Child Development, September/October 2002, Volume 73, Number 5, Pages 1392–1407

Cross-Cultural Similarities in the Predictors of Reading Acquisition

Catherine McBride-Chang and Robert V. Kail

Measures of Chinese character/English word recognition, phonological awareness, speeded naming, visual–spatial skill, and processing speed were administered to 190 kindergarten students in Hong Kong and 128 kindergarten and grade 1 students in the United States. Across groups, the strongest predictor of reading itself was phonological awareness; visual processing did not predict reading. For both groups, speed of processing strongly predicted speeded naming, visual processing, and phonological awareness. Despite diversities of culture, language, and orthography to be learned, models of early reading development were remarkably similar across cultures and first and second language orthographies.

INTRODUCTION

Like many developmental processes, learning to read involves some characteristics that are shared across cultures and some that are specific to individual cultures. The present study tested the extent to which predictors of early reading were similar for Hong Kong Chinese children who were learning to read Chinese and American children who were learning to read English. Also compared were models of Hong Kong Chinese children who were learning to read English as a second language and American children who were learning to read English as their first language. An explicit comparison of reading development between children who are Hong Kong Chinese and English-speaking Americans is of particular interest because of differences in cultural expectations, language background, and orthography to be learned.

Cultural Context

The cultural context in which children learn to read is very different in Hong Kong and in the United States. Cultural differences are evident in academic expectations and experiences, children's language backgrounds, and the orthography to be mastered.

Academic setting. At least three aspects of the academic setting are strikingly different in Hong Kong and in the United States. First, Chinese parents tend to be much more concerned about their children's academic development than are American parents (e.g., Chen, Rubin, & Li, 1997). Chinese children, in turn, tend to attain much higher scores in reading than do American children (Stevenson, Chen, & Lee, 1992; Stevenson et al., 1990), even in early primary school. Second, and related to this point, formal reading instruction typically begins in Hong Kong in the first year of kindergarten, at ages 3 to 4 years (McBride-Chang & Ho, 2000), when simple character recognition is taught. American schoolchildren typically receive some formal instruction in letter name and letter sound knowledge at age 5, but do not begin to learn to read at school until age 6. Thus, Hong Kong children have received 2 years of academic schooling in reading before their American counterparts have even begun formal learning of the alphabet. Third, Hong Kong students are generally taught to read using the "look and say" method (Hanley, Tzeng, & Huang, 1999; Holm & Dodd, 1996, Huang & Hanley, 1995), whereas American children are usually taught some phonics to aid in word recognition (e.g., Adams, 1990). These differences in teaching styles affect phonological awareness, a construct that is consistently associated with early reading skills (Goswami, 1999), in both children (e.g., Huang & Hanley, 1995) and adults (Holm & Dodd, 1996). Phonics-based reading instruction improves phonological skills.

Language background. Language differences may also bear on learning to read in Hong Kong and in the United States. The first language of Hong Kong Chinese children is Cantonese, which is analytic, tonal, and noninflected. In stark contrast, English is synthetic, atonal, and inflected. Native language background may affect phonological processing skills (Caravolas & Bruck, 1993; Cheung, Chen, Lai, & Wong, 2001; Cossu, Shankweiler, Liberman, Katz, & Tola, 1988), which have been linked to reading across different cultures (Goswami, 1999). For example, Chinese languages contain very few consonant clusters, whereas English contains relatively many consonant clusters. This difference may affect children's awareness of the phoneme, or single speech sound, in the native language: Chinese children are unlikely to be aware of individual phonemes in Chinese, whereas English-speaking children are much more likely to be sensitized to phonemes in English (Cheung et al., 2001).

In addition to native language spoken, Hong Kong

 0009-3920/2002/7305-0005

and the United States differ in exposure to second-language instruction. In Hong Kong, beginning in the first year of kindergarten (ages 3–4), children routinely receive written and oral instruction in both Mandarin and English, as well as their native Cantonese. Because of the strong emphasis on both international and Chinese relations in Hong Kong, English and Mandarin are introduced in early kindergarten to the 95% of children who attend local kindergartens (McBride-Chang & Ho, 2000). In the United States, second-language instruction typically does not start until secondary school.

Interest in the extent to which learning to read in a second language parallels learning to read in the native language has focused primarily on the role of phonological processing across orthographies (e.g., Bruck & Genesee, 1995; Comeau, Cormier, Grandmaison, & Lacroix, 1999; Durgunoglu, Nagy, & Hancin-Bhatt, 1993; Geva, Wade-Woolley, & Shany, 1997). No known previous studies have examined the contribution of cognitive skills other than phonological processing in learning to read in a second language. The present study examined the role of four cognitive processes in the ability of Hong Kong Chinese children to learn to read English.

Orthography to be learned. Perhaps the most obvious difference between Hong Kong and America with respect to first language reading development is the orthography to be learned in each. The basic unit of reading Chinese is the Chinese character, which simultaneously represents a morpheme and a syllable. In contrast, the basic unit of reading English is the letter, which represents only a single phoneme, or speech sound. As proposed above for language processing, the differences across orthographies in unit of analysis—syllable versus phoneme—may be important for the development of reading. For Chinese children, learning to read requires mapping of spoken syllables onto written characters. For English-reading children, learning to read requires cracking the alphabetic code and learning to synthesize printed letters together to recognize spoken words in printed form. These differences in mapping of oral vocabulary to printed symbols appear to call on phonological, visual, and speeded processes, in varying degrees, to facilitate reading acquisition across orthographies (Hu & Catts, 1998; Kail, Hall, & Caskey, 1999; Kail & Park, 1992; McBride-Chang, 1996; Tzeng & Wang, 1983).

Cognitive Skills That Influence Learning to Read

The present study examined the extent to which four cognitive constructs predicted young children's reading skill.

Phonological awareness. The role of phonological skills in learning to read English has been researched thoroughly in the last few decades (Adams, 1990; Goswami, 1999). Wagner and Torgesen (1987) distinguished three separate phonological processing skills: phonological awareness, verbal memory, and speeded naming. However, subsequent research has revealed that in Chinese (e.g., McBride-Chang & Ho, 2000) as well as English (McBride-Chang, 1996; Wagner, Torgesen, & Rashotte, 1994; Wagner et al., 1997), when all three of these skills are included in a given study, verbal memory does not uniquely predict reading. In contrast, phonological awareness and speeded naming tend to predict unique variance in initial reading acquisition. Therefore, only measures of phonological awareness and speeded naming were included in the present models of Chinese character/English word recognition.

Phonological awareness, defined as awareness of and access to the sound structure of a language, is the best researched area of the three phonological processing skills in the reading acquisition literature. Awareness of the same levels of phonological information (e.g., onsets and rimes, syllables, or phonemes) across languages does not necessarily predict reading development similarly (Goswami, 1999). Rather, the importance of phonological awareness for predicting reading skill depends on the orthography to be learned and the phonology of the spoken language corresponding to that orthography (Goswami, 1999).

Phonological awareness is one of the strongest predictors of learning to read in English (Adams, 1990) and has been shown to predict reading acquisition across cultures (Goswami, 1999), including Chinese (e.g., Ho & Bryant, 1997; McBride-Chang & Ho, 2000). However, the relative importance of phonological awareness for Chinese character recognition as compared with English word recognition remains unclear, because phonological awareness can be measured at different levels (Adams, 1990), ranging from phonological sensitivity (Stanovich, 1991) to phonemic awareness. The few studies that have examined the role of phonological awareness in Chinese character acquisition have not systematically controlled for level of phonological awareness relative to developmental level. Because Hong Kong Chinese children must learn to map syllables to Chinese characters and American children must learn to map letters to phonemes (a smaller unit of analysis), it was assumed that a comprehensive measurement of phonological awareness for reading could not be precisely equivalent across Chinese and English languages (Cheung et al., 2001). Yet the basic importance of phonological awareness, which lies in isolating speech segments and mapping them to a graphical representation, is universal for learning to read. Thus, the present study sought to test phonological awareness in a way that would be sensitive to reading needs in each culture.

