SCIENTIFIC STUDIES OF READING, *9*(2), 117–144

Predictors of Beginning Reading in Chinese and English: A 2-Year Longitudinal Study of Chinese Kindergartners

Catherine McBride-Chang
Chinese University of Hong Kong

Connie Suk-Han Ho
The University of Hong Kong

Ninety Chinese children were tested once at age 4 and again 22 months later on phonological-processing and other reading skills. Chinese phonological-processing skills alone modestly predicted Chinese character recognition, and English letter-name knowledge uniquely predicted reading of both Chinese and English 2 years later. Furthermore, concurrently measured phonological-processing skills in Chinese, but not English, accounted for unique variance in both English and Chinese word recognition. English invented spelling was strongly associated with reading in English only, and orthographic knowledge significantly accounted for unique variance in Chinese reading only. Results suggest both universal and specific characteristics of the development of English word and Chinese character recognition among young native Chinese speakers learning to read English as a second language.

This study examined reading development in Chinese and English among Hong Kong Chinese children learning English as a second language. We tested children first at age 4 primarily on Chinese reading-related abilities and again 2 years later on both Chinese and English reading and reading-related skills. We focused on two questions involving phonological predictors of reading skills. First, to what extent are Chinese phonological-processing skills involved in learning to read both Chinese and English in young children across time? Ours

---

Requests for reprints should be sent to Catherine McBride-Chang, Psychology Department, Chinese University of Hong Kong, Shatin, N. T., Hong Kong. E-mail: cmcbride@psy.cuhk.edu.hk

is among the first longitudinal studies to examine how Chinese phonological-processing skills predict subsequent reading in both Chinese and English in young children. Second, to what extent are phonological-processing skills in each language concurrently associated with Chinese character and English word recognition? This question is relevant for developing a better understanding of the nature of phonological-processing skills, including phonological awareness, as language general or language specific.

Because there tends to be relatively strong transfer across languages of phonological awareness, phonological awareness has been argued to be a language-general rather than a language-specific contributor to reading development (Comeau, Cormier, Grandmaison, & Lacroix, 1999; Lindsey, Manis, & Bailey, 2003). However, the process of learning to read involves script-specific knowledge represented at different levels in Chinese as compared to English. In particular, learning to read English requires children to learn to blend letter sounds at the phoneme level. In contrast, Chinese character recognition involves mapping spoken words at the syllable level to Chinese characters. Thus, learning to read English requires more fine-grained phonological analysis than does learning to read Chinese. Previous studies (e.g., Mann, 1986; Perfetti, Beck, Bell, & Hughes, 1987; Read, Zhang, Nie, & Ding, 1986) have also demonstrated that phonological awareness is both a predictor and a consequence of the orthography being read.

In this study, we were interested in whether second-language (English) phonological-processing measures, as compared to first-language (Chinese) phonological-processing skills, were equally good predictors of reading in both scripts. If phonological processing is a language-general contributor to reading, we would expect that a battery of phonological-processing tasks, administered in either the first or second language, would be similarly associated with reading, in either a first or second language and writing system. However, because the syllable is the basic unit of phonology in Chinese and the phoneme is the basic phonological unit in English, we explored whether tasks tapping the phoneme level of analysis might be more predictive for English than for Chinese, even in young second-language learners of English.

We also examined how two aspects of children's early print knowledge were associated with early reading. First, we looked at the extent to which English letter-name knowledge, measured at the first testing time, would predict subsequent English word reading and Chinese character recognition, tested 2 years later. Second, we examined orthographic knowledge, measured at the second testing time, in relation to word recognition in both Chinese and English. The importance of phonological-processing skills across languages, letter-name knowledge, and orthographic knowledge for beginning reading are reviewed in turn.

PHONOLOGICAL PROCESSING ACROSS LANGUAGES

Phonological-processing abilities make use of speech sounds within a language. Wagner and Torgesen (1987) identified three unique, though correlated, phonological-processing skills: phonological awareness, phonological recoding in lexical access (generally measured using speeded naming tasks), and verbal working memory. A variety of phonological-processing skills are important for the development of reading in both alphabetic scripts (e.g., Adams, 1990; Goswami & Bryant, 1990; Wagner, Torgesen, Laughon, Simmons, & Rashotte, 1993) and Chinese scripts (e.g., Gottardo, Yan, Siegel, & Wade-Woolley, 2001; Ho & Bryant, 1997; Hu & Catts, 1998; McBride-Chang & Ho, 2000; McBride-Chang & Kail, 2002; So & Siegel, 1997). Learning to map a spoken referent to its written symbol makes use of phonology at some level, regardless of the language spoken or the orthography being learned (Hu & Catts, 1998).

Although phonological-processing abilities have been shown to correlate with reading across languages and orthographies as diverse as Hebrew (Ben-Dror, Bentin, & Frost, 1995), Chinese (e.g., Hu & Catts, 1998), and English (Wagner et al., 1997), the nature of these phonological-processing skills may differ depending on the language in which they are measured. This is clearest for measures of phonological awareness. For example, Cheung, Chen, Lai, Wong, and Hills (2001) demonstrated that, prior to literacy training, Chinese children tended to be poorer in phonemic awareness relative to New Zealand children. They suggested that the explanation for this phenomenon lies in the differences across languages used by the children. Specifically, because English has relatively many consonant clusters and Chinese has virtually none, English-speaking children may be primed to attend to phonemic units in their language to a greater extent than Chinese-speaking children. Such differences may reflect the phonological characteristics of the languages themselves (Bruck & Genessee, 1995).

Phonological awareness may also be affected by literacy instruction (e.g., Morais, Cary, Alegria, & Bertelson, 1979; Perfetti et al., 1987). For example, both English and Taiwanese children tend to be better in phonemic awareness than are Hong Kong Chinese children (Huang & Hanley, 1995). Similarly, phonemic awareness in Hong Kong Chinese college students tends to be inferior to phonemic awareness in Mainland Chinese college students despite comparable word recognition skills (Holm & Dodd, 1996). These differences are likely attributable to the fact that Hong Kong students receive no instruction in phonological decoding as an aid to Chinese character recognition in school, although their counterparts in other Chinese societies do (Holm & Dodd, 1996; Huang & Hanley, 1995).

Despite some differences in phonological awareness across languages and orthographies, there is growing evidence that some phonological-processing abilities are associated across languages. For example, bilinguals who are skilled in phonological awareness in their first language tend to be relatively able in phonological awareness in their second language as well (Bruck & Genesee, 1995; Cisero & Royer, 1995; Durgunoglu, Nagy, & Hancin-Bhatt, 1993; Gottardo et al., 2001; Lindsey et al., 2003). Furthermore, among English-speaking children in French immersion classes, phonological awareness in both English and French were strongly correlated even over a 1-year period (Comeau et al., 1999). However, most previous studies of phonological awareness across languages have involved comparing phonological awareness in languages that are relatively similar in overall structure and derivation, such as English and French (Bruck & Genessee, 1995; Comeau et al., 1999) or English and Spanish (Cisero & Royer, 1995; Durgunoglu et al., 1993). In contrast, Chinese, which is analytic, tonal, and noninflected, differs more strongly from English, a synthetic, atonal, inflected language, in linguistic properties. Nevertheless, Gottardo et al. (2001) did find evidence for Chinese–English transfer in phonological awareness. They demonstrated correlations of above magnitude .50 for Chinese rhyme detection with English rhyme detection and English phoneme deletion among children varying widely in age. In another study of Chinese adults, McBride-Chang (1998) also found moderate associations of speeded naming and verbal memory in English and Chinese.

PHONOLOGICAL PROCESSING AND READING ACROSS ORTHOGRAPHIES

Phonological-processing skills may be substantially correlated with reading in a first and in a second language. Previous research has demonstrated that good and poor readers are equally distinguishable based on proficiency in word recognition in the first (English) and in the second (Hebrew) languages (Geva, Wade-Woolley, & Shany, 1993, 1997). Durgunoglu et al. (1993) also demonstrated that phonological processing in Spanish distinguished native Spanish-speaking children's reading performance in English and Spanish, although oral proficiency in Spanish did not. Lindsey et al. (2003), in a study following children from kindergarten through first grade, found that Spanish letter-naming was a particularly good longitudinal predictor of English and Spanish word recognition. In another longitudinal study of native English-speaking children in Grades 1, 3, and 5 who were learning to speak and read French, Comeau et al. (1999) showed that phonological awareness in English and French equally predicted reading in English and French 1 year later. Among 8-year-old Chinese children, Huang and Hanley (1995) also found that a Chinese phoneme deletion task was approximately equally correlated with reading of both Chinese and English. Finally, Gottardo et al. (2001) demonstrated that both Chinese rhyme detection and English phoneme deletion uniquely predicted English word-reading in Chinese bilinguals in Grades 1 to 8.

