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Developmental Issues in Chinese Children's Character Acquisition

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Measures of phonological processing, speech perception, and Chinese character recognition were administered to 109 Hong Kong Chinese 3- and 4-year-olds. A model predicting phonological awareness from vocabulary, verbal short-term memory, and speech perception was supported. Both phonological awareness and letter naming predicted unique variance in character recognition after controlling for other phonological processing and vocabulary skills, similar to previous studies of Western readers.

We focused our study of beginning Chinese readers in Hong Kong on three questions: First, following McBride-Chang's (1995) study of western children, what is the nature of phonological awareness in a Chinese context? Second, to what extent are phonological processing skills uniquely associated with Chinese character recognition? Third, is letter naming, as a measure of pairing visual symbols with their spoken referents, independently correlated with Chinese character recognition? Following a definition of phonological processing skills, we consider each of these questions in turn.

What Is Phonological Processing?

Phonological processing skills make use of the sound structure of language. Wagner and Torgesen (1987) initially identified phonological awareness, phonological recoding in lexical access, and verbal short-term memory as the three primary phonological processing skills that were most strongly associated with alphabetic reading ability in both normal and disabled readers.

The importance of phonological processing skills for reading was initially recognized because of the phonemic nature of the alphabetic orthography used in mapping spoken to written English. In English the ability to perceive and manipulate individual phonemes is helpful in learning to read (e.g., blending the sounds /k/ (*c*), /æ/ (*a*), and /t/ (*t*) yields the word *cat*). However, the significance of phonological processing skills in reading nonalphabetic scripts (e.g., Chinese) is less clear.

The association of speech and reading in Chinese is logographic and morphosyllabic. Each Chinese character reflects a syllable as well as a unit of meaning, or morpheme. Indeed, most Chinese characters consist of both a phonetic component and a semantic component. Chinese reading has been described as holistic (Wang, 1981) or part-to-whole (Ho & Bryant, 1997b), with only one orthographic unit (the phonetic component) encoding or specifying the syllabic pronunciation of the whole character (e.g., the character 燈 [dang1] with a phonetic component of 登 [dang1]). Nevertheless, phonological processing skills may also be important for reading Chinese because mapping oral Chinese to its graphic representation probably requires at least partial access to the phonology of spoken Chinese (Hu & Catts, 1998). Thus, in the present study of Chinese readers, we tested each of the three phonological processing skills initially identified by Wagner and Torgesen (1987).

The first phonological processing skill, phonological awareness, has been demonstrated to be an important early predictor of Chinese reading. A basic level of phonological awareness, phonological sensitivity, correlated with Chinese character recognition in several studies of Chinese children (e.g., Ho & Bryant, 1997a, 1997b, 1997c; Hu & Catts, 1998; Huang & Hanley, 1995). Huang and Hanley (1994, 1995) also found that phoneme deletion was associated with Chinese character recognition in children from Taiwan and Hong Kong.

The second phonological processing skill identified by Wagner and Torgesen (1987), phonological recoding in lexical access, is most often measured using speeded naming tasks, which measure speed and automaticity of symbol recognition (Wolf, Bally, & Morris, 1986). In Western studies of disabled readers and beginning readers, speeded naming tasks have been predictive of unique variance in word recognition (e.g., Ackerman & Dykman, 1993; Blachman, 1984; Bowers, 1989; Wolf et al., 1986). Hu and Catts (1998) found that their naming task, in which Chinese children were required to name sequences including both the pictures and their colored backgrounds (e.g., blue pig, red horse), was strongly associated with Chinese character recognition.

Studies of Chinese children have also found the third phonological processing skill, verbal memory, to be significantly associated with Chinese character recognition (e.g., Ho, 1997; Hu & Catts, 1998; So & Siegel, 1997). However, some have argued that verbal memory may be better conceptualized as a component of phonological awareness rather than as a primary phonological processing skill (e.g., McBride-Chang, 1995), as discussed in the section titled The Nature of Phonological Awareness.

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The Nature of Phonological Awareness

Our interest in phonological processing centered particularly on phonological awareness. The syllable deletion task, which we designed to measure phonological awareness, required students to manipulate speech sounds and generate their own oral feedback. This task reduced the effects of guessing of previous measures of phonological sensitivity to partial homophones and rhymes in Chinese (Ho & Bryant, 1997a; Hu & Catts, 1998). In addition, it was more faithful to the syllabic nature of Chinese than previous measures of phoneme deletion (Huang & Hanley, 1994). Finally, it was particularly useful for younger children, for whom phoneme deletion is too difficult.