To strive toward approximate equivalence across languages, the primary task used to measure phonological awareness was syllable manipulation. This task was strongly correlated with initial character recognition in a previous study of beginning Chinese readers (McBride-Chang & Ho, 2000) because the syllable is the basic unit of both oral and written Chinese. Bilinguals' phonological awareness transfers across languages (e.g., Bruck & Genesee, 1995; Cisero & Royer, 1995; Comeau et al., 1999; Durgunoglu et al., 1993; Huang & Hanley, 1995); thus, the Hong Kong students were administered tasks of syllable deletion in both Cantonese and English. That is, phonological awareness in one's native language tends to predict reading performance approximately equally for either the first or second orthography (Chiappe & Siegel, 1999; Comeau et al., 1999; Huang & Hanley, 1995). In contrast, few studies have examined the extent to which syllable manipulation uniquely predicts beginning reading of English (Goswami, 1999), because most studies of reading in English have focused on onset-rime distinctions and not on syllables. Consequently, American students were administered a syllable deletion task as well as a letter sound knowledge task, which has been conceptualized as a phonemic awareness task (McBride-Chang, 1999).

Speeded naming. The second phonological processing construct tested consisted of speeded naming tasks, as measured in Rapid Automatized Naming (RAN) tasks (Denckla & Rudel, 1976). In these tasks, participants are asked to name as quickly as possible visually presented stimuli, which may be either graphological (e.g., letters, numbers, Chinese radicals—any formal written symbols) or nongraphological, such as blocks of color or easily identifiable pictures (e.g., dog, hat). Speeded naming tasks distinguish good from poor readers both in English (Wagner, Torgesen, & Rashotte, 1994) and Chinese (Ho & Lai, 1999). In addition, speeded naming tasks sometimes account for unique variance in children's early word recognition (Wagner et al., 1997) and Chinese character recognition (Hu & Catts, 1998; McBride-Chang & Ho, 2000). Indeed, in some orthographies such as German, speeded naming distinguishes good and poor readers, whereas phonological awareness does not (Wimmer, 1995). Such speeded naming tasks have been said to reflect phonological recoding in lexical access (Wagner & Torgesen, 1987). The present study tested the extent to which speeded naming would uniquely predict early reading in a model of word/character recognition that also included global speed of processing.

Visual processing. Visual processing is the perception and interpretation of visual forms (Gardner, 1996). Word and character recognition both involve pairing a visual symbol or group of symbols with a spoken referent. Thus, learning to read surely requires some visual capacities. This may be particularly true for Chinese because sentences that are written using Chinese characters tend to contain more visual information than do those written in English (Chen, 1996). Although a variety of visual skills have been shown to correlate with reading among Chinese children in some studies (Ho & Bryant, 1999; Huang & Hanley, 1995), other studies have not found associations between visual skills and Chinese character recognition (Ho, 1997; Hu & Catts, 1998). Thus, research on the association of primary visual skills to early Chinese character recognition has yielded mixed results.

The link between early visual skills and initial English word recognition is also unclear. Although visual processing is recognized as important for word recognition at higher levels of processing (Jorm & Share, 1983), its role in initial alphabetic reading has been downplayed considerably in recent years. A notable exception is the research on developmental dyslexia that argues for a visual subtype of dyslexia (Manis, Seidenberg, Doi, McBride-Chang, & Petersen, 1996). However, overall, almost no attention has been paid to whether or how visual skills predict English word recognition with development.

The present study looked at visual skills in relation to character and word recognition across Chinese and American beginning readers, and examined whether visual skills would contribute unique variance to reading in either Chinese or English in a model that also included phonological processing and speed of processing constructs.

Speed of processing. Processing speed was the fourth cognitive construct investigated. Processing speed refers to the rate with which individuals can execute basic cognitive processes, such as search, retrieve, and compare. Processing speed increases substantially during childhood: On a range of perceptual and cognitive tasks, children respond more rapidly as they develop (Kail, 1995). Furthermore, increased processing speed has been associated with age-related change in cognitive skills, including reading. For example, Kail et al. (1999) found that although processing speed did not predict word decoding skill directly, it did predict performance on naming tasks, which, in turn, predicted decoding skill.

The particular interest in the present study was in processing speed as a mediator of age-related change in the predictors of word / character recognition. That is, based on the findings of Kail et al. (1999), processing speed was not anticipated to predict reading directly. Instead, we hypothesized that processing speed would mediate age-related change in phonological awareness, speeded naming, and visual–spatial skills, because each of these cognitive constructs may be directly affected by speed of processing (Kail et al., 1999).

Focus of the Present Study

The general framework that links the present study's primary constructs of interest is shown in Figure 1. In this model, which is similar to one proposed by Cutting, Carlisle, and Denckla (1998, cited in Denckla & Cutting, 1999), age is linked to speed, which, in turn, is linked to phonological awareness, naming, and visual skill; each of these latter constructs is linked directly to reading. A primary focus of the present work was to examine the extent to which phonological awareness, naming skill, and visual skill would have independent, direct influences on reading, and whether these influences would be similar for children in Hong Kong and the United States and for English word recognition in first and second language learners.

METHOD

Participants

Participants were 190 Hong Kong kindergarten students and 128 American kindergarten and first-grade students. In Hong Kong, kindergarten lasts 3 years (K1–K3), and this sample consisted of 60 K1 (ages 3–4 years), 70 K2 (ages 4–5), and 60 K3 (ages 5–6) Hong Kong children from six schools. The mean ages of the kindergarten children were 4.42 (*SD* = .30), 4.91 (*SD* = .28), and 5.91 (*SD* = .35) years for K1, K2, and K3, respectively. There were 32 boys and 28 girls in the K1 group and equal numbers of boys and girls in the other two groups. The American students came from two schools in the midwestern United States. The kindergarten students (32 boys, 31 girls) had a mean age of 6.10 years (*SD* = .43), and the first graders (36 boys, 29 girls) had a mean age of 7.10 years (*SD* = .55).

Tasks

A battery of tasks was devised to assess children's reading skill, processing speed, phonological awareness, naming, and visual–spatial skill. In addition, because general cognitive ability may be an important factor in reading acquisition (Stringer & Stanovich, 2000), children's basic vocabulary knowledge was measured as a proxy for general ability. A description of each task follows, organized by the skills measured.

Reading. To measure ability to read Chinese, Hong Kong children were administered a character reading task (Ho & Bryant, 1997) that consisted of 61 Chinese words to identify. First, 27 one-character words were tested. If a child failed to name 20 words or more of these one-character items, the test was terminated. Those who named more than 19 one-character words were asked to name 34 additional two-character words. The internal consistency reliability of this test was .98.

Pilot testing of several standardized English word recognition tasks revealed that none was adequate to reflect Hong Kong kindergartners' knowledge of

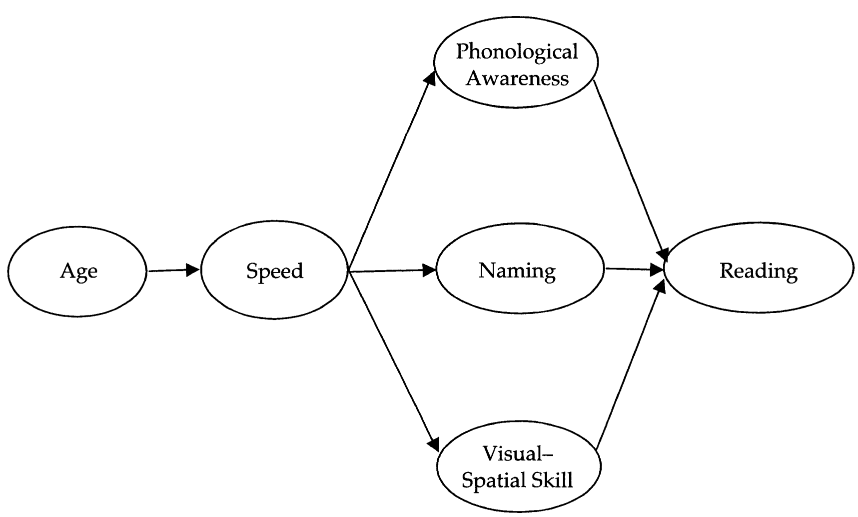

Figure 1 A theoretical model that links the constructs of interest.