In this study, we examined the extent to which phonological-processing skills administered in Chinese would be longitudinally predictive of subsequent reading of English and Chinese among beginning readers in Hong Kong. We also tested the concurrent associations of phonological-processing skills administered in English and Chinese with reading in each orthography. Although a few studies have examined phonological processing skills in two languages simultaneously (e.g., Comeau et al., 1999; Lindsey et al., 2003), there is relatively little data on associations of phonological-processing skills across languages.

SPECIFICITY OF PHONOLOGICAL AWARENESS

In Chinese, the basic unit of reading is the syllable (Leong, 1997). Thus, awareness of individual phonemes may be unnecessary for recognizing Chinese characters (Read et al., 1986). This may be particularly true for Hong Kong children. Hong Kong uses no formal subsyllabic (as does Taiwan, which uses Zhuyin-Fuhao) or alphabetic (as does Mainland China, which uses Hanyu Pinyin) coding systems to teach reading of Chinese. Rather, teachers use the "look and say" method to teach character recognition; the same method is used to teach English word-reading (Holm & Dodd, 1996). For example, Hong Kong children are not taught to associate letter names with phonemes, making it difficult to test their letter-sound knowledge explicitly (e.g., McBride-Chang & Treiman, 2003).

Among young children learning to read either Chinese or English, phonological awareness at the syllable level has been shown to predict concurrent reading (McBride-Chang & Kail, 2002). These authors argued that awareness of the syllable is relevant for beginning reading acquisition across cultures among children. We, therefore, made use of a syllable deletion task to measure phonological awareness in both Chinese and English in this study.

In addition, because it is clear that phonemic knowledge is important for learning to read English (Adams, 1990; Snow, Burns, & Griffin, 1998), we also sought to measure this construct in our kindergarten sample. A strict definition of the term *phonemic awareness* focuses on awareness of and access to phonemes throughout a word. There are at least three ways to measure this skill in English: (a) by blending phonemes together (e.g., */k/-/ae/-/t/ = cat*), (b) by deleting them (*mint* without the */n/* is *mit*), or (c) by counting them (e.g., how many phonemes are there in *hot*?). Because young Hong Kong students have no explicit experience with phonetic coding systems, our own pilot studies attempting to study these children's phonemic awareness have yielded floor effects. For our very young Hong Kong sample, the concept of manipulating a phoneme within an English word was confusing. This is likely attributable in part to the characteristics of the Chinese orthography, reflecting Chinese language. Onset-rime distinctions tend to be clearest in Chinese (Siok & Fletcher, 2001). In addition, Chinese lacks consonant clusters. Thus, among Huang and Hanley's (1995) sample of 8-year-olds, only deletion of the first or final phonemes of the English (and Chinese) words was tested.

Evidence for Hong Kong children's considerable difficulties on phonemic awareness tasks comes from a study (Bialystok, McBride-Chang, & Luk, 2004) comparing Chinese children across cultures. In this study, 15 out of 35 Hong Kong 6-year-olds presented with an English phoneme counting task (e.g., how many phonemes are in the word *hot*?) scored 0 out of 15 on the measure, and only 2 of the 35 children scored above 3 out of 15 on this task. These scores are remarkably skewed in comparison with those of age-matched children in Toronto. In the sample of 35 English–Chinese bilingual students, who had been exposed to a phonemic coding system, only 1 scored 0, and 11 scored above 3 on this task. Thus, the Hong Kong children's performance on this phonemic awareness task was clearly poor. It may further be argued that this particular phonemic awareness task has an element of guessing, because an item is scored based on the number response a child gives (e.g., 4). Therefore, this task was relatively easy in comparison to a strict production task (where children actually have to blend or delete sounds themselves).

Balancing our previous lack of success in measuring explicit phonemic awareness in English among Hong Kong kindergartners against our strong desire to measure some aspect of children's knowledge of phonemes and letter sounds, in this study we made use of Tangel and Blachman's (1992) test of developmental spelling. In pilot testing of this measure, we found that Hong Kong children are willing to write letters on a piece of paper, as required for the developmental spelling measure. Furthermore, in these writings, we observed wide variability in phonological faithfulness to the words included. Invented spelling has been used as a proxy for phonological awareness among young English readers and speakers (Mann, Tobin, & Wilson, 1987). In the developmental spelling task (Tangel & Blachman, 1992), children's knowledge of phonemes is assessed based on their written depictions of five English real words. Typically, young English-speaking children's invented spellings are fairly accurate representations of the underlying phonological structure of words, and they are systematically different from standard spellings (Mann et al., 1987; Treiman, 1993). In American kindergartners, invented spelling tasks have been shown to be strongly associated with phonemic awareness (Mann et al., 1987).

The developmental spelling test (Tangel & Blachman, 1992) makes use of multiple processes, including letter-name and letter-sound knowledge, phonemic awareness, and orthographic skills. Furthermore, phonemic awareness is reciprocally related to reading acquisition (Mann, 1986; Perfetti et al., 1987). Despite the fact that this task taps multiple constructs, we viewed it as the best available task to measure variability in young Hong Kong Chinese children's sensitivity to phoneme-level information.

LETTER-NAME KNOWLEDGE

We also examined the extent to which letter-name knowledge, assessed using the English alphabet, would be developmentally predictive of both English word-reading and Chinese character recognition. Knowing the letter names is clearly helpful for learning to read English, because letter names often provide clues to the sounds of the letters, which are useful in decoding new words (Treiman, Tincoff, & Richmond-Welty, 1996; Treiman, Weatherston, & Berch, 1994). Why might letter-name knowledge be associated with Chinese character recognition? This study followed up on the results of McBride-Chang and Ho (2000), who noted that letter-name knowledge was concurrently predictive of Chinese character recognition in young Chinese readers after statistically controlling vocabulary and phonological-processing skills. In fact, the magnitude of the association of letter-name knowledge with Chinese character recognition in that study (.66) was on par with many studies of beginning English reading (see, e.g., Adams, 1990). We interpreted this result as suggesting that letter-name knowledge represented graphological, or printed symbol identification, skill. In particular, learning to identify letters by name is similar in its reliance on pairing a visual referent with an oral symbol to the processes involved in first learning to identify Chinese characters.

ORTHOGRAPHIC PROCESSING

Apart from phonological-processing skills and letter knowledge, some investigators have noted the utility of orthographic-processing abilities for children's reading of English (e.g., Berninger, Cartwright, Yates, Swanson, & Abbott, 1994). Thus, we also created a new measure of orthographic processing administered at Time 2 that tested basic graphological-orientation knowledge of Chinese characters and radicals, English letters, and Roman numerals. In Hong Kong kindergartens and indeed in Hong Kong society, young children tend to encounter Chinese characters (and character components, or radicals), English letters, and Roman numerals simultaneously. For example, signs in Hong Kong are posted in both Chinese and English. In addition, kindergartens tend to introduce English letters at the same time they begin teaching Chinese character recognition. Because of these features of Hong Kong education and society, and also our previous finding that Chinese character recognition and letter-name knowledge strongly overlap in Hong Kong kindergartners, our task of orthographic skill included letter, character, and number stimuli together. We hypothesized that this measure would account for unique variance in both Chinese character recognition and English word-reading because it was a relatively pure measure of graphological knowledge.

