First-Language Longitudinal Predictors of Second-Language Literacy in Young L2 Learners

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Abstract

Can children's early reading abilities in their first language (L1) predict later literacy development in a second language (L2)? The cross-language relationships between Chinese (L1) and English (L2) among 87 Hong Kong children were explored in a longitudinal study. Chinese word reading fluency, Chinese rapid digit naming, and Chinese rhyme awareness at age 7 (Grade 1), with age and IQ taken into account, were significant concurrent and longitudinal predictors of English word reading, and text-level reading and writing skills across ages 7-10. These three Chinese measures together accounted for 16-28% of unique variance in the English literacy tasks across the three-year period. Children who showed word reading difficulties in Chinese in Grade 1 also performed more poorly than average Chinese readers in English reading and related cognitive tasks later on, especially on phonological tasks. The results provided evidence for the cross-language transfer of cognitive-linguistic abilities between two distinctly different orthographies. L1 markers underlying reading difficulties in both L1 and L2 can serve as early indicators of possible reading problems that may arise later in L2. These findings have clinical and educational as well as theoretical implications.

Keywords:

cross-language transfer, reading development, longitudinal predictors, Chinese, English as L2

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Fluency in more than one language is rapidly becoming a sine qua non in the global marketplace. As a result, massive biliteracy education programs have been implemented in many regions worldwide, with children beginning to learn a second language (L2) at school in their early years. Children generally have a considerable head start in their first language (L1), so they often display unbalanced biliteracy skills in primary grades. Educators and practitioners typically find it challenging to determine at an early stage which L2 learners are at risk for reading difficulties, and whether assessments should be conducted in the child's L1 or L2. If early reading abilities in an L1 can be used to predict later literacy development in an L2, then perhaps weaknesses in these L1 abilities may serve as a warning of learning difficulties to come in L2. The present study addressed this issue by investigating the cross-language relationships in reading development between two vastly distinct orthographic systems—Chinese and English—based on a cognitive theoretical perspective.

Cross-Language Prediction of L2 Literacy from L1 Abilities

Cummins' (1979) linguistic interdependence hypothesis of cross-language transfer proposes that L2 development depends in part on L1 proficiency when intensive exposure to L2 begins. Positive transfer of language-related cognitive skills can occur between L1 and L2, provided that certain threshold competence is achieved in both languages. Such transfer, Cummins (1981) postulated, can be explained by a common underlying proficiency (CUP) so that skills and metalinguistic knowledge acquired in learning one language can be drawn upon when learning another language. Moreover, building up the CUP—which covers both language-specific and language-general knowledge and skills—in one language may facilitate learning other language(s). Extending this theory to literacy development, Cummins (1981) proposed the central processing hypothesis (also known as the universalist hypothesis) to posit common underlying cognitive processes contributing to literacy development in different languages irrespective of orthography. Hence, learners with deficits in these common linguistic skills should display difficulties in reading acquisition in any language, be it L1 or L2 (Geva & Ryan, 1993).

By contrast, the script-dependent hypothesis highlights the role of orthographic transparency in the execution of component skills in reading (Frost, Katz, & Bentin, 1987; Katz & Frost, 1992; Seymour, Aro, & Erskine, 2003; Ziegler et al., 2010). Shallow (transparent) orthographies (e.g., Spanish and Finnish) have more predictable grapheme-phoneme correspondences than deep (opaque) orthographies (e.g., English and French). Variations in orthographic regularity may lead to different patterns of reading development and reading problems across languages (Landerl et al., 2013; Ziegler & Goswami, 2006). How well cognitive skills transfer between L1 and L2 is thought to depend on the similarities and differences between the two orthographies (Low & Siegel, 2009).

These two theoretical positions may complement each other; some reading-related cognitive abilities may be common to all languages and scripts, while others may be more language/script-specific. Should this be the case, at issue will be which of those abilities are general and which are language/script-specific. Furthermore, if similarities in script indeed affect cross-language transfer, then to what extent transfer of cognitive skills might occur across distinctly different orthographies, such as between Chinese and English?