English reading because their kindergarten curriculae tend to focus on different vocabulary items than do standard tests from America or England. Therefore, we created our own task of word reading, a Hong Kong English reading test, which was based on reviews of English reading series used in four different kindergartens. The 30 items that comprised this test are listed in the Appendix. The internal consistency reliability of this measure was .94. This test, which correlated .88 with the standardized Woodcock Word Identification subtest (Woodcock, 1987) among the American students, was administered to students in Hong Kong and in the United States. In addition, students in the United States were administered the Woodcock Word Identification subtest of the Woodcock Reading Mastery Tests (Woodcock, 1987).

Phonological awareness. Because previous researchers have noted that syllable awareness typically emerges as a precursor to the development of reading in English (Goswami & Bryant, 1990; Morais, 1991) and because the syllable is the basic language and reading processing unit of Chinese, phonological awareness was measured in both groups with a syllable deletion task that consisted of 25 compound words or phrases from which children were asked to delete a word or syllable. In both measures, the first 10 items consisted of two-syllable compound words (e.g., tee-shirt). From these items, children were asked to delete either the first word or the second word as requested. The remaining 15 items consisted of three-syllable phrases (e.g., big teacup). Children were asked to delete the first, middle, or last syllable from each of these. The U.S. students completed the task with 25 English words or phrases; Hong Kong students completed the task with 25 English words as well as an analogous task consisting of 25 Chinese words or phrases. The internal consistency for deletion was .96 in English (applying to the American children's scores) and .97 in Chinese.

A second measure of phonological awareness for U.S. children consisted of a task of letter sound knowledge. Children were first asked to name all 26 letters of the alphabet from a sheet on which the capital letters were arranged in a fixed order that did not conform to the actual ordering of the alphabet. This measure of letter name knowledge was computed for comparison purposes across each group of children. After children had labeled each letter, they were asked to state what sound the letter made. Any sound made by the letter was considered acceptable; thus, the total score for this task was 26, and its internal consistency reliability was .90.

Speeded naming. Four measures of RAN (Denckla & Rudel, 1976) were administered: number naming in Chinese and English, letter naming, and picture naming. The stimuli were five single-syllable numbers (5, 4, 3, 1, and 8) for number naming and five single-syllable letters (I, O, M, J, and B) for letter naming. The stimuli for picture naming were five pictures (apple, scissors, lemon, pencil, and rainbow), each of which is a two-syllable word in both English and Cantonese. In all tasks, each stimulus appeared once in each of five columns, for a total of 25 stimuli to be named. Naming of pictures was done in the child's native language.

Children were first asked to identify each of the five stimuli individually. If they failed to identify any item, they were not given the timed test. Children were asked to name the stimuli from top to bottom and left to right as quickly as they could. Hong Kong children completed all four tasks; American children did not name numbers in Chinese but completed the other three tasks. Each task was administered twice and the average of the two times was used as the total score. Test–retest reliabilities were as follows: for naming numbers in Chinese and English, .92 and .97, respectively; for naming letters, .85; and for naming pictures, .87.

Visual–spatial skill. Two subtests from the Test of Visual-Perceptual Skills Revised (Gardner, 1996) were used to assess visual–spatial skill. The visual–spatial relationships subtest contains one practice item and 16 test items, each consisting of black-and-white line drawings. On each item, children are asked to select from a group of five figures the one for which the whole figure, or some parts of it, are in a different direction from the others. For example, in Trial 1, the first item displays four vertical lines and one horizontal line; the horizontal line is the target. This task tests children's spatial orientation skills. The test is terminated if the child fails to choose the correct answer in four out of five consecutive trials.

The visual figure ground subtest contains one practice item and 16 test items. For each item, children are asked to locate a given figure from among five line drawings. Each figure is embedded within a larger, more complicated line drawing. For example, in Trial 1, a crescent moon shape must be identified from within one of four patterned circle shapes. When the child fails three out of four consecutive items, the test is terminated.

Processing speed. Two subtests from the Woodcock-Johnson Tests of Cognitive Ability (Woodcock & Johnson, 1989) were used to assess processing speed. In the visual matching subtest, children first were given a practice exercise in which they were asked to locate and circle two identical numbers in a row of six numbers. Then children were given a 3-minute time limit to complete as many rows as possible. The task advanced in difficulty from single-digit numbers to triple-digit numbers. In the cross-out subtest, children were asked to mark 5 drawings in a row of 20 that were identical to the target drawing for the row. They were given a practice exercise and a 3-min test session in which they were to complete as many rows as possible.

General ability. A Hong Kong adaptation and translation of the Stanford-Binet Intelligence Scale (fourth edition) vocabulary subtest (Thorndike, Hagen, & Sattler, 1986) was administered to assess general ability. In the first part, children were asked to name or explain each of 14 pictures; in the second, children were asked to define each of 26 words presented orally. The task was terminated when children failed five consecutive items. The internal consistency reliability of this measure was .86. The Americans were administered the original Stanford-Binet Intelligence Scale (fourth edition) vocabulary subtest (Thorndike et al., 1986).

Procedure

Children were tested individually by trained undergraduate and graduate students in psychology. For all Hong Kong students, testing took place in a quiet room at school during school hours. The American students were brought to a child development laboratory at the university by their parents and tested in a quiet room in the laboratory. In addition to the vocabulary measure, all students were administered tasks to represent the constructs of phonological awareness, visual–spatial processing, speed of processing, and reading. The Hong Kong students were given tasks of reading and phonological processing in both Chinese and English, whereas the American students were tested in reading and phonological processing of English only. The order of task presentation was counterbalanced. The Hong Kong children participated in four sessions that lasted between 20 and 30 min. After each session, the Chinese children were given stickers as rewards for participation. All four sessions were completed within 6 weeks during June and July 1999. The American children participated in two 30- to 40-min sessions. After each session, American families received U.S. $5.00 for participation.

RESULTS

Descriptive Statistics

Tables 1 and 2 show the means, standard deviations, and *N*s for all tasks completed, separately for each grade in Hong Kong and the United States. Missing data for these groups are attributable to students being unable to complete given tasks. This inability to complete the tasks was particularly evident for speeded naming tasks, for which some children did not know the names of letters or numbers to begin with (especially English names of numbers among the Chinese children). For example, 16 of the Hong Kong K1 children and 19 of the U.S. kindergartners could not complete the letter naming task.

Analyses of variance revealed that within each culture, performance improved with grade. In Hong Kong, the means for the three kindergarten groups differed significantly for 12 of the 13 measures, all Fs > 37.0. In the United States, the means for the kindergarten and first-grade children differed significantly for all 12 measures listed in Table 1, all ts > 2.2, $p < .03$. For naming numbers in English, the means for K2 and K3

Table 1 Means and Standard Deviations for All Measures Included in the Study for Hong Kong (K1–K3)

	K1		K2		K3	
Variable	*M* (*SD*)	*N*	*M* (*SD*)	*N*	*M* (*SD*)	*N*
Chinese word reading	17.22 (10.68)	60	37.29 (37.29)	70	50.32 (9.63)	60
Hong Kong English word reading	1.68 (3.90)	60	6.51 (6.02)	69	11.62 (7.20)	60
Vocabulary	7.42 (2.53)	55	10.16 (3.44)	70	12.30 (3.17)	60
Chinese syllable deletion	5.17 (6.56)	59	16.33 (6.690)	69	21.03 (3.46)	60
English syllable deletion	3.03 (4.50)	60	11.89 (6.63)	70	17.25 (5.48)	60
Visual spatial relationships	2.55 (2.94)	60	9.25 (3.88)	69	11.57 (3.55)	60
Visual figure ground	2.07 (2.17)	60	5.04 (3.34)	69	7.47 (3.96)	60
Visual matching	5.87 (5.05)	60	15.73 (5.38)	70	22.72 (4.64)	60
Cross out	3.03 (2.22)	55	8.22 (2.80)	69	11.25 (2.25)	60
Chinese number naming	40.01 (16.41)	8	21.55 (6.58)	70	17.82 (4.73)	60
English number naming	44.62 (10.90)	43	50.11 (38.85)	43	45.11 (25.64)	52
Letter naming	45.67 (19.49)	57	26.54 (10.90)	69	21.35 (7.89)	60
Picture naming	52.92 (16.64)	58	36.47 (11.62)	69	30.54 (7.84)	60

Note: K1, $N = 60$; K2, $N = 70$; K3, $N = 60$.