THIS STUDY

To summarize, we tested five hypotheses in this study. First, at Time1, we expected Chinese phonological-processing skills would positively account for variance in reading of Chinese and English at Time 2, 2 years later. Second, we hypothesized that phonological processing of Chinese and English at Time 2 would be associated with reading in each orthography. We were particularly interested in the extent to which the same phonological- processing skills administered in English and in Chinese would explain reading in each orthography. Third, we hypothesized that the task of developmental spelling, which makes use of phoneme-level units, and letter-sound and orthographic knowledge specific to English, would better account for variance in English word-reading than in Chinese character recognition. Fourth, we anticipated that letter-name knowledge at Time 1 would uniquely predict reading of Chinese and English 2 years later. Finally, we tested the extent to which orthographic knowledge at Time 2 would be uniquely associated with reading across orthographies.

METHOD

Participants

Participants were 90 native Chinese children (34 girls, 56 boys) from a single school in Hong Kong who completed all testing at both testing times. The first testing time was in the second semester of Kindergarten 1 (K1; 1st year of kindergarten). The second testing time was in the second semester of Kindergarten 3 (K3; 3rd year of kindergarten). (In Hong Kong, kindergarten lasts 3 years, beginning when the children are 3 years old.) The average age of the children at Time 1 was 4.02 (range = 3.50–4.62 years); at Time 2, their mean age was 5.85 (range = 5.33–6.45). Originally, at Time 1, 109 children had participated. However, testing had only been completed for 106 of these children. Twenty-two months later, only 90 children who were still enrolled at the same school completed all testing at Time 2.

At this school, formal instruction in letter and number names and single Chinese characters begins in the second semester of K1. Names of the letters from the English alphabet are also covered in K1. Children learn to read single English words and Chinese multiple-character words and short phrases in K2. Thus, on average, Hong Kong students by kindergarten (K3) should know approximately 150 to 200 Chinese characters and can also read some short phrases and sentences in Chinese. In addition, K3 children can recognize about 50 to 80 isolated English words but few phrases or sentences.

This particular school prides itself on maintaining relatively low academic pressure on pupils. Parents of these students tend to be middle- to upper middle-class Hong Kongers, many of whom may speak some English in the home, although the native language of all children from this study was Cantonese.

Procedure

All testing took place at school. Testing at Time 1 consisted of three individually administered sessions conducted by undergraduate psychology majors. At Time 2, the mathematics and orthographic-processing tests were administered to students in groups of up to 30 at a time in regular classrooms. The students also participated in three individual sessions, each of which lasted approximately 20 to 25 min. Testers were undergraduate and graduate psychology students. After each session, children were given stickers in appreciation for their participation. All testing instructions were given in Cantonese by five trained graduate and undergraduate psychology majors. The order of tasks was counterbalanced. Testing of reading and phonological processing of English were administered at Time 2 only, because at the first testing time, teachers reported that the children had virtually no knowledge of written or spoken English. The following measures were administered.

Chinese vocabulary. At Time 1, a Hong Kong adaptation and translation to Cantonese of the Stanford–Binet Intelligence Scale (4th ed.). Vocabulary subtest (Thorndike, Hagen, & Sattler, 1986) was administered. Raw scores (out of a possible 30 points) were used for this measure. The internal consistency reliability for the sample at Time 1 was .77.

Letter-name knowledge. At Time 1 only, all 26 letters of the alphabet were displayed on a sheet for the children. The letters were in a fixed, random order, and the children were asked to identify, by name, each letter. The internal consistency reliability for the entire sample for this measure was .94.

Syllable deletion. This phonological-awareness measure was administered in Chinese at both testing times and in English at Time 2 only. Each consisted of 25 items and required participants to delete a word from a compound word or phrase. Because Chinese is morphosyllabic, with each syllable reflecting both a morpheme and a syllable simultaneously, all items included in this study were multimorpheme words. Thus, this task was one of morphosyllable deletion in English and Chinese because we wanted to have parallel versions of the task across languages. For a defense of this task as a measure of phonological awareness in Chinese and English, please see McBride-Chang and Kail (2002). For both measures, the first 5 items consisted of two-syllable compound words or phrases from which the first word was to be deleted (e.g., say *hot dog* without saying *hot*) and the second 5 items consisted of two-syllable compound words from which the second word was to be deleted (e.g., say *good-bye* without saying *bye*). The third, fourth, and fifth sets of 5 items consisted of three-syllable words or phrases (e.g., *big tee-shirt*), from which the first, last, and middle syllables were to be deleted, respectively. Cantonese items from this task were similar (e.g., in Chinese, say *hok6 haau6* without saying *hok6* or say *din6 daan1 ce1* without saying *din6*). The obtained internal consistency reliabilities for syllable deletion in Chinese and English at Time 2 were, respectively, .88 and .92 (.97 for Time 1 in Chinese).

Verbal memory. At Time 1, verbal memory was measured in Chinese using strings of one-syllable words that were semantically unrelated and familiar to very young children. There were 36 items in this instrument, with three strings each of three syllables, four syllables, and five syllables, and its reliability was .90 (McBride-Chang & Ho, 2000). Verbal memory at Time 2 consisted of a task of number memory, to facilitate Chinese–English memory comparisons. This measure was administered once in English and once in Cantonese, across two sessions. All numbers included were one syllable in English and one syllable in Cantonese. Students were given three trials for each number string, beginning with a single item (e.g., *8*) and continuing through a set of 8-item number strings (e.g., *1–3–4–9–5–6–8–2*). The Cantonese and English memory tasks were tape-recorded by native speakers of each language, respectively, at a rate of 1 item per second. Students, wearing headphones, listened to each tape and immediately recited the given number string back to the experimenter. Testing was discontinued only when children incorrectly repeated back all three word strings within a set of a given length. Obtained internal consistency reliabilities were .78 for the Cantonese task and .71 for the English task.

Speeded naming. At Time 1, all 90 children had completed a speeded picture naming task, which consisted of three rows of the same five stimuli presented in different orders. All five stimuli included were two-syllable words in Cantonese. Each measure was administered twice in a testing session, and the average of these two speeds is given in Table 1. The test–retest reliability for this measure was .80.

Three measures of speeded naming (Denckla & Rudel, 1976) were administered to the children at Time 2. Across measures, prior to administering the speeded-naming task, we had the children name the symbols (five for each task) slowly. We gave them two opportunities to name these stimuli. If they failed correctly to identify all five stimuli by the second trial, they were not given the timed test. The timed test was also administered twice, and the times across tests averaged for the final average speeds listed in Table 1. The first two speeded-naming measures, of number naming, were identical, except that one was administered in English and the other was administered in Cantonese, across two different testing

TABLE 1
Means, Standard Deviations, and Ranges for all Measures in the Study

Variable	*M*	*SD*	*Range*	*Max*
Age in years, t1	4.04	.29	3.50–4.62	n/a
Chinese vocabulary, t1	9.54	3.12	5–30	30
Letter name knowledge, t1	18.48	6.72	1–26	26
Chinese syllable deletion, t1	7.48	8.43	0–25	25
Chinese verbal memory for word strings, t1	26.46	6.73	0–36	36
Chinese speeded picture-naming, t1	53.59	15.02	16.85–99.50	n/a
Chinese character recognition, t1	14.88	8.00	0–27	27
Chinese syllable deletion, t2	21.76	4.08	0–25	25
English syllable deletion, t2	17.09	6.51	0–25	25
Chinese verbal memory for numbers, t2	14.52	3.25	7–22	24
English verbal memory for numbers, t2	10.38	2.57	2–17	24
Chinese speeded number-naming, t2	18.98	4.15	10.94–28.29	n/a
English speeded number-naming, t2	32.15	13.98	12.99–96.17	n/a
Letter-naming, t2	24.15	7.61	13.33–55.17	n/a
Chinese character recognition, t2	26.97	5.34	10–34	34
English word recognition, t2	11.19	6.51	0–28	30
English developmental spelling, t2	3.59	3.80	0–20	30
Orthographic measure, t2	89.68	12.58	57–120	120
Mathematics test, t2	13.40	2.36	3–15	15

Note. For English speeded number-naming, t2 only, $n = 87$; for all other variables, $n = 90$. t1 = Time 1; t2 = Time 2.

sessions. They consisted of five columns of the same five one-syllable (in English and in Cantonese: *5, 4, 3, 1, 8*) numbers presented in different orders on a single white sheet of paper. The test–retest reliability for the English speeded number-naming measure was .65; for the Cantonese number-naming measure the reliability was .86. Letter naming was also administered and consisted of five columns of five, nonrhyming letters (*I, O, M, J, B*) presented in various orders on a single sheet of paper. Its test–retest reliability was .69. For all speeded-naming measures tested at either time, most children missed fewer than three or four items.