Chinese orthography is non-alphabetic and differs from English in terms of orthographic form and layout, phonological mapping, and morphological structure. The basic units in Chinese writing are characters, each representing a morpheme (unit of meaning) and mapping onto a syllable. Unlike the linear layout of letters to form words in alphabetic systems, each Chinese character is composed of one or more stroke-patterns (often called radicals) arranged in a rectangular configuration. Most radicals may either be associated with the meaning of the character (semantic radicals) or provide clues to its pronunciation (phonetic radicals). Phonological information is thus encoded orthographically at the syllable level in Chinese, rather than at the phoneme level as in English. Phonetic radicals occur in about 80% of Chinese characters, allowing the pronunciation to be inferred from the phonetic information about 40% of the time, although with only 23-26% predictive accuracy when lexical tones are also considered (Chung & Leung, 2008; Shu, Chen, Anderson, Wu, & Xuan, 2003). Hence, Chinese is regarded as an opaque orthography in terms of print-to-sound translation.

Phonological structure in Chinese is simpler than in English. Each Chinese syllable can be divided into onset (a consonant) and rime (a vowel or diphthong, and some with a final consonant), with no consonant clusters. For morphology, Chinese characters (each corresponding to a morpheme) are often combined through lexical compounding to form words. Most Chinese words are built from two or more morphemes. Other prevalent morphological structures in English, such as prefixes, suffixes, and grammatical inflections, are virtually non-existent in Chinese. These two vastly different writing systems may pose very different cognitive demands on reading.

To date, much of the theory building concerning common cognitive processes subserving literacy development across different languages has been based on alphabetic languages. Given the fundamental differences between Chinese and English, these two languages together offer an excellent test case for the robustness of various theoretical accounts. Which account(s) will prove useful for understanding common underlying cognitive processes for literacy development across languages as different as English and Chinese? Which cognitive processes that had been considered common across alphabetic languages will prove rather specific to certain language family or cluster for predicting literacy development? The present study will speak to these important theoretical issues.

Phonological Awareness

Phonological awareness, in particular phoneme awareness, predicts reading acquisition robustly across alphabetic languages including English (Goswami & Bryant, 1990; Rack, Snowling, & Olson, 1992; Shankweiler & Fowler, 2004). Melby-Lervåg, Lyster, and Hulme (2012) concluded from a meta-analysis of 235 studies that phonemic awareness is a critical determinant of reading development as it reflects the lexical organization of phonological representations, which underlies the success in learning to read.

Unlike English, for which reading often involves blending letter sounds at the phoneme level, Chinese character recognition requires mapping spoken words at the syllable level to written Chinese characters (McBride-Chang & Ho, 2005). Thus, syllable awareness may suffice for reading Chinese (McBride-Chang, Bialystok, Chong, & Li, 2004; Perfetti, Cao, & Booth, 2013). Indeed, the psycholinguistic grain size theory (Ziegler & Goswami, 2005) postulates that phonemic awareness is fostered when orthographies are coded at the phoneme level, and predicts larger grain sizes for the phonological representations of Chinese as compared to English words. Based on this assumption, would grain-size differences in phonological representations between Chinese and English words weaken the transfer of phonological awareness across these two orthographies?

Phonological skills have been shown to transfer readily across alphabetic languages (Comeau, Cormier, Grandmaison, & Lacroix, 1999; D'Angiulli, Siegel, & Serra, 2001; Durgunoglu, Nagy, & Hancin-Bhatt, 1993). For children learning English as an L2 with Chinese as L1, significant concurrent correlations between Cantonese Chinese (L1) rhyme detection and English (L2) phonological and reading measures have been documented (Gottardo, Yan, Siegel, & Wade-Woolley, 2001). Cross-language transfer from English (L2) to Chinese (L1) has also been demonstrated: L2 instruction focusing on listening, speaking, and reading significantly enhanced children's L1 Mandarin Chinese phonological awareness and Pinyin skills (a Mandarin phonetic system; Chen, Xu, Nguyen, Hong, & Wang, 2010). Indeed, bidirectional transfer of phonological skills between Chinese and English seems quite robust (e.g., Keung & Ho, 2009; Yeong & Rickard Liow, 2012). Although phonological units encoded in orthography are likely more fine-grained in English (phonemes) than in Chinese (syllables), phonological skills nonetheless seem transferable across these languages—hinting at a universal phonological core intrinsic to reading development across orthographies (Perfetti, Zhang, & Berent, 1992).