Table 2 Means and Standard Deviations for All Measures Included in the Study for American (Kindergarten, First-Grade) Students

	Kindergarten		First Grade	
Variables	*M* (*SD*)	*N*	*M* (*SD*)	*N*
Hong Kong English word reading	7.68 (10.22)	63	18.06 (10.69)	65
Woodcock word identification	10.87 (19.04)	63	25.20 (22.74)	65
Letter sound knowledge	13.84 (9.85)	63	23.74 (3.04)	65
Vocabulary	18.24 (3.41)	63	19.60 (3.43)	65
English syllable deletion	14.95 (7.56)	63	19.09 (5.04)	65
Visual spatial relationships	9.70 (4.68)	63	11.74 (4.18)	65
Visual figure ground	9.05 (3.84)	63	11.00 (3.24)	65
Visual matching	17.57 (5.93)	63	22.35 (5.93)	65
Cross out	8.43 (3.15)	63	11.20 (3.65)	65
English number naming	25.30 (9.11)	61	19.80 (7.24)	65
Letter naming	24.58 (10.87)	44	19.37 (7.95)	65
Picture naming	34.07 (8.88)	63	30.21 (10.17)	65

Note: Kindergarten, $N = 63$; first grade, $N = 65$.

differed significantly, but they were not compared with the mean for K1 because only 8 of 60 grade-K1 children completed this task.

Table 3 shows correlations among all variables separately for children in Hong Kong and in the United States. Several features of these correlations are noteworthy. First, correlations between measures thought to reflect the same construct (e.g., speeded naming) tended to be greater than correlations between measures tapping different constructs. Second, in both Hong Kong and the United States, the correlations with reading were greatest for phonological tasks (syllable deletion, naming, and letter sound knowledge) and smallest for the visual–spatial tasks. Third, for Hong Kong children, the pattern of correlates of reading skill was similar for reading in English and Chinese (an outcome that is not surprising considering that reading of Chinese and English was highly correlated).

Model Testing

Only those participants who had complete data ($N = 164$ for Chinese; $N = 109$ for Americans) were included in the subsequent model testing to examine predictors of character/word recognition across orthographies. The data were analyzed using structural equation modeling, the general aim of which is to determine if the observed pattern of correlations is consistent with a specified set of structural relations among a set of variables. Least squares and maximum likelihood techniques are used to find path coefficients that minimize the difference between the predicted pattern of correlations and those that are actually observed. Of course, consistency between model and data do not prove the model (other untested models might also be consistent), but inconsistency can be used to reject a model.

All structural modeling was performed with the EzPATH module (Steiger, 1989) in which least-squares estimates of path coefficients were produced and used as starting values in maximum likelihood estimation. Several measures were used to evaluate the fit of the models. χ^2 can determine if differences between the data and the model are significant statistically and can evaluate the relative fit of models of differing complexity. However, χ^2 is limited as an overall measure of the fit of the data to the model because when samples are large, conceptually minor deviations from the model can cause the model to be rejected (Loehlin, 1992). Consequently, several other measures were also calculated. The Adjusted Population Gamma Index (APGI) and the Comparative Fit Index (CFI) both range from 0 to 1, with the latter indicating perfect correspondence between model and data; values greater than .90 indicate a good fit (Jaccard & Wan, 1996; Steiger, 1989). The Root Mean Square Error of Approximation (RMSEA) is a measure of the size of the residuals, adjusted for the complexity of the model; values less than .08 indicate a good fit of the data to the model (Browne & Cudeck, 1993).

The findings for the U.S. children are reported first. The initial, "full" model was a more elaborate version of the model shown in Figure 1. Specifically, in addition to the paths shown in Figure 1, paths to reading from processing speed and age were included. As noted previously, based on the results of Kail et al. (1999), processing speed was expected to influence reading indirectly and the path from processing speed to reading was not expected to be significant. The path from age to reading was included as a measure of the adequacy of the entire model. If the four theoretical constructs of interest provide a sufficient account of age-related change in early reading, the path from age to reading skill should not be significant.

The theoretical constructs were measured in the following manner: processing speed was estimated from performance on the cross-out and visual matching subtests; visual–spatial skill was estimated from performance on the visual figure ground and visual–spatial relationships subtests; phonological skill was estimated from performance on syllable deletion and letter sound knowledge; naming was estimated from naming numbers, letters, and pictures; and reading skill was estimated from performance on the Woodcock-Johnson Word Identification task and the Hong Kong English reading test.

Table 3 Correlations among All Variables

	Maximum Score	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Woodcock word identification	106		.88**	n.a.	.35**	.40**	.50**	n.a.	.35**	.35**	.57**	.45**	−.49**	n.a.	−.45**	−.35**
2. English word reading	30	n.a.		n.a.	.52**	.45**	.57**	n.a.	.41**	.41**	.58**	.47**	−.59**	n.a.	−.58**	−.45**
3. Chinese word reading	61	n.a.	.59**		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
4. Letter sound knowledge	26	n.a.	n.a.	n.a.		.32**	.42**	n.a.	.21*	.47**	.35**	.31**	−.36**	n.a.	−.53**	−.28**
5. Vocabulary	40	n.a.	.17*	.25**	n.a.		.41**	n.a.	.31**	.21*	.29**	.22*	−.26**	n.a.	−.29**	−.27**
6. English syllable deletion	25	n.a.	.41**	.49**	n.a.	.34**		n.a.	.36**	.36**	.37**	.32**	−.44**	n.a.	−.48**	−.30**
7. Chinese syllable deletion	25	n.a.	.42**	.63**	n.a.	.25**	.67**		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
8. Visual spatial relationships	17	n.a.	.23**	.32**	n.a.	.20*	.24**	.38**		.46**	.49**	.53**	−.32**	n.a.	−.34**	−.29**
9. Visual figure ground	17	n.a.	.28**	.25**	n.a.	.18*	.22**	.23**	.34**		.47**	.49**	−.37**	n.a.	−.35**	−.36**
10. Visual matching	60	n.a.	.34**	.43**	n.a.	.31**	.40**	.39**	.37**	.18*		.62**	−.62**	n.a.	−.56**	−.57**
11. Cross out	30	n.a.	.24**	.37**	n.a.	.29**	.29**	.45**	.44**	.19*	.45**		−.44**	n.a.	−.44**	−.51**
12. English number naming		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.		n.a.	.85**	.78**
13. Chinese number naming		n.a.	−.31**	−.46**	n.a.	−.16*	−.33**	−.42**	−.34**	−.18*	−.43**	−.31**	n.a.		n.a.	n.a.
14. Letter naming		n.a.	−.36**	−.46**	n.a.	−.22**	−.40**	−.47**	−.21**	−.15	−.39**	−.28**	n.a.	.78**		.70**
15. Picture naming		n.a.	−.26**	−.35**	n.a.	−.21**	−.26**	−.36**	−.30**	−.13	−.35**	−.35**	n.a.	.73**	.62**	

Note: Values above the diagonal are for American students ($N = 109$); values below the diagonal are for Hong Kong students ($N = 165$). n.a. = tasks that were not administered (e.g., Chinese word reading and phonological processing for American students; letter sound knowledge and Woodcock word identification for Hong Kong students) or could not be completed by a large number of students (e.g., English number naming for the Hong Kong students).
$^{*}p < .05$; $^{**}p < .01$.