Chinese character recognition. At Time 1, the Chinese character reading task (Ho & Bryant, 1997), consisting of 27 single characters, was administered to all children and yielded an internal consistency reliability of .94. At Time 2, two-character words were given to the children to identify individually. The internal consistency reliability of this 34-item measure was .90.

English word recognition. At Time 2 only, children were administered an experimental task of English word-reading. Initially, we had hoped to use a standardized measure of reading for this group, but pilot testing at another school revealed that most of the words taught in the reading curriculum, with which these school children were familiar, were not included on the standardized measures we examined. Thus, we used another English word recognition task used previously in studies of Hong Kong kindergartners (McBride-Chang & Kail, 2002; McBride-Chang & Treiman, 2003). It consists of 30 common English words. In this study, the internal consistency reliability of this measure was .90.

Invented spelling. Tangel and Blachman's (1992) measure of developmental spelling was administered at Time 2 only. The task consists of five English words (*lap, sick, elephant, pretty, train*), which the experimenter asked the children to spell on a sheet of paper. This sheet of paper had the alphabet, in capital letters, printed at the top for the childrens' reference. It also had five blank lines on which the children were asked to print the words. Many children were unfamiliar with these English words (e.g., *lap*). Thus, the experimenters first said each word aloud in English and then gave a definition, in Cantonese, for the word. The children then heard a tape of a native English speaker saying the target word three times in isolation. Throughout the task, experimenters encouraged the children to do their best and to guess any letter they thought might be associated with each word. The words were subsequently scored on a scale from 0 (*random letter string*) to 6 (*correct spelling*), for a total possible score of 30. Spelling is scored based on both phonological accuracy in mapping letters to sounds and adequate orthographic representations. Complete details on scoring this task are available in Tangel and Blachman. The internal consistency reliability for this measure was .69.

Orthographic processing. This 120-item task (Ho, Chan, Tsang, & Lee, 2002) was administered to the children at Time 2 only. It consisted of 32 small and capital English alphabet letters, 14 numbers, and 74 Chinese radicals and simple Chinese characters. Half of the items were left–right reversed. Children were asked to cross out all items with an incorrect orientation and to leave those with a correct orientation blank. The internal consistency reliability of this task was .91.

Mathematics. This experimental task consisted of simple addition items, in which two single-digit numbers were added together. The task was administered at Time 2 as a proxy for learning. We assumed that children with good reading ability might be good readers because of general academic competence rather than because of skill in phonological processing or orthographic processing. Therefore, we administered this task as a learning control variable. In groups, children were given pencils and test sheets and asked to complete all 15 items on their own, within a 15-min period. Its internal consistency reliability was .85.

RESULTS

Table 1 shows the means, standard deviations, and ranges of all variables included in this study. For number naming in English, only 87 participants' data could be included, because 3 of the children could not independently name each of the five numbers in English. The tasks generally showed good variability, although the mean scores on the math and Chinese syllable deletion tasks from Time 2 were close to ceiling levels. The English speeded number-naming task also showed greater variability than most other tasks.

On the developmental spelling task, 20 children had a score of 0, 27 scored either 1 or 2 total, and 43 scored 3 or greater. Tangel and Blachman's (1992) criteria (7-point scale for each word) specify that a perfect score on any of the five words requires a perfect spelling. This occurred in four instances (i.e., four times out of a possible of five words × 90 children = 450), once for *elephant*, twice for *lap*, and once for *sick*. Only in one instance did a child get a score of 5, indicating phonological faithfulness (though orthographically incorrect), for *sik* (*sick*). For eight of the example words (out of 450), a score of 4 was earned, twice for *sick* (spelled one time each as *sek* or *sac*), once for *train* (spelled as *tiren*), and five times for *lap* (spelled as *lamp* 4 times and *laep* once). Scores of 3 on a single word occurred 15 times, with examples such as *pt* for *pretty*, *lp* for *lap*, or *sk* for *sick*. Scores of 2 or 1 on a single word were most common. A score of 2 on a word was earned for the correct first letter of the word, and a score of 1 was awarded for a phonetically related letter (e.g., *g*, *h*, *ch*, *j* were all offered as the first letter of *train* at least twice in this sample). In general, responses demonstrated a mixture of phonological and orthographic knowledge. For example, *elephant* was spelled multiple ways, including *laalaft*, *elf*, *elephle*, *ele*, *etetet*, *l*, *ll*, and *lf*.

The following analyses begin by demonstrating associations from Time 1 to Time 2 variables. We first tested the extent to which Time 1 Chinese phonological-processing abilities would predict reading in Chinese and in English at Time 2. We then used our letter-name knowledge task as an additional predictor of reading in both scripts at Time 2 to test Hypothesis 4, that letter-name knowledge would uniquely predict reading in both Chinese and English.

Prediction of Time 2 Word-Reading in Chinese and English From Chinese Phonological-Processing Skills and Letter-Name Knowledge at Time 1

Table 2 shows the intercorrelations among all variables included in this study. This table indicates that phonological-processing skills tended to be moderately correlated across time and languages. However, of the three phonological-processing variables measured at Time 1, only Chinese syllable deletion was significantly associated with reading of both Chinese and English at Time 2.

TABLE 2
Correlations Among All Variables in This Study

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*
Age in years, t1	1.00																	
Chinese vocabulary, t1	.02	1.00																
Letter name knowledge, t1	.06	.19	1.00															
Chinese syllable deletion, t1	.23	.27	.32	1.00														
Chinese verbal memory for word strings, t1	.33	.07	.19	.44	1.00													
Chinese speeded picture-naming, t1	–.22	–.08	–.40	–.39	–.27	1.00												
Chinese character recognition, t1	.14	.30	.58	.47	.28	–.34	1.00											
Chinese syllable deletion, t2	.01	.05	.26	.34	.10	–.11	.11	1.00										
English syllable deletion, t2	.16	.20	.33	.40	.12	–.29	.30	.30	1.00									
Chinese verbal memory for numbers, t2	.18	–.12	.18	.13	.23	–.15	.09	.25	.36	1.00								
English verbal memory for numbers, t2	.09	–.14	.11	.09	–.04	–.14	.10	.10	.40	.41	1.00							
Chinese speeded number-naming, t2	–.20	–.06	–.18	–.22	–.16	.31	–.23	–.09	–.12	–.24	–.15	1.00						
Letter-naming, t2	–.01	–.02	–.23	–.16	–.02	.27	–.19	–.08	–.14	–.22	–.17	.61	1.00					
Chinese character recognition, t2	.13	.16	.45	32	.11	–.13	.36	.32	.18	.26	.01	–.34	–.26	1.00				
English word recognition, t2	.08	.05	.35	.27	.17	–.03	.35	.34	.31	.46	.17	–.22	–.28	.63	1.00			
English developmental spelling, t2	.11	.07	.16	.09	.09	–.12	.09	.12	.08	.12	.11	–.22	–.30	.20	.41	1.00		
Mathematics test, t2	.12	–.11	.37	.35	.23	–.22	.24	.18	.36	.42	.21	–.23	–.15	.41	.38	.15	1.00	
Orthographic processing, t2	.26	.11	.13	–.03	.01	.14	.10	.08	.14	.07	.00	–.09	–.09	.30	.24	.12	.09	1.00
English speeded number-naming, t2	–.11	.07	–.30	–.20	–.11	.15	–.31	–.07	–.33	–.36	–.33	.45	.41	–.33	–.37	–.21	–.48	–.07

Note. For English speeded number-naming, t2, $n = 87$ and correlations of magnitude .28 are significant at $p < .05$. For other variables, $n = 90$ and correlations of magnitude .22 and greater are significant at $p < .05$. t1 = Time 1; t2 = Time 2.

To test the hypothesis that Time 1 phonological-processing skills in Chinese would significantly predict English and Chinese reading at Time 2, we used regression equations. When only the Chinese phonological-processing skills at Time 1 (all three tasks included simultaneously) were used as predictors of reading, they predicted 11% of the variance in Chinese character recognition, $F(3, 86) = 3.39$, $p < .05$, and 8% of the variance in English word recognition, $F(3, 86) = 2.59$, $p > .05$.