Are there components of phonological awareness? This issue relates both to normal development of literacy skills (Elbro, 1996; Fowler, 1991; McBride-Chang, 1995) and to impaired reading (Elbro, Borstrom, & Petersen, 1998). Early precursors of phonological awareness may consist of a variety of language and speech skills (Fowler, 1991; Walley, 1993). McBride-Chang (1995) showed that speech perception, short-term verbal memory, and cognitive ability (particularly verbal skill) all contributed unique variance to a phonological awareness construct in third-grade American children. Measures of speech perception, short-term verbal memory, and cognitive skill also longitudinally predicted a measure of phoneme deletion in first graders (McBride-Chang, Wagner, & Chang, 1997). We examined the extent to which these factors predict phonological awareness in Chinese.

A related challenge of this research was to create a reliable, valid measure of speech perception for young Chinese children. Although few studies have examined children's speech perception development (for a review, see Nusbaum & Goodman, 1994), we sought to create a task that would test and compare several speech contrasts. Ho and Bryant (1997a), who varied both rhyme and tone, rhyme alone, and tone alone within their phonological sensitivity measure, found that when words differed in both rhyme and tone, they were significantly easier for young children to match than were words differing in tone alone. Thus, we expected that tonal contrasts would be more difficult to distinguish than would items varying in both rhyme and tone in a speech perception task.

Predicting Chinese Character Recognition

A second focus of this investigation was the extent to which our measures of phonological awareness, verbal memory, and speeded naming would each account for unique variance in Chinese character recognition, when all three were measured in the same sample, in order to identify which abilities predict unique variance in character recognition, as in the Western literature on alphabetic reading (Wagner & Torgesen, 1987). We expected that phonological awareness would contribute unique variance to character recognition (Ho & Bryant, 1997c; Huang & Hanley, 1994). Because correlational (McBride-Chang, 1996; McBride-Chang & Chang, 1996) and longitudinal Western studies (Wagner, Torgesen, & Rashotte, 1994; Wagner et al., 1997) have demonstrated that verbal short-term memory is not a unique predictor of children's alphabetic reading, we hypothesized that verbal memory would not be a unique predictor of Chinese character recognition.

Letter Name Knowledge as Symbol Learning

Beyond phonological processing, some (e.g., Chen, 1996) have argued that Chinese character recognition requires visual ability. The extent to which visual skill correlates with character recognition may depend on several factors, including the particular visual task administered and the developmental level of the participants in the study. There is a significant correlation between various visual skills and Chinese children's reading (Ho & Bryant, 1999; Huang & Hanley, 1995; Lee, Stigler, & Stevenson, 1986), although this correlation is not always obtained (Ho, 1997; Hu & Catts, 1998; McBride-Chang & Chang, 1995). It is striking that Huang and Hanley (1995) found correlations of .76 and .70, respectively, between Chinese character recognition and the Visual Paired Associates Learning subtest of the Wechsler Memory Scale—Revised for 8-year-olds from Taiwan and Hong Kong. This task requires participants to learn associations between blocks of color and verbally uncodable squiggles. Although the color blocks are presented visually, some people may code these stimuli verbally (Hu & Catts, 1998). Because the correlation between visual skill and character recognition was so strong in this study (Huang & Hanley, 1995) relative to those found in other studies, we considered why the Visual Paired Associates Learning task might be unique among visual tasks. Following Hu and Catts (1998), we noted the potential for verbal mediation in this task and hypothesized that visual–verbal paired associate learning may be fundamental to learning to read Chinese. In the present study we sought a task that was explicitly both visual and verbal, similar to character learning, to predict variance in character recognition. We settled on letter name knowledge as such a task. Although letter names fall within a completely different system than do Chinese characters, they both require similar graphological skills. For example, unlike number learning, within each system knowledge of each symbol is relatively independent: If one can recognize *Z*, this does not help in recognizing *A*. Thus, we hypothesized that letter naming would predict unique variance in character recognition, independently of phonological processing skills.