Morphological Awareness

Morphological awareness in Chinese, especially homophone and compound awareness, has been found to predict Chinese character recognition in young children, even after controlling for phonological awareness, rapid naming, speed of processing, and vocabulary (McBride-Chang, Shu, Zhou, Wat, & Wagner, 2003). Based on strong correlations between morphological skills and vocabulary knowledge, McBride-Chang et al. (2003) proposed that morphological awareness might affect reading by way of enriching vocabulary knowledge, which—including knowledge of the constituent words in compounds—might reciprocally enhance development of morphological skills.

Similarly in English, morphological measures were found to predict vocabulary knowledge in young children above and beyond phonological processing and reading ability (McBride-Chang, Wagner, Muse, Chow, & Shu, 2005). Moreover, both inflectional and derivational morphological awareness contributed significantly to reading comprehension (Deacon & Kirby, 2004; Kieffer & Lesaux, 2008; Nagy, Berninger, & Abbott, 2006). An awareness of the internal constituents of multi-morphemic words may therefore promote the understanding of morphologically complex words in text, thereby facilitating text comprehension (Tong, Deacon, Kirby, Cain, & Parrila, 2011).

Despite morphological differences between Chinese and English words, Chinese character recognition, vocabulary, and reading comprehension of children with Chinese as L1 turned out to correlate with morphological awareness of compound structure in their L2 English (Pasquarella, Chen, Lam, Luo, & Ramirez, 2011; Wang, Cheng, & Chen, 2006). There is also some evidence for transfer in the opposite direction: lexical compounding skills from L1 Chinese seemed to transfer to L2 English word reading (Chung & Ho, 2010). Importantly, most of these studies adopted a cross-sectional design, and very few have investigated the relationships longitudinally.

Rapid Automatized Naming

By contrast, the results are unclear for rapid automatized naming (RAN)—the ability to quickly name a series of highly familiar visual stimuli, such as colors, objects, numerical digits, and alphabetical letters. RAN consistently predicts reading concurrently and longitudinally in various languages (e.g., Cheung, McBride-Chang, & Chow, 2006; Georgiou, Parrila, & Papadopoulos, 2008; Lepola, Poskiparta, Laakkonen, & Niemi, 2005). Indeed, RAN is considered as "one of the best" predictors of reading fluency (Norton & Wolf, 2012), possibly because both entail the coordination and timed execution of similar component skills, such as visual processing, retrieval and integration of lexical information, and motoric activation that leads to articulation (Wolf & Bowers, 1999).

In theory, RAN abilities measured in L1 should predict RAN performance—and perhaps also reading—in L2, yet what little empirical findings available to date are inconsistent and need clarification. For instance, in one study, Chinese and English rapid picture naming predicted Chinese word reading but not English word reading (Keung & Ho, 2009), but in another study (Chung & Ho, 2010), Chinese rapid digit naming predicted English word reading and yet English rapid letter naming did not predict Chinese word reading. These discrepancies could be due to variations across studies in the types of stimuli (pictures, digits, and letters) used in the rapid naming tasks.

Moreover, cross-language relationships between cognitive and reading abilities in Chinese and English reported to date have primarily been concurrent relationships. The few longitudinal studies published thus far have neither examined the development of reading abilities beyond word level, nor spanned more than two years (Chow, McBride-Chang, & Burgess, 2005; McBride-Chang & Ho, 2005). Our study responded to these research gaps by examining whether early cognitive abilities in L1 Chinese predict higher-order literacy skills (e.g., reading comprehension, text-level reading and writing fluency) in English as L2 across first to fourth grade in elementary school. One focus was on whether rapid naming abilities in L1 Chinese could predict the development of literacy skills in L2 English. The findings can help clarify prior inconsistent results and can offer new insights to cross-language transfer.