As a more stringent test of the effects of phonological processing on subsequent reading, we controlled for Time 1 reading and vocabulary knowledge to explore the extent to which phonological-processing skills would still uniquely predict reading. As shown in Table 3 (Step 2 of the analysis), with Time 1 Chinese character recognition and vocabulary, in addition to the Time 1 phonological-processing variables included in the analyses, across both equations, 16% of the variance in Time 2 reading was predicted: reading Chinese, $F(5, 84) = 3.31$, $p < .01$; reading English, $F(5, 84) = 3.16$, $p < .05$. Changes in variance with the introduction of the phonological-processing skills were not significant in predicting reading of either script. Across both equations, only the final Beta weight for Chinese character recognition at Time 1 was significant; none of the three phonological-processing skills emerged as a unique predictor of reading at Time 2. These results demonstrate that phonological-processing skills themselves only very modestly predicted Chinese character recognition across time and failed to predict unique variance in English word-reading. Controlling for the autoregressive effects of previous reading skill in Chinese, Chinese phonological-processing skills did not predict significant, unique variance in reading of either Chinese or English. Hypothesis 1 was, therefore, only weakly supported.

We also explored the extent to which Time 1 letter-name knowledge would predict unique variance in reading of English and Chinese at Time 2. Table 2 indeed

TABLE 3
Hierarchical Regression Equations Predicting Word Recognition of Chinese and English at Time 2 From All Time 1 Manipulated Variables

	Chinese Character Recognition		*English Word Reading*	
Step/Variable	*R^2 Change*	*R^2*	*R^2 Change*	*R^2*
1. Chinese character recognition, t1	.13**	.13	.12**	.12
Chinese vocabulary, t1				
2. Chinese verbal memory for word strings, t1	.03	.16	.04	.16
Chinese syllable deletion, t1				
Chinese speeded picture-naming, t1				
3. Letter-name knowledge, t1	.10**	.26	.05*	.21

Note. t1 = Time1; t2 = Time 2.
*$p < .05$. **$p < .01$.

TABLE 4
Standardized Betas for Regression Equation Predicting Word Recognition of Both Chinese and English at Time 2 From All Time 1 Manipulated Variables

	Chinese Character Recognition		*English Word Reading*	
Variable	β	*t*	β	*t*
Chinese character recognition, t1	.08	.63	.19	1.41
Chinese vocabulary, t1	.01	.08	–.09	–.88
Chinese verbal memory for word strings, t1	–.06	–.60	.05	.42
Chinese syllable deletion, t1	.24	1.98	.18	1.47
Chinese speeded picture-naming, t1	.13	1.21	.21	1.90
Letter name knowledge, t1	.39	3.29**	.28	2.24*

Note. For Chinese character recognition, $F(5, 84) = 4.88$, $p < .001$; $R^2 = .26$ (adjusted $R^2 = .21$). For English word-reading, $F(5, 84) = 3.59$, $p = .003$; $R^2 = .21$ (adjusted $R^2 = .15$). t1 = Time 1; t2 = Time 2.
*$p < .05$. **$p < .01$.

indicates that letter-name knowledge from Time 1 was significantly associated with Time 2 reading in Chinese ($r = .45$) and English ($r = .35$), as hypothesized. To test the relative contributions of letter-name knowledge at Time 1 to reading of Chinese and English, we entered letter-name knowledge into the hierarchical regression equations predicting Chinese and English word recognition at Time 2, respectively, after statistically controlling for Chinese vocabulary, character recognition, and the three Chinese phonological-processing skills, all administered at Time 1. Results of these analyses are shown in the final step of Table 3. For Chinese character recognition at Time 2, Time 1 letter-name knowledge contributed an additional 10% of the variance, for a total of 26% of the variance in Time 2 Chinese reading explained. This additional variance change was significant, $F(1, 83) = 10.81$, $p < .001$. Letter-name knowledge also improved the variance explained in reading English at Time 2 from 16% to 21%, a significant increase, $F(1, 83) = 5.02$, $p < .05$. Of interest, as shown in Table 4, across all phonological processing, reading, Chinese vocabulary, and letter-name knowledge variables, only the final Beta weight for letter-name knowledge was significant. These results support Hypothesis 4, in that letter-name knowledge uniquely predicted reading over time.

Variance in Time 2 Word-Reading in Chinese and English Explained from Phonological-Processing and Orthographic Skills Administered at Time 2

Having analyzed the associations from Time 1 to Time 2 variables, we then tested the associations among Time 2 variables themselves. In this section, we tested the extent that phonological processing in Chinese and in English would be associated with reading of both Chinese and English (Hypothesis 2). Hypothesis 3, that the developmental spelling task would contribute uniquely to reading of English but not Chinese, was tested next. Finally, we looked at how the measure of orthographic knowledge was associated with reading across orthographies, a test of Hypothesis 5.

To test Hypothesis 2, we used hierarchical regression equations to examine the amount of variance in reading in both English and Chinese at Time 2 that could be explained using Time 2 phonological-processing variables and letter-name knowledge at Time 1. Letter-name knowledge was included to establish the strength of this variable in accounting for variance in reading, once other Time 2 variables were statistically controlled. We analyzed the data separately using Chinese phonological-processing skills (Time 2 Chinese syllable deletion, number naming, and verbal memory; $n = 90$) and English phonological-processing skills (Time 2 English syllable deletion, number naming, and verbal memory; $n = 87$). Chinese character recognition and Chinese vocabulary knowledge at Time 1 and mathematics skill at Time 2 were also included in the equations to control for the autoregressive effects of reading and for other knowledge. Table 5 shows the results of these analyses using Chinese phonological-processing skills. Approximately equal amounts of variance in Chinese ($R^2 = .34$) and in English ($R^2 = .36$) were accounted for from the control and phonological-processing variables together. In addition, the Chinese phonological-processing skills contributed unique variance to reading in Chinese and in English once Time 1 reading and Chinese vocabulary knowledge and Time 2 mathematics knowledge were statistically controlled. At Step 3, letter-name knowledge at Time 1 did not account for unique variance in either orthography. In contrast, when

TABLE 5
Accounting for Chinese Character Recognition and English Word Reading at Time 2 from Chinese Time 2 Phonological Processing, Control Variables, and Letter-Name Knowledge

	Chinese Character Recognition		*English Word Reading*	
Steps and Variables	*R^2 Change*	*R^2*	*R^2 Change*	*R^2*
1. Chinese vocabulary t1, Chinese character recognition t1, and Mathematics t2	.25***	.25	.21***	.21
2. Chinese syllable deletion t2, Chinese speeded number-naming t2, and Chinese verbal memory for numbers t2	.09*	.34	.15**	.36
3. Letter name knowledge t1	.03+	.37	.00	.36

Note. $N = 90$. t1 = Time 1; t2 = Time 2.
+$p < .07$. *$p < .05$. **$p < .01$. ***$p < .001$.

the three parallel English phonological-processing skills were substituted into these equations predicting reading of Chinese and English at Time 2, they accounted for no significant variance in either Chinese or English reading, as shown in Table 6. In these equations, letter-name knowledge at Time 1 did contribute unique variance to Chinese character recognition at Time 2, but not to English reading at Time 2, beyond that of the other six variables included. Overall, these results demonstrate that native (Chinese) language phonological-processing skills are better than are second-language (English) phonological-processing skills in accounting for variance in reading in both a first and second script.

We had also hypothesized that the developmental spelling task would explain unique variance in reading of English, though not of reading Chinese. To test this hypothesis, we examined the variance in Time 2 reading of both Chinese and English accounted for from the developmental spelling task, once Time 1 Chinese reading, Chinese vocabulary and letter knowledge, Time 2 mathematics ability, and Time 2 Chinese phonological-processing variables (not English ones, given that they were poorer predictors of reading in either orthography as indicated in Table 6) were entered in each equation, as shown in Table 7 (Step 3). Developmental spelling accounted for an additional 9% of the variance in reading of English, which represented a significant change in the multiple correlation squared, $F(1, 81) = 13.69$, $p < .001$, and a nonsignificant change of 0% of the variance in reading of Chinese. This result supports Hypothesis 3.