Method

One hundred nine Hong Kong Chinese children (65 males, 44 females) in their first year of kindergarten participated. These children, ages 3 and 4 years, were from a single school. Kindergarten schools, which last 3 years, are attended by approximately 95% of Hong Kong children and generally have some cost associated with them. Families of children in this kindergarten tend to be uniformly well educated or to earn relatively high incomes. Classroom teachers judged that these children did not have any obvious physical, emotional, or cognitive difficulties, and all were native Cantonese speakers.

Testing took place in April and May of 1997, after these students had had approximately 8–9 months of formal instruction in letter and number names and 3 months of formal instruction in Chinese character recognition. All tasks were administered by trained undergraduate psychology majors individually during school hours in a quiet room at school. Testing sessions generally lasted between 20 and 30 min. Stickers were given to the children following testing. The following tasks were administered (all in Cantonese).

Syllable Deletion

In this 25-item task (5 of each type), children were initially asked to delete syllables of two-syllable words from the beginning (e.g., "Say '火車 [foh2] - [che1]' [English meaning = *train*]; now say '火車 [foh2] - [che1]' without saying '火 [foh2]' ") and then from the end of the item. As the test progressed, children were then asked to segment syllables from the beginning, end, and middle of three-syllable words. The internal consistency reliability for this measure was .97.

Vocabulary

We measured vocabulary using an adaptation and translation of the Stanford–Binet Intelligence Scale (4th edition; Thorndike, Hagen, & Sattler, 1986). The maximum score possible on this test, used as a proxy for general verbal ability, was 30, and its internal consistency reliability was .77.

Short-Term Verbal Memory

We measured verbal memory using a 36-item instrument. Strings of semantically unrelated familiar single Chinese syllables were orally presented by the experimenter. Immediately following the experimenter's presentation, children were asked to repeat each string. Three strings of three syllables, three strings of four syllables, and three strings of five syllables were administered. An example of a 4-syllable string is 羽 [yue5] (*feather*), 通 [tung1] (*through*), 牙 [nga4] (*tooth*), and 土 [to2] (*soil*). Children were required to repeat each string of syllables, in order, to the experimenter. This measure had an internal consistency reliability of .90.

Speech Perception

We measured speech perception using a 27-item task in which pairs of familiar pictures were presented. Simultaneously, a tape-recorded reader identified the pictures and asked the participant to point to a target item. For example (in Chinese), "Here you see two pictures: Number 1 is 花 [fa1] (*flower*) and number 2 is 瓜 [gwa1] (*melon*). Point to 花 [fa1]." As the tape identified the pictures, the examiner simultaneously pointed to each. This task varied items by single phonemes falling at the beginning of the word, rhymes at the end of the word, both rhymes and tone, or by tones only. The internal consistency reliability for this measure was .84.

Speeded Naming

Two measures of speeded naming were administered. Children were presented with three rows of five 2-syllable (in Cantonese) pictures each (蘋果 [ping4] - [gwoh2] [*apple*], 蝴蝶 [woo4] - [dip6] [*butterfly*], 飛機 [fei1] - [gei1] [*airplane*], 太陽 [taai3] - [yeung4] [*sun*], 西瓜 [sai1] - [gwa1] [*watermelon*]). They were also presented with a number-naming task of digits 1–6. The test–retest reliability for the number-naming task was .83 and for the picture-naming task was .80.

Letter Naming

Children were shown all 26 capital letters of the English alphabet, presented in a fixed, random order on a single sheet of paper, and were asked to name each letter in turn. The internal consistency for this task was .94.

Chinese Character Recognition

Students were given the Chinese character reading task (Ho & Bryant, 1997c), which measures recognition of single Chinese characters and had an internal consistency reliability of .94.

Results

Means, standard deviations, and correlations among all variables are presented in Table 1. Generally, there was adequate variability for each measure.

