to visual processing of text is relatively lacking for beginning readers. Based on the results of the present study and previous ones (Ho & Bryant, 1999; Ho et al., 2002; Siok & Fletcher, 2001), visual skills involving spatial relations, shape constancy, and visual memory may be the central ones to focus on in future research on beginning Chinese character acquisition.

Finally, the suggestion that script itself might affect visual skills is virtually impossible to test in Chinese children. Children learning to read Chinese as their native script are learning within specific environments that differ in a number of ways from one another. For example, the children from Xiangtan and Hong Kong differed in the languages spoken, the age at which they began formal instruction in reading, and the method by which they were taught to read, among others. All of these differences might conceivably affect their approach to character recognition; all are confounded with script used.

Despite these potential problems of interpretation, this study underscores two interesting aspects of reading development. First, beginning reading clearly makes use of visual spatial relations. This notion fits well with previous researchers' observations that children typically confuse left–right visual orientation in early childhood because, perceptually, in the environment, such reversals are often mirror images of one another, representing the same object (e.g., Bornstein et al., 1978). Sensitivity to left–right orientation is helpful for young children learning to read, both in English (e.g., distinguishing *b* from *d*) and in Chinese (Lu & Jackson, 1993, as cited in Geva & Willows, 1994). The importance of a visual spatial relations task may lie in making this crucial distinction, in distinguishing characters based on features as suggested above, or both. Other aspects of visual discrimination may be less centrally related to early Chinese print recognition.

Second, it is possible that the type of script children learn to read affects the importance of visual skills for literacy acquisition. Share and Gur (1999), for example, have suggested that, in contrast to English, Hebrew may prompt children to use more visuographic strategies in early word recognition because of features of its script. Such features include a consistent letter square shape allotted for each letter and absence of uppercase letters, making it necessary to pay more attention to the entire visual configuration of the word when distinguishing it from others. In English, in contrast, children may be more likely to pay attention to a single letter only, because initial letters may be more visually distinct in this orthography. The present study suggests that the same phenomenon may be true across two Chinese scripts. When fewer visual features are available as cues to distinguish among characters, children may attend to the visual configuration across characters in a holistic way.

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References

Adi-Japha, E., & Freeman, N. H. (2001). Development of differentiation between writing and drawing systems. *Developmental Psychology, 37*, 101–114.

Biederman, I., & Cooper, E. E. (1991). Evidence for complete translational and reflectional invariance in visual object priming. *Perception, 20*, 585–593.

Bornstein, M. H., Gross, J., & Wolf, J. (1978). Perceptual similarity of mirror images in infancy. *Cognition, 6*, 89–116.

Chan, L., & Louie, L. (1992). Developmental trend of Chinese preschool children in drawing and writing. *Journal of Research in Childhood Education, 6*, 93–99.

Chan, L., & Nunes, T. (1998). Children's understanding of the formal and functional characteristics of written Chinese. *Applied Psycholinguistics, 19*, 115–131.

Chan, L., & Wang, L. (2003). Linguistic awareness in learning to read Chinese: A comparative study of Beijing and Hong Kong children. In C. McBride-Chang & H.-C. Chen (Eds.), *Reading development in Chinese children* (pp. 91–106). Westport, CT: Praeger Press.

Chen, X., & Kao, H. S. R. (2002). Visual-spatial properties and orthographic processing of Chinese characters. In H. S. R. Kao, C.-K. Leong, & D.-G. Gao (Eds.), *Cognitive neuroscience studies of the Chinese language* (pp. 175–194). Hong Kong: Hong Kong University Press.

Chen, M. J., & Yuen, J. C.-K. (1991). Effects of pinyin and script type on verbal processing: Comparisons of China, Taiwan, and Hong Kong experience. *International Journal of Behavioral Development, 14*, 429–448.

Cheung, H., & Ng, L (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: Praeger Press.

Ehri, L. C., & Wilce, L. S. (1985). Movement into reading: Is the first stage of printed word learning visual or phonetic? *Reading Research Quarterly, 20*, 163–179.

Fisher, C. B., Bornstein, M. H., & Gross, G. G. (1985). Left-right coding skills related to beginning reading. *Journal of Developmental and Behavioral Pediatrics, 6*, 279–283.