To test the contribution of orthographic skill at Time 2 to Chinese character recognition and English word recognition at Time 2, we included orthographic processing in a fourth step in these hierarchical regression equations predicting reading in each orthography, as shown in Table 7. Orthographic processing accounted

TABLE 6
Accounting for Chinese Character Recognition and English Word Reading at Time 2 from English Time 2 Phonological Processing, Control Variables, and Letter-Name Knowledge

	Chinese Character Recognition		*English Word Reading*	
Variables	R^2 *Change*	R^2	R^2 *Change*	R^2
1. Chinese vocabulary t1, Chinese character recognition t1, and Mathematics t2	.27**	.27	.23**	.23**
2. English syllable deletion t2, English speeded number-naming t2, and English verbal memory for numbers t2	.02	.29	.03	.26
3. Letter-name knowledge t1	.05*	.34	.01	.27

Note. $N = 87$.
$^*p < .05$. $^{**}p < .001$.

TABLE 7
Hierarchical Regression Equations Accounting for Chinese Character Recognition and English Word Reading at Time 2

	Chinese Characters		*English Words*	
Variables	R^2 *Change*	R^2	R^2 *Change*	R^2
1. Chinese character recognition t1, Letter name knowledge t1, Chinese vocabulary t1, and Mathematics t2	.29***	.29	.22***	.22
2. Chinese syllable deletion t2, Chinese verbal memory for numbers t2, Chinese speeded number-naming t2	.07*	.37	.14**	.36
3. English developmental spelling t2	.00	.37	.09**	.45
4. Orthographic measure t2	.04*	.41	.02	.47

Note. $N = 90$. t1 = Time 1; t2 = Time 2.
*$p < .05$. **$p < .01$. ***$p < .001$.

TABLE 8
Final Beta Weights for Regressions of Chinese Character Recognition and English Word Reading on Key Variables

	Chinese Character Recognition			*English Word Reading*		
Variable	β	*SE* β	*t*	β	*SE* β	*t*
Mathematics, t2	.49	.22	2.10*	.29	.11	1.08
Chinese character recognition, t1	.01	.08	.72	.19	.23	2.20*
Chinese syllable deletion, t2	.22	.17	1.85+	.27	.17	1.97+
Chinese speeded number-naming, t2	–.24	–.19	–2.00*	.00	.03	.36
Chinese verbal memory for numbers, t2	.00	.03	.28	.61	.30	3.26**
Letter name knowledge, t1	.16	.20	1.76+	.00	.02	.20
Orthographic measure, t2	.01	.20	2.32*	.01	.14	1.71+
English developmental spelling, t2	.01	.04	.40	.51	.30	3.52**
Chinese vocabulary, t1	.13	.08	.83	–.00	–.02	–.18

Note. $N = 90$. For Chinese reading, $F(9, 80) = 6.17, p < .001; R^2 = .41$ (adjusted $R^2 = .34$). For English reading, $F(9, 80) = 7.90, p < .001; R^2 = .47$ (adjusted $R^2 = .41$).
+$p < .10$. *$p < .05$. **$p < .01$.

for additional variance in reading in Chinese but not English ($p < .10$), at Time 2. Table 8 displays final Beta weights for these variables, once all were entered into the regression equations. Unique predictors of Chinese character recognition at Time 2 with all variables included were Time 2 mathematics, number naming, and orthographic knowledge. In contrast, the unique predictors of English word recognition at Time 2 were Time 1 Chinese character recognition, Time 2 Chinese verbal memory, and Time 2 invented-spelling knowledge. Thus, Hypothesis 5, that orthographic knowledge would account for unique variance in reading, was supported for Chinese but not for English.

DISCUSSION

From our 2-year longitudinal study of children's reading in Chinese and English, we obtained the following results: First, Time 1 Chinese phonological-processing skills alone predicted only modest variance in reading of Chinese and no significant variance in English word recognition 2 years later. In contrast, Time 1 letter-name knowledge was a good predictor of reading in both scripts across time. Second, Chinese phonological-processing skills approximately equally accounted for variance in both Chinese and English reading, with measures of simple mathematics knowledge, reading, and Chinese vocabulary knowledge controlled. In contrast, phonological-processing skills in English did not account for unique variance in concurrently measured reading of either Chinese or English. One exception to this was that the English developmental spelling task was strongly associated with reading in English but not in Chinese. Finally, orthographic processing explained variance in reading in Chinese, but not in English, once other reading-related skills were statistically controlled. These findings are discussed next.

To begin, we found that phonological processing in Chinese was longitudinally and concurrently predictive of reading in Chinese. These results are consistent with previous concurrently (e.g., Hu & Catts, 1998; McBride-Chang & Ho, 2000) and longitudinally (Ho & Bryant, 1997) conducted studies demonstrating that phonological-processing skills predict Chinese character recognition. However, although phonological-processing skills in Chinese predicted unique variance in Chinese character recognition 2 years later, the variance predicted was modest. When autoregressive effects of previous reading skill were included in the equation, Chinese phonological-processing skills measured at Time 1 were no longer significant predictors of reading. Concurrently measured Chinese phonological-processing skills, in contrast, were relatively strong predictors of reading in both Chinese and English.

Thus, as previous studies have reported (Chiappe & Siegel, 1999; Durgunoglu et al., 1993; Geva et al., 1993, 1997; Gottardo et al., 2001), variance in reading in the first (Chinese) and second (English) languages were approximately equally explained concurrently by phonological processing in the native language. However, phonological-processing tasks administered in the second language, English, did not account for additional variance in reading in either orthography. The extent to which this finding is generalizable longitudinally cannot be determined by this study. It is possible that young children's native phonological-processing skills tend to be better associated with reading skills in any script that they are reading than are second-language phonological-processing skills, or it may be that this result is specific to very young learners or even to the nature of the two orthographies included in this study.

The only exception to the finding that phonological-processing skills in English were poorer in accounting for variance in reading than were phonological-processing skills in Chinese in this study was the developmental spelling measure, which explained unique variance in reading English but not in reading Chinese. The demonstration that developmental spelling was strongly associated with reading in English, but not in Chinese, in part highlights the importance of phoneme sensitivity for English reading. Because developmental spelling focuses on phoneme-level knowledge, it may be a particularly sensitive correlate of English word recognition, which demands phonemic skills. Tangel and Blachman's (1992) developmental spelling measure was sensitive to Hong Kong children's letter-sound awareness, awareness that they had never been explicitly taught. Unlike American children, who are routinely taught that *B* makes the /b/ sound, for example, Hong Kong students are not coached in these name-sound connections. Yet there was wide variability in students' spelling skills on this measure. Of 90 students spelling five words (i.e., 450 comparisons), only 4 of these were spelled correctly. Most of the errors children made suggest that they were not relying on rote memorization for spelling the words, despite the fact that that is the only way they were taught to read English. These results lead us to conclude that developmental spelling skill is a successful indicator of reading English in a second language, even among children who are native Chinese readers and who have only been taught to read English using the look and say method.

Although studies of invented spelling and native English reading have demonstrated a directional connection between early invented spelling and subsequent word-reading (Caravolas, Hulme, & Snowling, 2001), we cannot determine a causal association of these skills in this study. It may be that Hong Kong children who are better readers of English tend to perform better on the developmental spelling measure because reading promotes phonemic sensitivity in English. At the same time, sensitivity to letter-sound knowledge, as measured in the developmental spelling measure, may promote better reading. Future research should examine this association across time using a similar methodology to that of Caravolas and her colleagues to look at longitudinal associations in those learning to read English as a second language.

These results have some parallels with those of McBride-Chang and Treiman (2003), adapting a method developed by Ehri and Wilce (1985), who found that Hong Kong kindergartners' sensitivity to letter sounds varied both as a function of age and reading skills. In that study, children across three kindergarten age groups were taught to read made-up names "spelled" with only two letters. Conditions of these names varied. Cues to names in one condition made use of visual peculiarities (e.g., **D***k* spells *Jean*), others made use of letter-name cues (e.g., DK spells

Deke), and others made use of letter-sound knowledge cues (e.g., DK spells *Dick*). By ages 5 and 6, these children were more sensitive to letter sound than to visual cues, and performance on the letter-sound condition was strongly associated with English word-reading performance. These results, like those of the developmental spelling task, demonstrate that Hong Kong Chinese children's sensitivity to letter sounds is implicitly acquired by the end of kindergarten and strongly associated with English word-reading. Despite the fact that Hong Kong Chinese children are second-language learners of English without English phonics training, they are sensitive to letter sounds, perhaps one indication of phonemic awareness, because they tend to approach the task of reading analytically. Another way to view these results is that exposure to the English writing system can induce some combination of phoneme awareness and letter-sound association knowledge, even when they are not explicitly taught.