Phonological Awareness and Speech Perception

As shown in Table 1, vocabulary ($r = .31$), short-term verbal memory ($r = .42$), and speech perception ($r = .36$) were all significantly associated with syllable deletion. A hierarchical regression equation predicting deletion performance from these

Table 1
Means, Standard Deviations, and Correlations for All Measures

Measure	Range	*M*	*SD*	1	2	3	4	5	6	7	8	9
1. Age (years)	3.50–4.62	4.02	0.30	—								
2. Character recognition[a]	0–27	13.97	8.22	.19	—							
3. Vocabulary[a]	5–30	9.43	3.05	.06	.30	—						
4. Deletion[a]	0–25	7.83	8.66	.23	.51	.31	—					
5. Verbal memory[a]	0–36	25.96	7.31	.32	.36	.10	.42	—				
6. Picture naming[b]	16.85–96.00	52.04	13.82	−.31	−.23	−.03	−.31	−.28	—			
7. Number naming[b]	22.00–99.99	46.60	16.43	−.31	−.36	−.05	−.37	−.25	.52	—		
8. Letter naming[a]	0–26	17.78	7.42	.10	.66	.18	.39	.25	−.27	−.62	—	
9. Speech perception[a]	18–27	23.52	1.97	.19	.35	.22	.36	.18	−.06	−.19	.29	—

Note. $N = 109$, except for picture and number naming (and their correlations), for which $N = 94$. Correlations above .24 are significant at $p < .01$.
[a]Total score. [b]In seconds.

variables and age was significant, $F(4, 103) = 11.48, p < .001$. On the basis of previous research (McBride-Chang, 1995; McBride-Chang et al., 1997), we entered the following variables a priori into the equation, in order: Age contributed 5% of the variance, vocabulary contributed a unique 9% of the variance, verbal memory contributed 12% unique variance, and speech perception contributed 5% unique variance to the deletion task. All were significant ($p < .05$) and predicted a total of 31% of the variance in syllable deletion.

Within the speech task, an F test for an overall difference across the four speech sound types was significant, $F(3, 108) = 48.99, p < .001$. Individual t tests of difference revealed that sounds varying in both ending and tone were easiest (98% correct), beginning (88%) and rhyming sounds (89%) were of middle difficulty and did not differ from each other, and tones were most difficult (78% correct).

Phonological Processes and Chinese Character Recognition

Our second set of analyses centered on the extent to which each phonological processing skill would predict unique variance in Chinese character recognition. As indicated in Table 1, syllable deletion ($r = .51$), verbal memory ($r = .36$), and speeded number naming ($r = -.36$) were all significantly correlated with character recognition, though picture naming ($r = -.23$) was not. Fifteen children failed to identify some or all of the numbers or pictures in an initial untimed naming pretest; thus, they could not be administered either one or both of the naming speed tasks. However, we did not want to lose their data on verbal memory and phonological awareness. Therefore, we performed the hierarchical regression analyses two ways: first with the missing data artificially coded and second with the missing data omitted from the analyses. In the "coded" case, all missing data were recoded as 100.99, slower than any of the real data obtained.

Table 2 shows the hierarchical regression equations predicting Chinese character recognition in the coded and uncoded cases. When age, vocabulary, verbal memory, and both speeded naming tasks were entered first in the equation, syllable deletion contributed a significant unique 4% of the variance in both the coded and uncoded cases (Equation I). When age, vocabulary, and syllable deletion were statistically controlled, verbal memory was not predictive of character recognition in either the coded or uncoded cases (Equation II). When verbal memory was entered before phonological awareness, it was predictive of character recognition, however. Finally, when the missing data were coded, the naming speed measures predicted significant variance in character recognition even after statistically controlling age, vocabulary, syllable deletion, and verbal memory, whereas when the missing data were not included, the naming speed set did not predict unique variance in character recognition (Equation III).

Letter Name Knowledge as a Unique Predictor of Chinese Character Recognition

The final issue addressed in these analyses was the extent to which letter name knowledge would predict character recognition. Table 1 indicates that the associations among letter naming and character recognition ($r = .66$) and timed number naming ($r = -.62$) were both substantial. As shown in Table 2, once all other variables were statistically controlled, letter naming contributed an additional 10% of the variance in character recognition (final $R^2 = .52$) in the coded case and 13% (final $R^2 = .41$) in the uncoded case. Finally, syllable deletion contributed unique variance in character recognition when entered after letter naming. In the uncoded case, the explained variance increased from 37% to 40%; in the coded case it increased from 50% to 52%. Both increases were statistically significant ($p < .05$). Thus, the two primary predictors of character recognition were letter naming and syllable deletion.