All analyses were performed on the matrix of measured variables from which intelligence, as estimated by performance on the Stanford-Binet Vocabulary (Thorndike et al., 1986), was partialed from the correlation matrix. This was done so that the influence of IQ would be removed from relations between the constructs of interest. Modeling partial correlations is uncommon, but, in fact, is simply modeling the simple correlations between the residuals that result from partialing IQ (in this case, estimated by vocabulary scores). An alternative would be to include vocabulary as a latent variable estimated by all observed variables, but the present two-step approach produces simpler models. In any case, the models were also computed based on the simple correlations and the results were virtually unchanged. In particular, the paths from age to speed to phonological awareness to reading emerged in every analysis.

Table 4 shows the results of the test of the full model, denoted Model 1. Although the data were inconsistent with the model, the remaining descriptive indices indicated an adequate fit of the data to the model—that is, APGI was nearly .9, CFI was greater than .9, and the RMSEA index was nearly .08. However, paths to reading from processing speed and visual–spatial skill were not significant; consequently they were eliminated from the model to produce a simpler version, Model 2. Table 4 shows that despite having two fewer paths, Model 2 fit the data almost as well as did Model 1, $\chi^2(2, N = 109) < 1, p > .10$, which indicates that eliminating the two paths did not reduce the fit of Model 2 to the data. Efforts to simplify Model 2 by reducing additional paths were not successful (i.e., they resulted in a significantly poorer fit to the data). For example, a model that did not include the path from naming to reading fit the data marginally more poorly than did Model 2, $\chi^2(1, N = 109) = 2.72, p < .1$.

Table 4 Measures of the Fit of the Theoretical Models to the Data

Measure	Model 1	Model 2	Model 3
U.S. children			
$\chi^2(df)$	97.30**(46)	97.85**(48)	
APGI	.89	.90	
CFI	.94	.94	
RMSEA	.09	.09	
Hong Kong children reading Chinese			
$\chi^2(df)$	57.27*(37)	58.81*(39)	
APGI	.96	.96	
CFI	.98	.98	
RMSEA	.06	.05	
Hong Kong children reading English			
$\chi^2(df)$	59.79*(37)		64.07*(41)
APGI	.95		.96
CFI	.98		.98
RMSEA	.06		.06

Note: APGI = Adjusted Population Gamma Index; CFI = Comparative Fit Index; RMSEA = Root Mean Square Error of Approximation.
$^* p < .05$, $^{**} p < .01$.

Model 2 is shown in Figure 2A, along with the coefficient for each path. According to this model, many of the age-related changes in reading skill were mediated by processing speed and phonological skill. With increasing age, children processed information more rapidly, and more rapid processing was, in turn, associated with greater phonological skill, more rapid naming, and more accurate word decoding. The direct link from age to reading indicates that some age-related change in reading skills was not explained by the mediating influences of processing speed and phonological skill. Finally, in this model, visual–spatial skill did not contribute to reading skill when processing speed, phonological awareness, and naming speed were accounted for.

Next, similar analyses were conducted on the data for Hong Kong children. In the first step, the fit of the full model to the data was evaluated. Conceptually the full model was identical to the Model 1 that was used with the data from U.S. children. That is, in both models the primary constructs were age, processing speed, visual–spatial skill, phonological skill, naming, and reading. However, the models used with the data from Hong Kong children differed in two ways in terms of the measures used to estimate constructs of interest: First, phonological skill was estimated from syllable deletion in English and syllable deletion in Chinese. Second, reading in Chinese and English were examined separately, and reading skill in each language was estimated from performance on a single task.

With regard to the results for Hong Kong children who were learning to read Chinese, Table 4 shows that as was the case for U.S. children, the full model was inconsistent with the data but provided a reasonable characterization of the data according to the descriptive indices: Values for APGI and CFI were greater than .9 and values for the RMSEA index were less than .08. As was the case with the data for U.S. children, paths to reading from processing speed and from visual–spatial skills were not significant; Model 2 fit the data reasonably well based on the descriptive indices and did not differ significantly from Model 1 in its fit, $\chi^2(2, N = 169) = 1.54, p > .10$. Efforts to further simplify Model 2 (e.g., by

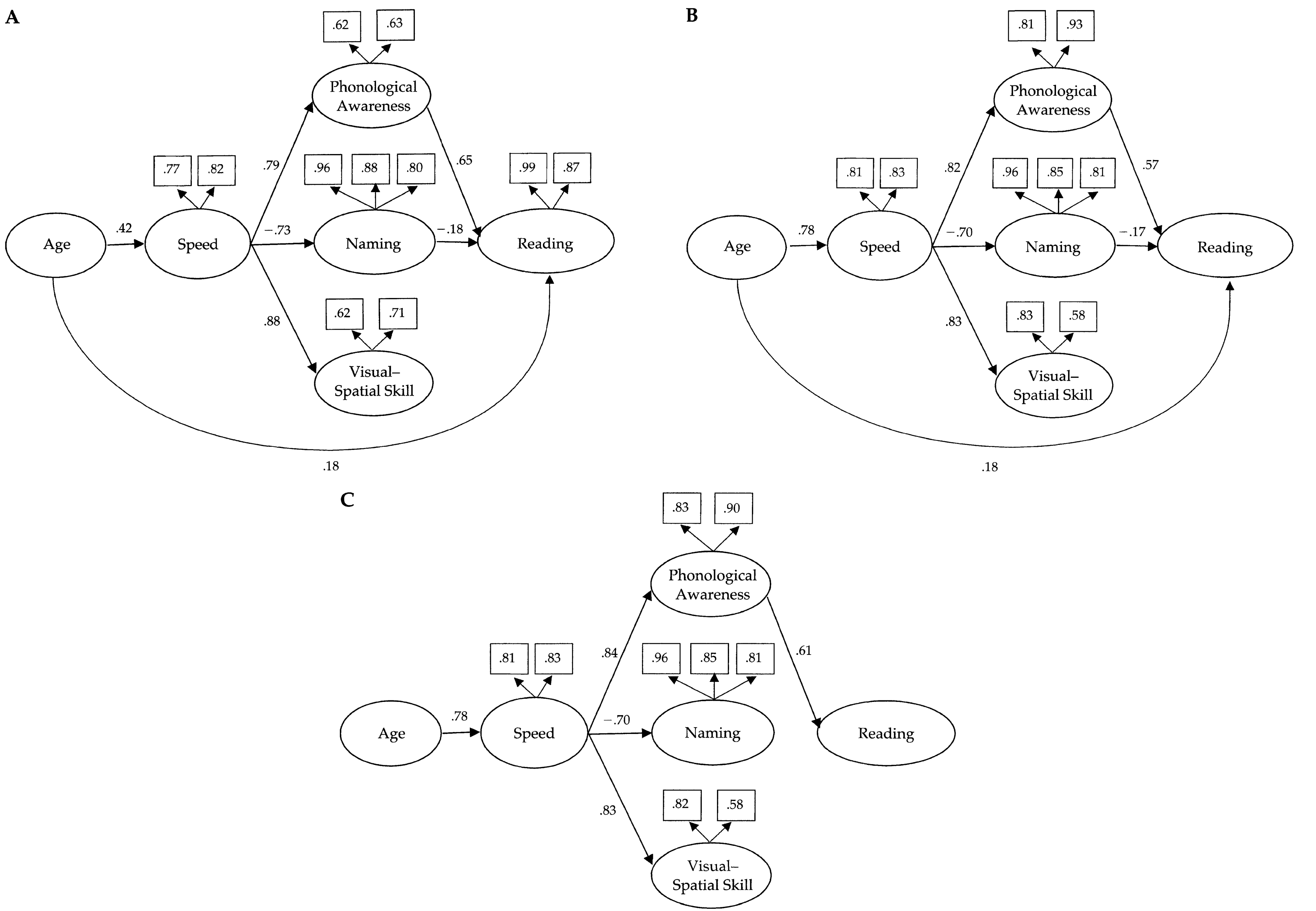

Figure 2 Path diagrams that depict the best-fitting models for (A) U.S. children, (B) Hong Kong children reading Chinese, and (C) Hong Kong children reading English. The path coefficients are standardized regression weights. Values in boxes are squared multiple correlations between a measured variable used to estimate a theoretical construct and all other measured variables.

deleting paths from age or naming to reading) produced models that fit the data significantly more poorly than did Model 2.