Cognitive Deficits Underlying Chinese and English Reading Difficulties

The central processing hypothesis postulates common cognitive processes underlying literacy development of languages in general; deficits in such processes will likely manifest as reading difficulties in learning any language (Cummins, 1981). Hence, high co-occurrence of reading difficulties in English and Chinese despite substantial differences between the two orthographies would lend support to this hypothesis. If, however, cognitive profiles of poor readers of Chinese differ significantly from those of poor readers of English, reading-related cognitive deficits would likely be language-specific rather than language-general.

Both types of evidence exist. Chung and Ho (2010) compared Chinese children learning L2 English who were dyslexic in L1 (Chinese) to age-matched average readers of

Chinese. The dyslexic children were significantly weaker in rapid naming, orthographic knowledge, phonological awareness, and morphological awareness in both Chinese and English concurrently, pointing to common language deficits.

However, a retrospective longitudinal study revealed that Hong Kong Cantonese-speaking children who were poor readers of Chinese at age 8 had had significantly weaker phonological and morphological awareness from age 5 on than age-matched controls, whereas those who were poor readers of English at age 8 showed early deficits only in phonological awareness (McBride-Chang, Liu, Wong, Wong, & Shu, 2012). In another retrospective study on Mandarin-speaking children in Beijing (McBride-Chang et al., 2013), poor reader status in Chinese but not in English correlated with prior morphological awareness deficits. RAN deficits were found in poor readers of both Chinese and English.

Deficits in phonological awareness and rapid naming, then, seemed to be language-general, whereas problems in morphological awareness seemed specific to reading difficulties in Chinese. One major limitation of retrospective longitudinal studies is that while they can reveal earlier cognitive deficits of poor readers, they are silent on how well cognitive deficits early on can predict reading difficulties later on. More research is clearly needed, especially prospective cross-linguistic studies, to shed light on whether and how early cognitive deficits in L1 Chinese predict later literacy problems in L2 English.

Assessment of L1 and L2 Reading Difficulties in Hong Kong Chinese Children

Most children in Hong Kong learn Chinese as L1 and subsequently English as L2 when they start formal education. Hence, the language environment in Hong Kong offers a good test case of the cross-language relationships between L1 and L2 development. In Hong Kong, children with difficulties in Chinese literacy are usually identified from the first grade with the widely used *Hong Kong Test of Specific Learning Difficulties in Reading and Writing for Primary School Students* (HKT-P(II); Ho et al., 2007)—a standardized test with local norms for children aged 6;1 to 12;6. This battery consists of 12 subtests combined to yield 5 composite scores in the domains of literacy, rapid naming, phonological awareness, phonological memory, and orthographic skills. Median reliability coefficients for eleven of these subtests ranged from .73 to .99, with good construct validity and convergent validity (Ho et al., 2007).

By contrast, reading difficulties in English as L2 are more difficult to identify so early because children's L2 proficiency is typically still too limited to reveal profound learning difficulties. Moreover, valid assessment tools for diagnosing English (L2) reading problems in young Hong Kong Chinese children are not available. Standardized tests available for assessing English literacy are based on Western norms developed with monolingual English-speaking populations. Such tests are rarely used by local practitioners because the test items presuppose far greater proficiency and vocabulary than Hong Kong Chinese children generally possess when they are just starting to learn English as an L2. Instead, educational psychologists in Hong Kong typically rely on teacher reports, work sample reviews, and other informal assessments to decide whether a child is exhibiting pronounced problems in learning English as an L2.

Hence from a practical point of view, if early reading difficulties in Chinese (L1) can indeed predict later reading problems in English (L2), Chinese word reading and related cognitive tasks in the widely used standardized HKT-P(II) test battery should predict word reading and higher-order literacy skills in English longitudinally. Should that be the case, in addition to being a diagnostic tool for reading difficulties in Chinese, subtests in the HKT-P(II) can perhaps serve as convenient proxy indicators for early identification of children at risk of later learning difficulties in L2, thereby offering a valuable window for early intervention.