It is likely that the developmental spelling task used in this study was not correlated with other phonological-processing measures for several reasons, both theoretical and task oriented. First, the developmental spelling measure focused on sound sensitivity at the level of the phoneme, rather than at the syllabic level, as did our oral measure of phonological awareness. Second, it was an English measure, which may have affected its familiarity to the students. Previous research has demonstrated differences in phonological-processing skills across children who are native speakers of English and Chinese (Holm & Dodd, 1996; Huang & Hanley, 1995) and even across native adult speakers of Chinese speaking English as a second language (Cheung & Kemper, 1993; McBride-Chang, 1998). For instance, in a study of adults, invented spelling was not correlated with speeded naming or verbal short-term memory in Chinese or English (McBride-Chang, 1998). Cheung and Kemper also demonstrated different short-term memory capacities and articulatory capacities for Chinese and English words in native Chinese speakers, underscoring phonological differences across these languages. Thus, although phonological-processing skills across languages often tend to be correlated, such associations may also be influenced by differences across units (e.g., syllable vs. phoneme) of phonological awareness and possibly by language familiarity.

A third reason that the developmental spelling measure was not associated with most other phonological-processing skills measured in this study is that it required a graphological component, which the other phonological-processing measures did not. That is, although we used the task of developmental spelling originally as a proxy for phonemic awareness, this task may also make use of orthographic skills. Furthermore, unlike the other phonological-processing tasks, it involves writing. A pure phonemic awareness measure administered in Chinese might make an interesting comparison for this developmental spelling task in future research. However, we have not yet found one that is suitable for Hong Kong kindergartners, based on pilot studies. It should further be noted that the developmental spelling measure was significantly associated with English reading even after knowledge of letter names and mathematics, which also required a written response, was statistically controlled, suggesting that this task was indeed measuring some aspects of phonemic awareness or knowledge of letter-sound associations, rather than simply symbol familiarity.

We also examined the extent to which letter-name knowledge and orthographic processing would be predictive of both Chinese character recognition and English word reading. We found that letter-name knowledge was a unique predictor of English word recognition from Time 1 to Time 2, as found previously for native English speakers learning to read English (e.g., Adams, 1990). Letter-name knowledge probably facilitates sensitivity to letter sounds, which is helpful to English word recognition (e.g., McBride-Chang, 1999; Treiman et al., 1996; Treiman et al., 1994). Letter-name knowledge was also predictive of Chinese character recognition, perhaps because paired visual associate learning, as is required in learning to name letters of the alphabet, is important for learning to read Chinese characters as well. Thus, letter-name knowledge is a sensitive predictor of subsequent Chinese character recognition in children who are learning an alphabet simultaneously because learning of both Chinese characters and letter names requires pairing an oral referent with a written one. This hypothesis will be pursued in future work.

Orthographic-processing skills were associated with Chinese as well. Orthographic codes, in conjunction with phonological codes, are used to learn to read and spell in English (e.g., Berninger, Yates, & Lester, 1991). The visually complicated Chinese script demands extensive visual discrimination abilities for stroke patterns and character orientation. Thus, orthographic skill is also important for reading Chinese. For example, attention to the positions of elements within characters is essential for successful character identification (Shu & Anderson, 1999).

FUTURE DIRECTIONS

Results of this study suggest some issues that should be pursued in future research. First, if possible, phoneme awareness should be examined more explicitly in future work on young Chinese children. Although we have suggested that phoneme awareness may not be necessary for beginning reading of Chinese, we did not test that hypothesis in this study. Huang and Hanley (1995) found fairly strong associations between phoneme (onset and final) awareness and reading in Chinese among older students. Direction of causality is particularly important in considering the utility of phonemic awareness for reading of Chinese and English (Read et al., 1986). Causal associations may also relate to method of literacy instruction.

Second, the importance of phonological processing for reading may differ across scripts. To some extent, phonological processing in one's native language is predictive of reading in a first and a second language, even when those languages are quite different, as are Chinese and English. Native language phonological-processing skills are universally relevant to very early reading development. However, future research should focus more clearly on those phonological-processing skills that are particularly important for reading in each orthography over time. For example, in this study, speeded naming appears to be the strongest of the three concurrently administered phonological-processing skills in predicting Chinese character recognition. In contrast, verbal memory appeared to be more important for learning to read English.

In addition, it should be pointed out that the phonological-processing tasks measured at Time 1 were only of limited use in predicting Chinese character or English word recognition skills 2 years later. This result was somewhat disappointing given the large body of research devoted to the importance of phonological processing for subsequent reading. Given the limited utility of phonological-processing measures for predicting subsequent reading, future research might explore other early cognitive skills that might be better predictors of subsequent reading in Chinese. Based on our finding of relatively strong associations of letter-name knowledge with subsequent reading in English and in Chinese, perhaps pure tasks of visual-paired associate learning might be useful in this regard, particularly among children taught to read with look and say methods.

Phonological processing in a second language may be of limited usefulness once phonological processing in the first language is taken into account, but this may depend on orthography and the type or level of phonological processing assessed. Phonemic awareness is an orthography-specific dimension of reading (Read et al., 1986). Phonemic awareness may be important for everyone learning to read English, even those children who are taught to read English using the holistic look and say method. Although the developmental spelling measure was neither a traditional nor a pure measure of phonemic awareness, it was probably the most accurate and practical way for us to measure knowledge of phonemes in children who have not been taught letter sounds or phonics explicitly. We suggest that future research focused on reading acquisition in a second language, particularly among young children, make use of the invented spelling paradigm, in part to tap children's phonological sensitivity.

Orthographic processing may also be a universal element of reading. Our test of orthographic processing focused primarily on left–right orientation skills, which may be more important in Chinese than in English. This may be the case because there are larger numbers of semantic radicals and phonetics, components of Chinese characters, that children must identify in Chinese relative to the mere 26 letters of the English alphabet. However, even in accounting for variance in English reading, the final Beta weight of the orthographic measure approached traditional significance ($p < .10$), suggesting that this orthographic measure may contribute some unique variance to early English word recognition in a large enough sample of Chinese children. In future research, different aspects of orthographic processing apart from left–right orientation, such as homophone recognition, might be included as additional predictors of reading skill in Chinese or English.

Finally, although letter-name knowledge strongly distinguished young Hong Kong children's ability to read both English and Chinese over time (though not when concurrent Time 2 reading-related measures were included), the meaning of the task of letter identification for reading each orthography may be different. Letter-name knowledge may represent a bridge toward learning letter sounds for English word recognition (e.g., Treiman et al., 1994). In contrast, letter-name knowledge may represent primarily facility with pairing visual and oral symbols in its association with Chinese character recognition. On the other hand, given that Hong Kong children are taught to read English holistically, there may be an element of paired visual associate learning of letters and English words as well. In future work, researchers might seek to understand the specific theoretical explanation for the unique variance of letter-name knowledge in predicting both subsequent Chinese character recognition and English word-reading. In relation to Chinese character recognition, there may be an analogy to findings related to rapid automatized naming (Denckla & Rudel, 1976) tasks: Rapid automatized naming tasks tend to be good predictors of reading at certain points in development (particularly for younger readers; e.g., Wagner et al., 1997). However, their theoretical meaning is unclear. The same may be true of letter-name knowledge for Hong Kong Chinese kindergartners.