Figure 2B shows the fit of Model 2 to the data for Hong Kong children. Coefficients for paths in Model 2 were remarkably like those in Model 2 for the U.S. children. That is, in both cases most of the age-related change in reading skill was mediated by processing speed and phonological skill. In contrast, the path from naming to reading accounted for little change in reading skill relative to the processing speed–phonological paths.

The final set of analyses concerned Hong Kong children who were learning to read English. Table 4 shows that Model 1 provided a reasonably good fit to the data in terms of the descriptive indices. However, eliminating four nonsignificant paths (all paths to reading except the one from phonological skill) produced a simpler model, Model 3. This model fit the data as well as did Model 1, $\chi^2(4, N = 169) = 4.29, p > .10$, despite having four fewer paths. Efforts to simplify Model 3 by eliminating other paths resulted in models that fit the data significantly more poorly than did Model 3.

Model 3, shown in Figure 2C, is a simplified version of Model 2. That is, like Model 2, Model 3 assumed that processing speed and phonological skill accounted for much of the age-related change in Hong Kong children's ability to read English. However, unlike the case for learning to read Chinese, age and naming were not linked directly to learning to read English.

Comparisons across Cultures

As discussed in the introduction, reading instruction begins at a much earlier age in Hong Kong than in the United States (age 3 versus ages 5 or 6). This provided an opportunity, in the present study, to examine the impact of schooling on cognitive processes. That is, children in the oldest group in the Hong Kong sample were nearly 6 years old and were in their third year of formal schooling, whereas children in the youngest group in the U.S. sample were slightly more than 6 years old. Of course, these two groups of 6-year-olds differed not only in amount of schooling, but also in a number of other ways that might influence cognitive development (e.g., being monolingual versus bilingual). Nevertheless, comparisons across groups in levels of performance are informative to assess the extent to which these cultural differences, collectively, influence cognitive processes.

Children's performance was compared on eight tasks: two measures of processing speed (visual matching, cross out), two measures of visual–spatial skill (visual–spatial relationships, visual figure ground), three naming tasks (naming letters, naming numbers in English, naming pictures) and English syllable deletion. Although the Hong Kong K3 students ($M = 5.91$, $SD = .35$) were nearly 2 months younger than the American kindergartners ($M = 6.10$, $SD = .43$), $t(1, 121) = 2.66, p < .01$, the Hong Kong K3 children had higher scores than did American kindergartners on six of the eight tasks: visual matching, cross out, visual–spatial relationships, naming letters, naming pictures, and English syllable deletion, $Fs(1, 101) \geq 4.52, p < .05$. The American kindergartners were faster on the English number-naming task, $F(1, 110) = 23.84, p < .001$. The groups did not differ in the visual figure ground test, $F(1, 120) = 1.95, p > .05$.

DISCUSSION

The present study has revealed remarkable similarities in the early phases of reading Chinese and English. The two models that predicted reading in a child's native language revealed identical results. Phonological awareness was strongly associated with character/word recognition, speeded naming was weakly associated with reading, and visual processing was unrelated to reading ability. Age-related change in processing speed was strongly related to speeded naming, phonological awareness, and visual processing abilities. Finally, age accounted for a small amount of variance in reading acquisition, suggesting that some of children's early reading skill is linked to age-related constructs that were not assessed in the present study. The model that predicted English word recognition for Chinese children was similar to the ones that predicted native reading acquisition, except that word recognition was not linked directly to either age or processing speed.

Predicting Reading Skill

Phonological awareness was strongly related to reading acquisition across English and Chinese. Similar results have been obtained in previous studies of Chinese (Ho & Bryant, 1997; Hu & Catts, 1998; McBride-Chang & Ho, 2000) as well as English (e.g., Adams, 1990). Such results have been linked to learning to read English as a second language as well (Durgunoglu et al., 1993). Despite the fact that phonological awareness was measured using syllable deletion tasks in both Chinese and English for the Hong Kong students and English letter sound (phonemic) and syllable deletion tasks for the American students, results of all models that predicted reading were remarkably similar, both qualitatively and in the size of the path coefficients. The importance of phonological awareness for reading acquisition across orthographies is that it involves mapping an oral referent to a written symbol, whether the symbol represents a morpheme/syllable, as in Chinese, or a phoneme, as in English (Hu & Catts, 1998). Thus, at least in the very earliest stages of reading acquisition, some level of phonological awareness, depending on orthography/language (Goswami, 1999), is probably a universal aspect of learning to read.

Visual processing was not directly associated with learning to read in either orthography. Individual correlations between the visual tasks and character/word recognition were generally moderate, however. Thus, it appears that in the present study, performances on visual tasks were correlated with scores on other measures, but that there was not a unique association of visual processing with reading. Recall also that in some previous studies a variety of visual skills have been shown to correlate with reading among Chinese children (Ho & Bryant, 1999; Huang & Hanley, 1995), but others have failed to find associations between visual skills and Chinese character recognition (Ho, 1997; Hu & Catts, 1998).

One tenable interpretation of the association between Chinese character recognition and visual skills may be that learning to read Chinese facilitates subsequent visual processing (Hoosain, 1986). Alternatively, visual skills and reading may be bidirectionally associated. For example, bilingual Singaporean children tend to use different visual search strategies when reading English and Chinese (Liow, 1999), perhaps indicating that visual skills develop with reading experience. Thus, learning to identify character strokes efficiently over time may facilitate subsequent performance on abstract visual tasks. Despite the initial enthusiasm (Tzeng & Wang, 1983) over the importance of visual skills for learning to read Chinese, there have been few studies that have demonstrated this connection so far. The causal link between visual skills and Chinese character acquisition remains unclear. Furthermore, there have been few attempts to analyze precisely which types of visual tasks should be expected to relate most strongly to reading acquisition. Future studies might test the associations of a larger, more comprehensive battery of visual tasks than was used in the present study on reading across orthographies.

The least clear result of the present study was the effect of naming speed on reading. For children who were learning to read in their native language, speeded naming had a significant but weak association with character/word recognition. In contrast, for Hong Kong children who were learning to read English, speed of naming had no effect on English word recognition. These results are similar to those of other studies in which links between speeded naming and word recognition are inconsistent, depending on children's developmental level (Wagner et al., 1997) and how speeded naming is measured (McBride-Chang & Ho, 2000) in a larger battery of phonological processing skills.

Finally, each of three primary constructs—phonological awareness, visual processing, and naming speed—was linked to processing speed, but reading was not. Thus, as Kail et al. (1999) reported for older readers, age-related increases in processing speed affect reading indirectly, by improving other processes that impact reading directly. Notably, the coefficients from processing speed to phonological awareness were significant and substantial for both U.S. and Hong Kong children.

Differences across Cultures

Although advanced kindergartners in Hong Kong were about the same age as beginning kindergartners in the United States, the former had higher scores on most of the cognitive tasks. As noted previously, these differences might reflect the early training of Hong Kong children or may reflect other cultural differences between Hong Kong and the United States.

One unanticipated, provocative outcome was that Chinese children were more accurate than were American children on the English syllable deletion task. We had assumed that a native language advantage would make this task naturally easier for Americans as compared with the Chinese. Nevertheless, these results fit with some previous research in which kindergarten and first-grade bilingual children, relative to their monolingual peers, were superior in early phonological awareness (Bruck & Genesee, 1995; Campbell & Sais, 1995; Rubin & Turner, 1989; Yelland, Pollard, & Mercuri, 1993). Bilingualism had apparently facilitated children's early metalinguistic ability to manipulate speech sounds, independent from their meanings, across languages.