Research Aims

The present study investigated longitudinal cross-language relationships in literacy development for Hong Kong Chinese children who spoke Cantonese Chinese as their L1 and learned English later as L2. This study examined whether Chinese reading and related cognitive abilities in Grade 1 predicted later word reading and higher-order literacy skills (including untimed reading comprehension, timed reading comprehension, and writing fluency) in English, and whether early reading difficulties in Chinese could predict later reading difficulties in English.

Cantonese-speaking children were tested, near the end of Grade 1, on word reading, rapid naming, phonological awareness, and morphological awareness in both Chinese and English, as these skills had been linked to literacy development. More advanced English literacy skills beyond word reading, and reading-related cognitive abilities in English were then assessed every 12 months for 3 years (i.e., near the end of Grades 2, 3, and 4). The main research questions were:

(1) Do Chinese metalinguistic and cognitive skills in Grade 1 predict English literacy and English-subject school performance concurrently and at later time points (i.e., Grades 2, 3, and 4)?

(2) Do standardized HKT-P(II) tasks in Chinese predict subsequent English literacy performance? That is, can HKT-P(II) subtests serve as proxy indicators for early identification of L2 English problems that will emerge later?

(3) Do children at risk for reading difficulties in Chinese (L1) in Grade 1 also display significant weaknesses in English (L2) reading later on, reflecting common cognitive deficits underlying these two vastly different orthographies and cross-linguistic transfer?

Method

Participants

A total of 104 children (50 boys and 54 girls; aged 6;5 to 7;7, M=7;0), were recruited in the study. They were all native Cantonese-speaking Chinese children attending the second semester of Grade 1 at a government-subsidized mainstream elementary school. The school was located within a private housing estate, and the majority of the students came from middle class families living nearby or within the same district. An invitation letter was sent to parents of all Grade 1 children in the school, and parents volunteered their children to participate in the study. Parental written consent and child oral assent were obtained before testing.

In Hong Kong, Cantonese is the dominant language spoken at home and in the community, while English is typically introduced as a second language very gradually in preschool, starting from 3 to 4 years of age. Given that Chinese reading instruction traditionally relies on a "look-and-say" approach to sound out characters, English in Hong Kong preschools is also commonly taught in a similar manner, starting with the memorization of letter names, and then proceeding to reading words and sentences, without much emphasis on teaching the alphabetic principle. The English Language curriculum in most elementary schools in Hong Kong follows the curriculum guideline recommended by the Education Bureau, which highlights the integration of listening, speaking, reading and writing skills in learning English, but a large proportion of instructional time is still typically dedicated to the learning of vocabulary, grammar and sentence patterns. In their regular school timetable, participants in the present study received on average 5 hours of English Language lessons per week, delivered by locally trained teachers who spoke English as their L2. Apart from English lessons, all other academic subjects were taught in Cantonese Chinese.

Prior to the initial assessment, all parents of the child participants completed a short demographic questionnaire, reporting their education level (1="below primary school level", 2="primary level", 3="secondary level", and 4= "tertiary level or above"), their English language proficiency (1="none", 2="limited", 3="average", 4="good", 5="excellent"), and the language(s) spoken in their home. Cantonese Chinese was confirmed to be the main language used at home for all participants. Self-reports revealed that almost all of the parents (mothers, 100%; fathers, 97%) had completed at least secondary school education, and about half had received tertiary level education (mothers, 46%; fathers, 58%). Proficiency in English varied considerably, with 16% of the mothers and 20% of the fathers self-reporting below-average proficiency, while 29% of the mothers and 33% of the fathers rated their own proficiency as "good" or "excellent". Detailed demographic information with respect to parents' self-reported education level and English proficiency level is provided in Appendix 1 (available online).

In this 3-year longitudinal study, 10 participants dropped out due to school transfer, 2 were withdrawn from the study by their parents, and 5 did not complete assessments at one of the time points. Only the children with complete data (N=87; 46 boys and 41 girls) were included in subsequent analyses. This group did not differ significantly from the 17 students not included in the analyses, in terms of mean age ($t(102)=.62$, $p=.54$), nonverbal IQ ($t(102)=.57$, $p=.57$), parents' self-reported education level ($ts(102)<1.68$, $ps>.10$), and parents' English proficiency level ($ts(102)<1.11$, $ps>.27$).