Overall, this study has contributed to understanding reading development across scripts in five ways. First, it demonstrates that, in children younger than previously tested (Gottardo et al., 2001), Chinese phonological-processing skills account for variance in both Chinese character and English word recognition skills, at least concurrently. Second, we have shown that generalizable native language phonological-processing skills are better for explaining variance in concurrent reading ability in either language than are second-language phonological-processing skills for Chinese–English bilinguals. In contrast, the language-specific phoneme-level developmental spelling task accounts for unique variance in English word recognition but not Chinese character recognition, a third contribution of our study. Fourth, we have demonstrated that letter-name knowledge is longitudinally strongly predictive of both English word recognition, as expected, and Chinese character recognition, a unique finding, among Hong Kong Chinese beginning readers. Finally, our measure of orthographic knowledge was useful in explaining variance in Chinese character recognition in these developing readers.

ACKNOWLEDGMENTS

This study was supported by Grants 2020336 and 2020695 from the Chinese University of Hong Kong and UGC Grants 4207/98H and 4257/03H.

REFERENCES

Adams, J. (1990). *Beginning to read: Thinking and learning about print*. Cambridge, MA: MIT Press.

Ben-Dror, I., Bentin, S., & Frost, R. (1995). Semantic, phonologic, and morphologic skills in reading disabled and normal children: Evidence from perception and production of spoken Hebrew. *Reading Research Quarterly*, *30*, 876–893.

Berninger, V. W., Cartwright, A. C., Yates, C. M., Swanson, H. L., & Abbott, R. D. (1994). Developmental skills related to writing and reading acquisition in the intermediate grades: shared and unique functional systems. *Reading and Writing, 6*, 161–196.

Berninger, V., Yates, C., & Lester, C. (1991). Multiple orthographic codes in acquisition of reading and writing skills. *Reading and Writing, 3,* 115–149.

Bialystok, E., McBride-Chang, C., & Luk, G. (2004). *Bilingualism, language proficiency, and learning to read in two writing systems*. Manuscript under review.

Bruck, M., & Genessee, F. (1995). Phonological awareness in young second language learners. *Journal of Child Language*, *22*, 307–324.

Caravolas, M., Hulme, C., & Snowling, M. J. (2001). The foundations of spelling ability: Evidence from a 3-year longitudinal study. *Journal of Memory and Language, 45*, 751–774.

Cheung, H., Chen, H.-C., Lai, C. Y., Wong, O. C., & Hills, M. (2001). The development of phonological awareness: Effects of spoken language experience and orthography. *Cognition, 81,* 227–241.

Cheung, H., & Kemper, S. (1993). Recall and articulation of English and Chinese words by Chinese-English bilinguals. *Memory and Cognition*, *21*, 666–670.

Chiappe, P., & Siegel, L. A. (1999). Phonological awareness and reading acquisition in English- and Punjabi-speaking Canadian children. *Journal of Educational Psychology*, *91*, 20–28.

Cisero, C., & Royer, J. (1995). The development and cross-language transfer of phonological awarenss. *Contemporary Educational Psychology*, *20*, 275–303.

Comeau, L., Cormier, P., Grandmaison, E., & Lacroix, D. (1999). A longitudinal study of phonological processing skills in children learning to read in a second language. *Journal of Educational Psychology*, *91*, 29–43.

Denckla, M., & Rudel, R. G. (1976). Rapid automatized naming (R.A.N.): Dyslexia differentiated from other learning disabilities, *Neuropsychologia*, *14*, 471–479.

Durgunoglu, A. Y., Nagy, W. W., & Hancin-Bhatt, B. J. (1993). Cross-language transfer of phonological awareness. *Journal of Educational Psychology*, *85*, 453–465.

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.

Geva, E., Wade-Woolley, L., & Shany, M. (1993). The concurrent development of spelling and decoding in different orthographies. *Journal of Reading Behavior*, *25*, 383–406.

Geva, E., Wade-Woolley, L., & Shany, M. (1997). Development of reading efficiency in first and second languages. *Scientific Studies of Reading*, *1*, 119–144.

Goswami, U., & Bryant, P. E. (1990). *Phonological skills and learning to read*. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Gottardo, A., Yan, B., Siegel, L. S., & Wade-Woolley, L. (2001). Factors related to English reading performance in children with Chinese as a first language: More evidence of cross-language transfer of phonological processing. *Journal of Educational Psychology, 93*, 530–542.

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., 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.

Holm, A., & Dodd, B. (1996). The effect of first written language on the acquisition of English literacy. *Cognition*, *59*, 119–147.

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.

Leong, C. K. (1997). Paradigmatic analysis of Chinese word reading: Research findings and classroom practices. In C. K. Leong & R. M. Joshi (Eds.), *Cross-language studies of learning to read and spell: Phonological and orthographic processing* (pp. 379–417). Dordrecht, The Netherlands: Kluwer Academic.

Lindsey, K. A., Manis, F. R., & Bailey, C. E. (2003). Prediction of first-grade reading in Spanish-speaking English-language learners. *Journal of Educational Psychology, 95*, 482–494.

Mann, V. A. (1986). Phonological awareness: The role of reading experience. *Cognition*, *24*, 65–92.

Mann, V. A., Tobin, P., & Wilson, R. (1987). Measuring phonological awareness through the invented spellings of kindergarten children. *Merrill-Palmer Quarterly*, *33*, 365–391.

McBride-Chang, C. (1998). Phonological transfer in Chinese and English. *Psychologia, 41,* 249–258.

McBride-Chang, C., & Ho, C. S.-H. (2000). Developmental issues in Chinese children's character recognition. *Journal of Educational Psychology, 92*, 1–6.

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

McBride-Chang, C., & Treiman, R. (2003). Use of letter names and letter sounds in learning to read English among young Hong Kong Chinese children. *Psychological Science, 14,* 138–143.

Morais, J., Cary, L., Alegria, J., & Bertelson, P. (1979). Does awareness of speech as a sequence of phones arise spontaneously? *Cognition, 7*, 323–331.

Perfetti, C. A., Beck, I., Bell, L. C., & Hughes, C. (1987). Phonemic knowledge and learning to read are reciprocal: A longitudinal study of first grade children. *Merrill-Palmer Quarterly*, *33*, 283–319.

Read, C., Zhang, Y., Nie, H., & Ding, B. (1986). The ability to manipulate speech sounds depends on knowing alphabetic spelling. *Cognition*, *24*, 31–44.

Shu, H. & Anderson, R. C. (1999). Learning to read Chinese: The development of metalinguistic awareness. In J. Wang, A. W. Inhoff, & H. C. Chen (Eds.), *Reading Chinese script: A cognitive perspective* (pp. 1–18). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

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

Snow, C. E., Burns, M. S., & Griffin, P. (Eds.). (1998). *Preventing reading difficulties in young children*. Washington, DC: National Academy Press.

So, D., & Siegel, L. S. (1997). Learning to read Chinese: Semantic, syntactic, phonological and working memory skills in normally achieving and poor Chinese readers. *Reading and Writing*, *9*, 1–21.

Tangel, D. M., & Blachman, B. A. (1992). Effect of phoneme awareness instruction on kindergarten children's invented spellings. *Journal of Reading Behavior*, *24*, 233–258.

Thorndike, R. L., Hagen, E. P., & Sattler, J. M. (1986). *Stanford-Binet Intelligence Scale* (4th ed.). Chicago: Riverside.

Treiman, R. (1993). *Beginning to spell: A study of first-grade children*. New York: Oxford University Press.

Treiman, R., Tincoff, R., & Richmond-Welty, E. D. (1996). Letter names help children to connect print and speech. *Developmental Psychology, 32,* 505–514.

Treiman, R., Weatherston, S., & Berch, D. (1994). The role of letter names in children's learning of phoneme-grapheme relations. *Applied Psycholinguistics, 15,* 97–122.

Wagner, R. K., & Torgesen, J. (1987). The nature of phonological processing and its causal role in the acquisition of reading skills. *Psychological Bulletin, 101*, 192–212.

Wagner, R. K., Torgesen, J. K., Laughon, P., Simmons, K., & Rashotte, C. A. (1993). Development of young readers' phonological processing abilities. *Journal of Educational Psychology*, *85*, 83–103.

Wagner, R. K., Torgesen, J. K., Rashotte, C. A., Hecht, S. A., Barker, T. A., Burgess, S. R., et al. (1997). Changing relations between phonological processing abilities and word-level reading as children develop from beginning to skilled readers: A 5-year longitudinal study. *Developmental Psychology*, *33*, 468–479.

Manuscript received March 26, 2001
Accepted July 27, 2004