The results of the present study are unique because they focus on phonological awareness at the syllable level among Chinese and English speakers. Past studies of bilingualism and phonological awareness all involved knowledge of two alphabetic orthographies (either English–Italian or English–French). Monolingual Chinese children and adults tend to be relatively poor in phonological awareness compared with English speakers, when this awareness is measured at the phonemic level (Holm & Dodd, 1996; Huang & Hanley, 1995). Because the linguistic structure of Chinese language is syllabic, syllable-level phonological awareness should be well developed in Chinese children. The demonstrated superiority on the English syllable deletion task of the bilingual Hong Kong children over the monolingual American children may indicate that bilingualism provides a metalinguistic advantage to children that extends to syllable-level phonological awareness in native Chinese speakers. Perhaps bilingualism enables children to understand the flexible relation between language form and function, facilitating easy manipulation of speech sounds in a second language. Future studies should test this hypothesis with well-controlled experiments on children with various language backgrounds.

Limiting Conditions

There were some limitations of the present study. One limitation centers on the analyses of the directionality of constructs measured. The models presented assumed a unidirectionality among measures that is undoubtedly overly simplistic. For example, several studies have demonstrated that the association of phonological awareness and reading is bidirectional, both in English (e.g., Perfetti, Beck, Bell, & Hughes, 1987; Wagner et al., 1994) and Chinese (Huang & Hanley, 1997; Read, Zhang, Nie, & Ding, 1986). It is likely that there is a reciprocal association among other variables, such as phonological awareness and speeded naming or visual skills and reading, as well. In fact, one interpretation of the present study results for the Hong Kong sample is that knowledge of English mediated the association of phonological awareness to Chinese character recognition. Although this relation is doubtful given the strong association between phonological awareness and Chinese character recognition in previous studies of Chinese monolinguals who were learning to read (Ho & Bryant, 1997), this possibility cannot be ruled out given the present data. Future studies should examine associations among the specified constructs using longitudinal data, which will facilitate specifications of directionality among them.

A second limitation of this study centers on the measures of phonological awareness that were used. For example, the syllable deletion tasks that were administered required deletion of units that were not only phonological, but, in many (although not all) cases, morphemes. Therefore, critics could argue that this task might have tapped children's lexical–semantic, rather than phonological, skills. The issue of strategy use in performing phonological awareness tasks is, of course, not a new one (Stuart, 1990).

Despite the importance of this critique, we argue that, given the many constraints related to measurement of phonological awareness in preschool Chinese children, the syllable deletion task used in the present study was the best possible available for four reasons. First, deletion at the syllable, rather than the phonemic, level was essential to be faithful to the structure of the Chinese language. Second, the task avoided effects of guessing that were impossible to circumvent in previous studies of very young Chinese children (Ho & Bryant, 1997). Third, a lexical–semantic approach to the items administered would not have been successful in many cases in which the meaning was radically changed by a syllable deletion (e.g., from *hot dog* to *dog*, *small cupcake* to *small cup*, *blackboard* to *black*). This is particularly clear in Chinese (e.g., *child* [three syllables] *to friend* [two syllables], *cute* [two syllables] to *love* [one syllable]). Fourth, previous researchers who have compared English-speaking preschool children's performances on deletion of syllables in real words, in which a lexical–semantic strategy might sometimes be possible, and nonwords, in which a lexical–semantic strategy is impossible, have found a relatively strong association, $r = .55$, between them (Wagner et al., 1987), suggesting that they tap the same underlying phonological construct. This correlation is similar to the one obtained in the present study, $r = .67$, for Hong Kong kindergartners, for whom it is likely that some of the English phrases administered were unfamiliar.

A related question in the measurement of the phonological awareness construct might be the extent to which letter sound knowledge was a fair representation of phonemic awareness in English. Given the history of phonological awareness measurement and its relation to the alphabetic principle (Adams, 1990), letter sound knowledge is, in some ways, an optimal measure of phoneme knowledge. Mann and colleagues (Mann, Tobin, & Wilson, 1987), for example, have characterized invented spelling tasks as one way to measure phonological awareness. The factor loadings of letter sound and syllable deletion knowledge on the phonological awareness construct for the American children were also fairly high, demonstrating consistency across tasks. Because this was a cross-cultural study of early reading, we were particularly interested in capturing the alphabetic principle, which is key to English reading, in a way that would have some parallel to the Chinese unit of reading, the syllable. The letter sound knowledge task made it possible to accomplish this. Admittedly, however, in future studies that examine reading development across time, care should be taken to distinguish general phonological sensitivity, which seems to be clearly associated with reading development across orthographies, from phonemic awareness, which may be specifically important for English, but not Chinese.

In this spirit, a third limitation of these data is that some aspects of reading development, which potentially may be of importance, were excluded from the model. The present study focused on constructs that were hypothesized to be cross-culturally relevant for learning to read. However, there are clearly other abilities that predict early reading development, such as general linguistic ability, that, for practical reasons, were omitted. In addition, certain orthography-specific skills, such as letter name knowledge in English or phonetic and semantic radical awareness in Chinese, were also, of necessity, left out of the models. Thus, the scope of these models of reading is modest in what they can explain about the reading process for Chinese or English.

The models are also clearly time limited. For example, in older students, character/word recognition might depend more on other abilities, such as orthographic processing. Furthermore, although phonological awareness is important for reading development in primary school children who are learning to read English, it is not clear that phonological awareness would be strongly associated with learning to read Chinese much past early elementary school. Phonemic awareness is unnecessary for learning to recognize Chinese characters, and children's proficiency in syllable awareness may reach ceiling early in development. A time-limited early emphasis on phonological awareness for reading has been found in other alphabetic orthographies, such as Turkish (Oney & Durgunoglu, 1997) and German (Wimmer, 1993), as well.

A final caution about the present data is that the constructs only explain character/word recognition. Clearly, the ultimate goal of learning to read is knowledge acquisition through reading. The model presented in this study offers no cross-language explanation of how reading comprehension itself takes place.

Conclusions

Despite these limitations, the present study reveals some extraordinary similarities in the very early phases of reading acquisition across cultures that vary tremendously in cultural expectations, language backgrounds, and orthographies to be learned. The importance of processing speed for basic cognitive development and of phonological awareness for character/word recognition emerge as universals in the models. Furthermore, phonological awareness is important for reading development in both a first and a second language.

However, the complexity of reading acquisition with development also demands that future work establish the extent to which certain cognitive processes may be more strongly linked to reading in one orthography as compared with another. For example, phonemic awareness in English, morphological awareness in Chinese (Shu & Andersen, 1997), and speeded naming in German (Wimmer, 1995) all may be especially critical for reading development in these specific orthographies, respectively, particularly in the intermediate and later stages of learning to read. Thus, both universal and specific characteristics of learning to read any given orthography should be considered in a comprehensive model of reading development.

The importance of the present findings lies primarily in the framing of the process of learning to read in a cross-cultural developmental context. The demonstration of a consistent model of reading acquisition across Hong Kong Chinese students and American native English-speaking students in this study underscores the applicability of specific cognitive skills to reading development in diverse cultures and orthographies. Despite enormous differences in educational practices across groups, patterns of reading development were virtually identical. Future research should test these findings in young readers of other orthographies.

ACKNOWLEDGMENTS

The authors wish to thank Sarah Wong and Laura Curry for their assistance in collecting data and Christopher Agnew, Michael Browne, John Horn, and James Steiger for their advice concerning data analyses. This research was partially supported by both Mainline research grant #44M2004 (from Chinese University of Hong Kong) and by a grant from the Research Grants Council of the Hong Kong Special Administrative Region (project #4207/98H).

ADDRESSES AND AFFILIATIONS

Corresponding author: Catherine McBride-Chang, Department of Psychology, Chinese University of Hong Kong, Shatin, N. T., Hong Kong; e-mail: cmcbride@psy.cuhk.edu.hk. Robert V. Kail is at Purdue University, West Lafayette, IN.

APPENDIX

Words used in the Hong Kong English word-reading task:

1. Go	11. Cat	21. Apple
2. Boy	12. Fish	22. King
3. Eye	13. Zoo	23. Orange
4. Nose	14. Pig	24. Van
5. Yes	15. Bus	25. Ink
6. Sun	16. Nine	26. Monkey
7. Egg	17. Yellow	27. Kite
8. School	18. Doctor	28. Quilt
9. Pencil	19. Up	29. Tree
10. Ball	20. Boat	30. Mouse

REFERENCES

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

Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K. A. Bollen & J. S. Long (Eds.), *Testing structural equation models* (pp. 136–162). Newbury Park, CA: Sage.