Design and Procedure

In this longitudinal study, children were tested individually in the second semester of Grade 1 (Time 1) and assessed again in 12 months (Time 2), 24 months (Time 3) and 36 months (Time 4) when they were in the second semester of Grades 2, 3 and 4 respectively. All testing was conducted near the end of the school year. Time 1 testing required two individual sessions conducted on different days to minimize fatigue, with all the Chinese measures and nonverbal IQ test in one session and all English tasks in another. Each session lasted about 40 minutes, and the order of the Chinese and English sessions was counterbalanced and randomized across children. From Time 2 onward, children were assessed only on English tasks, which took around 40 minutes. To avoid potential ceiling effects in measuring moderately constrained skills in phonological awareness and word recognition, a different set of tasks was used for rhyme awareness, phoneme awareness, and English word reading at Times 3 and 4, which included more difficult items and more demanding skills such as supplying rhyming words and substituting phonemes. Similarly, additional items involving more abstract concepts were included in the English morphological task assessed at Times 3 and 4. Text-level reading and writing abilities were only assessed at the last two time points. All assessments were conducted at the school during school hours by bilingual research assistants and interns majoring in Psychology. All experimenters were trained in the administration and scoring of the tests. All verbal responses were audio-recorded for later checking of scores.

Measures

Nonverbal Intelligence Task

Raven's Standard Progressive Matrices. To assess general cognitive ability at Time 1 (as a control variable), we used the short version (Sets A, B and C) of this standardized test, which included 36 items in ascending order of difficulty. Each item consisted of a pattern with a missing part, and children chose from either 6 (for Sets A and B) or 8 (for Set C) alternatives the one they thought would complete the pattern. Raw scores were converted into standard scores (Mean=100, SD=15) based on local norms obtained by the Hong Kong Education Department (Raven, 1986). Test-retest reliability was .88 in the original norming sample. Cronbach's alpha reliability coefficient for this sample was .80.

Literacy Tasks

We measured Chinese word reading in both untimed and timed context to see how Chinese reading accuracy and fluency contributed cross-linguistically to the development of

English literacy. English word reading was assessed at all time points, while literacy skills at the text level—including untimed reading comprehension, timed reading comprehension and writing fluency—were measured only at Times 3 and 4 because the children's L2 English proficiency had been too limited at Times 1 and 2.

Untimed Chinese word reading. This subtest from the standardized HKT-P(II) assessed children's Chinese word reading accuracy without time pressure. Children read aloud from a set of 150 two-character Chinese words listed in ascending order of difficulty. A child scored one point for pronouncing both characters of a word correctly; if a child scored 0 on 15 consecutive words, the test was discontinued. According to Ho et al. (2007), Spearman-Brown split-half reliabilities for age 6-8 ranged from .97 to .99 for this subtest. Cronbach's alpha obtained for this sample was .98.

Chinese one-minute word reading. Chinese word reading fluency was measured using this timed task from the HKT-P(II). Ninety simple two-character Chinese words were displayed in 9 rows containing 10 words each. Children read aloud as many words as they could in one minute, earning one point every time they read both characters of a word correctly. Test-retest reliabilities for age 6-8 ranged from .99 to 1.00 (Ho et al., 2007).

English word reading. At Times 1 and 2, children were tested with an English word reading task adopted from previous work (Chung & Ho, 2010). Children were asked to read aloud 80 English words selected from the most widely used local English textbooks. The words ranged from 2 to 10 letters (1 to 4 syllables) and were presented in ascending order of difficulty. One point was given for each word read correctly. Cronbach's alpha coefficient for this test was .98 both in the original study (Chung & Ho, 2010) and in the current study.

Word reading ability at Times 3 and 4 was assessed with the Letter-Word Identification subtest from *Woodcock-Johnson III Tests of Achievement Form A* (WJ III; Woodcock, McGrew, & Mather, 2001). Children read aloud from a list of words arranged in ascending order of difficulty until they pronounced 6 consecutive words incorrectly. One point was awarded for each correct response, and the maximum score possible was 76. Median split-half reliability was reported to be .94 for this subtest (Woodcock et al., 2001). We obtained a Cronbach's alpha coefficient of .88 for our sample.