Gao, D.-G., & Kao, H. S. R. (2002). Psycho-geometric analysis of commonly used Chinese characters. In H. S. R. Kao, C.-K. Leong, & D.-G. Gao (Eds.), *Cognitive neuroscience studies of the Chinese language* (pp. 195–206). Hong Kong: Hong Kong University Press.

Gardner, M. F. (1996). *Test of visual-perceptual skills (Non-motor): Revised manual.* Hydesville, CA: Psychological and Educational Publications.

Geva, E., & Willows, D. (1994). Orthographic knowledge is orthographic knowledge is orthographic knowledge. In V. W. Berninger (Ed.), *The varieties of orthographic knowledge I: Theoretical and developmental issues* (pp. 359–380). London: Kluwer Academic Publishers.

Gibson, E. J., & Levin, H. (1975). *The psychology of reading*. Cambridge, MA: MIT Press.

Gombert, J. E., & Fayol, M. (1992). Writing in preliterate children. *Learning and Instruction 2*, 23–41.

Harbaugh, R. (2003). *Chinese characters and culture*. Retrieved from http://www. zhongwen. com.

Ho, C. S.-H. (1997). The importance of phonological awareness and verbal short-term memory to children's success in learning to read Chinese. *Psychologia, 40*, 211–219.

Ho, C. S.-H., & Bryant, P. (1997). Phonological skills are important in learning to read Chinese. *Developmental Psychology, 33*, 946–951.

Ho, C. S.-H., & Bryant, P. (1999). Different visual skills are important in learning to read English and Chinese. *Educational and Child Psychology, 16*, 4–14.

Ho, C. S.-H, Chan, D. W.-O., Tsang, S.-M., & Lee, S.-H. (2002). The cognitive profile and multiple-deficit hypothesis in Chinese developmental dyslexia. *Developmental Psychology, 38*, 543–553.

Ho, C. S.-H., & Lai, D. N.-C. (1999). Naming speed deficits and phonological memory deficits in Chinese developmental dyslexia. *Learning and Individual Differences, 2*, 1–14.

Hoosain, R. (1991). *Psycholinguistic implications for linguistic relativity: A case study of Chinese*. Hillsdale, HJ: Erlbaum.

Hu, C. F., & Catts, H. W. (1998). The role of phonological processing in early reading ability: What we can learn from Chinese. *Scientific Studies of Reading, 2*, 55–79.

Huang, H.-S., & Hanley, J. R. (1995). Phonological awareness and visual skills in learning to read Chinese and English. *Cognition, 54*, 73–98.

Huang, H.-S., & Hanley, J. R. (1997). A longitudinal study of phonological awareness, visual skills and Chinese reading acquisition among first graders in Taiwan. *International Journal of Behavioural Development, 20*, 249–268.

Ingulsrud, J. E., & Allen, K. (1999). *Learning to read in China: Sociolinguistic perspectives on the acquisition of literacy*. Lewiston, NY: E. Mellen.

Ko, H., & Wu, C. F. (2003). The role of character components in reading Chinese. In C. McBride-Chang & H.-C. Chen (Eds.), *Reading development in Chinese children* (pp. 73–79). Westport, CT: Praeger Press.

Kummer, R. (2001). *Chinese language*. Retrieved December 9, 2002, from http:// lobota.tripod.com/language.html.

Lee, S. Y., Stigler, J. W., & Stevenson, H. W. (1986). Beginning reading in Chinese and English. In B. R. Foorrnan and A. W. Siegel (Eds.), *Acquisition of reading skills: Cultural constraints and cognitive universals*. Hillsdale: Lawrence Erlbaum Associates.

Li, H. (2003). Response errors in reading Chinese characters: a developmental and sociocontextual perspective. In C. McBride-Chang & H.-C. Chen (Eds.), *Reading development in Chinese children* (pp. 81–89). Westport, CT: Praeger Press.

Li, H., & Rao, N. (2000). Parental influences on Chinese literacy development: A comparison of preschoolers in Beijing, Hong Kong, and Singapore. *International Journal of Behavioral Development, 24*, 82–90.