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

Campbell, R., & Sais, E. (1995). Accelerated metalinguistic (phonological) awareness in bilingual children. *British Journal of Developmental Psychology, 13*, 61–68.

Caravolas, M., & Bruck, M. (1993). The effect of oral and written language input on children's phonological awareness: A cross-linguistic study. *Journal of Experimental Child Psychology, 55*, 1–30.

Chen, H.-C. (1996). Chinese reading and comprehension: A cognitive psychology perspective. In M. H. Bond (Ed.), *The handbook of Chinese psychology* (pp. 43–62). Oxford, U.K.: Oxford University Press.

Chen, X., Rubin, K. H., & Li, D. (1997). Relation between academic achievement and social adjustment: Evidence from Chinese children. *Developmental Psychology, 33*, 518–525.

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

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 awareness. *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.

Cossu, G., Shankweiler, D., Liberman, I. Y., Katz, L., & Tola, G. (1988). Awareness of phonological segments and reading ability of Italian children. *Applied Psycholinguistics, 9*, 1–16.

Denckla, M. B., & Cutting, L. E. (1999). History and significance of rapid automatized naming. *Annals of Dyslexia, 49*, 29–42.

Denckla, M. B., & 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 phonemic awareness. *Journal of Educational Psychology, 85*, 453–465.

Gardner, M. F. (1996). *Test of Visual–Perceptual Skills (n–m) revised manual*. New York: Psychological and Educational Publications.

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

Goswami, U. (1999). The relationship between phonological awareness and orthographic representation in different orthographies. In M. Harris & G. Hatano (Eds.), *Learning to read and write: A cross-linguistic perspective* (pp. 134–156). New York: Cambridge University Press.

Goswami, U., & Bryant, P. (1990). *Phonological skills and learning to read*. Hove, U.K.: Erlbaum.

Hanley, J. R., Tzeng, O., & Huang, H.-S. (1999). Learning to read Chinese. In M. Harris & G. Hatano (Eds.), *Learning to read and write: A cross-linguistic perspective* (pp. 173–195). Cambridge, U.K.: Cambridge University Press.

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

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

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

Ho, C. S.-H., & Lai, D. N.-C. (1999). Naming speed deficits and phonological memory deficits in Chinese developmental dyslexia. *Learning and Individual Differences, 11*, 173–186.

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

Hoosain, R. (1986). Language, orthography, and cognitive processes: Chinese perspectives for the Sapir-Whorf hypothesis. *International Journal of Behavioral Development, 9*, 507–525.

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

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

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

Jaccard, J., & Wan, C. K. (1996). *LISREL approaches to interaction effects in multiple regression*. Thousand Oaks, CA: Sage.

Jorm, A. F., & Share, D. L. (1983). Phonological recoding and reading acquisition. *Applied Psycholinguistics, 4*, 103–147.

Kail, R. (1995). Processing speed, memory, and cognition. In F. E. Weinert & W. Schneider (Eds.), *Memory performance and competencies: Issues in growth and development* (pp. 71–88). Hillsdale, NJ: Erlbaum.

Kail, R., Hall, L. K., & Caskey, B. J. (1999). Processing speed, exposure to print, and naming speed. *Applied Psycholinguistics, 20*, 303–314.

Kail, R., & Park, Y. (1992). Global developmental change in processing time. *Merrill-Palmer Quarterly, 38*, 525–541.

Liow, S. R. (1999). Reading skill development in bilingual Singaporean children. In M. Harris & G. Hatano (Eds.), *Learning to read and write: A cross linguistic perspective* (pp. 196–213). New York: Cambridge University Press.

Loehlin, J. C. (1992). *Latent variable models* (2nd ed.) Hillsdale, NJ: Erlbaum.

Manis, F. R., Seidenberg, M. S., Doi, L. M., McBride-Chang, C., & Petersen, A. (1996). On the bases of two subtypes of developmental dyslexia. *Cognition, 58*, 157–195.

Mann, V. A., Tobin, P., & Wilson, R. (1987). Measuring phonological awareness through the invented spellings of kindergarten children. *Merrill-Palmer Quarterly, 3*, 365–391.

McBride-Chang, C. (1996). Models of speech perception and phonological processing in reading. *Child Development, 67*, 1836–1856.

McBride-Chang, C. (1999). The ABCs of the ABCs: The development of letter-name and letter-sound knowledge. *Merrill-Palmer Quarterly, 45*, 285–308.

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

Morais, J. (1991). Constraints on the development of phonemic awareness. In S. A. Brady & D. P. Shankweiler (Eds.), *Phonological processes in literacy* (pp. 5–27). Hillsdale, NJ: Erlbaum.

Oney, B., & Durgunoglu, A. Y. (1997). Beginning to read in Turkish: A phonologically transparent orthography. *Applied Psycholinguistics, 18*, 1–15.

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 writing. *Cognition, 24*, 31–44.

Rubin, H., & Turner, A. (1989). Linguistic awareness skills in grade one children in a French immersion setting. *Reading and Writing: An Interdisciplinary Journal, 1*, 73–86.

Shu, H., & Anderson, R. C. (1997). Role of radical awareness in the character and word acquisition of Chinese children. *Reading Research Quarterly, 32*, 78–89.

Stanovich, K. E. (1991). Changing models of reading and reading acquisition. In L. Rieben & C. A. Perfetti (Eds.), *Learning to read: Basic research and its implications* (pp. 19–32). Hillsdale, NJ: Erlbaum.

Steiger, J. H. (1989). *EZPath: Causal modeling*. Evanston, IL: Systat.

Stevenson, H. W., Chen, C., & Lee, S. (1992). Chinese families. In J. L. Roopnarine & D. B. Carter (Eds.), *Parent–child socialization in diverse cultures* (pp. 17–33). Norwood, NJ: Ablex.

Stevenson, H. W., Lee, S., Chen, C., Stigler, J. W., Hsu, C., & Kitamura, S. (1990). Contexts of achievement: A study of American, Chinese, and Japanese children. *Monographs of the Society for Research in Child Development, 55*(1–2, Serial No. 221).

Stringer, R., & Stanovich, K. E. (2000). The connection between reaction time and variation in reading ability: Unravelling covariance relationships with cognitive ability and phonological sensitivity. *Scientific Studies of Reading, 4*, 41–53.

Stuart, M. (1990). Processing strategies in a phoneme deletion task. *The Quarterly Journal of Experimental Psychology, 42A*, 305–327.

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

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

Wagner, R. K., Balzhazor, M., Hurley, S., Morgan, S., Rashotte, C., Shaner, R., Simmons, K., & Stage, S. (1987). The nature of prereaders' phonological processing abilities. *Cognitive Development, 2*, 355–373.

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

Wagner, R. K., Torgesen, J. K., & Rashotte, C. A. (1994). Development of reading-related phonological processing abilities: New evidence of bidirectional causality from a latent variable longitudinal study. *Developmental Psychology, 30*, 73–87.

Wagner, R. K., Torgesen, J. K., Rashotte, C. A., Hecht, S. A., Barker, T. A., Burgess, S. R., Donahue, J., & Garon, T. (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.

Wimmer, H. (1993). Characteristics of developmental dyslexia in a regular writing system. *Applied Psycholinguistics, 14*, 1–33.

Wimmer, H. (1995). From the perspective of a more regular orthography. *Issues in Education, 1*, 101–104.

Woodcock, R. W. (1987). *Woodcock Reading Mastery Tests.* Circle Pines, MN: American Guidance Service.

Woodcock, R. W., & Johnson, M. B. (1989). *Woodcock-Johnson Tests of Cognitive Ability.* Allen, TX: DLM Teaching Resources.

Yelland, G. W., Pollard, J., & Mercuri, A. (1993). The metalinguistic benefits of limited contact with a second language. *Applied Psycholinguistics, 14*, 423–444.