Table 2
Hierarchical Regression Predicting Character Recognition

	Missing data			
	Coded		Uncoded	
Variables entered	R^2_{change}	R^2	R^2_{change}	R^2
1. Age	.03†	.03	.03†	.03
2. Vocabulary	.08*	.11	.05*	.08
I				
3. Verbal memory	.09*	.20	.07*	.15
4. Naming[a]	.18*	.38	.08*	.23
5. Deletion	.04*	.42	.04*	.27
II				
3. Deletion	.17*	.28	.14*	.22
4. Verbal memory	.03†	.31	.03†	.25
5. Naming[a]	.11*	.42	.03†	.28
III				
3. Verbal memory	.09*	.20	.07*	.15
4. Deletion	.11*	.31	.10*	.25
5. Naming[a]	.11*	.42	.03†	.28
6. Letter naming	.10*	.52	.13*	.41

Note. $F(7, 100) = 15.74, p < .001$ (coded); $F(7, 86) = 8.46, p < .001$ (uncoded).
[a]Includes both picture and number naming as a set.
†$p < .10$ (marginally significant). *$p < .05$.

Discussion

Our findings were similar, in three ways, to the results of studies of Western children learning to read an alphabetic orthography. First, speech perception contributed to a phonological awareness measure, after age, vocabulary, and verbal memory were statistically controlled, similar to results from Western studies. The association between speech perception and phoneme deletion suggests the utility of speech perception as a predictor of future reading skills in young children across languages, though the extent to which it may be longitudinally predictive of phonological awareness or character recognition must be explored in future research. It may also be possible to measure some aspects of speech perception using different sound contrasts. Tones in isolation were more difficult to perceive than syllables differing in both tone and rhyme, consistent with previous research on Cantonese children (Ho & Bryant, 1997a).

Second, phonological awareness emerged as a primary phonological processing skill, whereas the importance of verbal memory and naming speed were relatively diminished, in predicting unique variance in Chinese character recognition. Verbal memory, though associated with character recognition, failed to predict unique variance in it once syllable deletion was controlled. Perhaps verbal memory is best conceptualized as a component of phonological awareness rather than as a primary phonological processing skill itself. Naming speed distinguished students who were knowledgeable about number and picture names from those who were not, as indicated by the difference in results with the missing data coded and uncoded. Our measure of phonological awareness, syllable deletion, emerged as the strongest predictor of character recognition.

Third, letter naming uniquely predicted character recognition. Hence, graphological skill may be an important predictor of reading across orthographies. Some of the skill involved may be related to formal instruction, of course; however, our vocabulary measure partially controlled for effects of IQ (i.e., learning ability [e.g., Sternberg, 1998]). In addition, all children in the school had had at least 3 months of formal instruction in character recognition and 8 months of formal instruction in number and letter identification. Therefore, the high association between letter naming and character recognition is at least in part because both involve pairing oral names with written forms. The real utility of the letter naming task may not be in letter naming itself, which is merely correlated with character recognition. Rather, visual paired associates learning may be among the best "visual" tasks for predicting Chinese character recognition. Such tasks are not pure visual measures but rather, the process of combining visual and speech information together. In future work, tasks pairing arbitrary visual stimuli with meaningful vocabulary may prove maximally predictive of Chinese character acquisition in children.

Limitations and Future Directions

The present study has some limitations. First, single indicators of each ability were used. Multiple indicators, to form constructs of each concept, should be used in future work to reduce measurement error. Second, it is possible that the children's informal exposure to English may have influenced these results. For example, in one recent study (Bialystok, 1997), Chinese–English bilinguals in Canada had more advanced concepts of print relative to English-speaking monolinguals. Thus, the benefits of bilingualism for reading and alphabet knowledge should be pursued in future studies. Third, all of the measures from the present study were collected simultaneously, so that questions about causal relations among reading-related skills and character recognition, which have received considerable attention in the Western literature (Wagner et al., 1994, 1997), remain largely unanswered in the literature on Chinese reading development. Finally, only approximately 50% or less of the variance in character recognition was explained by all reading measures in the present study. Future studies must, therefore, seek additional skills that may be associated with Chinese reading.

Nevertheless, the present study underscored three striking similarities between previous research on beginning readers in the West and Chinese readers. First, speech perception is associated with phonological awareness across languages. Second, phonological awareness emerges as the primary phonological processing skill in normally developing Chinese readers. Third, letter name knowledge predicts unique variance in Chinese character recognition. Letter name knowledge may measure skill in pairing visual and verbal stimuli, which is also required in character recognition.

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