Untimed English reading comprehension (Times 3 and 4 only). The Passage Comprehension subtest of WJ III was administered. In the first 10 items, children chose, from among several alternatives, the picture that corresponded to a printed target phrase (e.g., "yellow bird"). In each of the remaining items, children silently read a short passage in which a key word was missing and had to supply a word that would make sense in the context (e.g., "The farmer is proud of his white hen. He says that she produces at least one ______ every day." Correct answer here is "egg"). Thus, both reading and oral cloze skills were assessed. Items became more difficult as the passage length and syntactic and semantic complexity gradually increased. If a child gave 6 consecutive wrong answers, the test was discontinued. Each correct response was worth one point, and the maximum score possible was 47. Split-half reliability coefficient for this test was .88 (Woodcock et al., 2001). Cronbach's alpha was .83 in our study.

Timed English reading comprehension (Times 3 and 4 only). In this timed test from WJ III, children read short simple sentences (e.g., "An apple is blue.") and indicated whether the statements were true or false by circling "Yes" or "No". They were given 3 minutes to complete as many items as they could, and their scores were calculated by subtracting the number they got wrong from the number they got right. The maximum score was 98. Test-retest reliability was .94 according to the manual (Woodcock et al., 2001), and .88 for the current sample.

English writing fluency (Times 3 and 4 only). In this WJ III task, each item consisted of a picture (e.g., a pig) and a set of 3 words that went with it ("pig", "fat", "is"). Children had 7 minutes to write sentences about as many of the pictures as they could using the given words. Each correct sentence received one point, and the maximum score was 40. Test-retest reliability coefficient for this subtest was .76 as reported in the manual (Woodcock et al., 2001), as well as in our study.

Rapid Automatized Naming Tasks

RAN abilities were tested using rapid digit naming in Chinese and rapid letter naming in English. Alphabetical letters and numerical digits both come from closed sets of highly familiar visual symbols with distinct members and unambiguous names, and thus both types of tasks generally showed higher correlations with reading than those that employed non-alphanumeric stimuli (e.g., colors and objects; Kirby, Georgiou, Martinussen, & Parrila, 2010). Naming speed of letters was measured here instead of digits in English, as all students should be highly familiar with letter names by Grade 1, but not necessarily with the English names of digits.

Chinese rapid digit naming. Naming speed was measured using the Digit Rapid Naming subtest from the HKT-P(II). Children were presented with a matrix consisted of 8 rows of 5 digits arranged in random sequence in each row, and asked to name all the digits in serial order in Cantonese Chinese as quickly and as accurately as they could. They had two trials each, and their average time across trials was their score. Better performance in RAN was indicated by a lower score (i.e., less time taken) on this task. Test-retest reliabilities of this subtest for age 6-8 ranged from .78 to .93 (Ho et al., 2007). We obtained a reliability coefficient of .84 for our sample.

English rapid letter naming. The format and scoring procedures of this test were similar to the Chinese rapid naming task. The visual material consisted of 8 rows of English lowercase letters, 5 in each row, printed in random order. Children were instructed to name the letters in serial order as quickly as they could, with average completion time across two trials used for analysis. Test-retest reliability for this task was reported to be .88 in earlier work (Chung & Ho, 2010). For this study, test-retest reliability was .93.

Phonological Awareness Tasks

For phonological awareness, we adopted widely used tests of rhyme awareness in Chinese and tests of rhyme and phoneme awareness in English (Chen et al., 2010; Chung & Ho, 2010; Keung & Ho, 2009). Rhyme awareness has been shown to predict Chinese reading in elementary students (Huang & Hanley, 1997; Siok & Fletcher, 2001). Perhaps due to the salience of syllables in Chinese—which map onto morphemes and orthographic characters—syllable awareness tests usually yield ceiling performance from even Grade 1 children in Hong Kong (Shu, Peng, & McBride-Chang, 2008) and were hence not included here. Note that phoneme awareness in English is a better predictor of reading acquisition than rhyme awareness (Melby-Lervåg et al., 2012). Nevertheless, we included measures of English rhyme awareness to see whether phonological awareness at the rhyme level in Chinese was related to both rhyme awareness and the more fine-grained phoneme awareness in English. These measures may also detect significant phonological weaknesses, if any, that occurred at either the rhyme or phoneme level in English, among poor readers of Chinese.