McBride-Chang, C., & Ho, C.S.-H. (2000). Developmental issues in Chinese children's character acquisition. *Journal of Educational Psychology, 92*, 50–55.

McBride-Chang, C., & Kail, R. (2002). Cross-cultural similarities in the predictors of reading acquisition. *Child Development, 73*, 1392–1407.

McBride-Chang, C., & Zhong, Y.-P. (2003). A longitudinal study of the effects of phonological awareness and speed of processing on early Chinese character recognition. In C. McBride-Chang & H.-C. Chen (Eds.), *Reading development in Chinese children* "(pp. 37–49). Westport, CT: Praeger Press.

Miller, K. F. (2002). Children's early understanding of writing and language: The impact of characters and alphabetic orthographies. In W. Li, J. S. Gaffney, & J. L. Packard (Eds.), *Chinese children's reading acquisition: Theoretical and pedagogical issues* (pp. 17–30). London: Kluwer Academic Publishers.

Seybolt, P. J., & Chiang, G.K.-K. (1979). Introduction. In P. J Seybolt & G. K.-K. Chiang (Eds.), *Language reform in China: Documents and commentary* (pp. 1–10). NY: M.E. Sharpe.

Share, D. L., & Gur, T. (1999). How reading begins: A study of preschoolers' print identification strategies. *Cognition and Instruction,* 17, 177–213.

Shu, H., Chen, X., Anderson, R.C., Wu, N., & Yue, X. (2003). Properties of School Chinese: Implications for Learning to Read. *Child Development, 74*, 27–47.

Shu, H., Li, W., Anderson, R., Ku, Y.-M., & Yue, X. (2002). The role of home-literacy environment in learning to read Chinese. In W. Li., J. S. Gaffney, & J. L. Packard (Eds.), *Chinese children's reading acquisition: Theoretical and pedagogical issues* (pp. 207 –224). London: Kluwer Academic Publishers.

Shu, H., Meng, X., & Lai, A. C. (2003). Lexical representation and processing in Chinese-speaking poor Readers. In C. McBride-Chang & H.-C. Chen (Eds.), *Reading development in Chinese children* (pp. 199–213). Westport, CT: Praeger Press.

Siok, W.T., & Fletcher, P. (2001). The role of phonological awareness and visual-orthographic Skills in Chinese reading acquisition. *Developmental Psychology, 37*, 886–899.

Teng, J.-M., & Jiang, H.-Z. (2000). 中國的文字改革 (Reform of Chinese characters). 保定市：河北大學出版社 (Baoding, China: Hebei University Press).

Thorndike, R. L., Hagen, E. P., & Sattler, J. M. (1986). *Stanford-Binet intelligence scale: Fourth edition*. Chicago: Riverside.

Treiman, R., & Rodriguez, K. (1999). Young children use letter names in learning to read words. *Psychological Science, 10*, 334–338.

Treiman, R., Sotak, L., & Bowman, M. (2001). The roles of letter names and letter sounds in connecting print and speech. *Memory & Cognition, 29*, 860–873.

Tsai, K.-C., & Nunes, T. (2003). The role of character schema in learning novel Chinese characters. In C. McBride-Chang & H.-C. Chen (Eds.), *Reading development in Chinese children* (pp. l09–125). Westport, CT: Praeger Press.

Tversky, A. (1977). Features of similarity. *Psychological Review, 84*, 327–352.

Tzeng, O., & Wang, W. S.-Y. (1983). The first two R's. *American Scientist, 71*, 238–243.

Willows, D. M., Kruk, R. S., & Corcos, E. (1993). *Visual processes in reading and reading disabilities*. Hillsdale, N. J.: Lawrence Erlbaum Associates.

Wu, X., Anderson, R. C., Li, W., Chen, X., & Meng, X. (2002). Morphological instruction and teacher training. In W. Li, J.S. Gaffney, & J.L. Packard (Eds.), *Chinese children's reading acquisition: Theoretical and pedagogical issues* (pp. 157–174). London: Kluwer Academic Publishers.

Wu, X., Li, W., & Anderson, R. C. (1999). Reading instruction in China. *Journal of Curriculum Studies, 31*, 571–586.

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