Chinese rhyme awareness. For every item on this HKT-P(II) test, children listened to digital sound tracks of three Chinese syllables — e.g., [saa]^1 (sand “沙”)、[haa]^1 (shrimp “蝦”)、[jin]^1 (smoke “煙”) — each illustrated with a picture to reduce memory load. Children indicated which two syllables rhymed by pointing to the corresponding pictures. Three demonstration trials preceded 18 test trials. One point was given for each correct response. Split-half reliabilities for this subtest ranged from .55 to .75 for age groups between 6 to 8 (Ho et al., 2007). Cronbach’s alpha for our sample reached .77.

English rhyme awareness. Rhyme awareness in English was measured at Times 1 and 2 based on the rhyme detection test described by Muter, Hulme, Snowling, and Taylor (1998). The test format was similar to that for Chinese rhyme detection. Children heard three monosyllabic words (e.g., “cat, hat, fish”) twice via digital sound tracks and then indicated which two words rhymed by pointing at corresponding pictures. Two demonstration trials preceded 10 test trials. The test score was the number of correct responses. In Muter et al.’s (1998) study, split-half reliability estimate after Spearman-Brown correction was .80. Cronbach’s alpha coefficient obtained for our sample was .65.

At Times 3 and 4, rhyme awareness was assessed by the Rhyming subtest in WJ III. The administration and scoring procedures for the first 3 items were the same as the rhyme detection task just outlined. In subsequent items, children were asked to provide, on their own, words that rhymed with stimulus words (e.g., what rhymes with “fan”?). Each correct response earned one point, and the maximum score possible was 17. If a child missed 4 consecutive items, the test was stopped. Reliability indicated by Cronbach’s alpha was .70 for this task.

English phoneme awareness. At Times 1 and 2, we used the onset deletion task from Muter et al.’s study (1998) to test phoneme awareness in English. For each item, children saw a picture of a common object, and simultaneously heard the object label pronounced via digital sound tracks. They were then asked to say the word without its initial phoneme (e.g., “bus without the /b/ is —”). In this case, the correct response was “us”. Two demonstration items—with corrective feedback if needed—preceded 10 test items. Split-half reliability for this task was reported to be .86 (Muter et al., 1998). Cronbach’s alpha was .82 in this study.

At Times 3 and 4, we administered two subtests from WJ III. In one, the Deletion Task, children were given a word and asked to turn it into a new word either by removing a letter sound (e.g., say “snap” without “/n/”) or, if it was a compound word, by removing one of its parts (e.g., say “raincoat” without “rain”). In the other subtest, the Substitution Task, children were given a word and asked to replace a part of it or a phoneme in it with a particular sound—e.g., change “/sh/” in “fish” to “/st/”. All items were presented through digital sound tracks. The maximum score was 10 for Deletion and 9 for Substitution, and these tests were each terminated after 4 and 3 consecutive mistakes, respectively. A median split-half reliability estimate of .81 was originally reported (Woodcock et al., 2001). Cronbach’s alpha coefficient here was .75.

Morphological Awareness Tasks

Morphological awareness was assessed with lexical compounding (McBride-Chang et al., 2003), since other types of morphological structures (e.g., prefixes, suffixes, and grammatical inflections) are rare in Chinese.

Chinese morphological construction. To test morphological awareness in Chinese, we used a task devised by McBride-Chang et al. (2003). In each of 27 items, we described a concept to children and then labeled it with a compound noun. We next described an analogous concept and asked children to name it. The correct answer was a novel compound noun analogous to the first one. Here is an example: “由一隻蜘蛛織成嘅網，我哋會叫佢做蜘蛛網。咁由一隻螞蟻織成嘅網，我哋會點叫佢呀?” (“When a spider spins a web, we call it spider web. So when an ant spins a web, what do we call it?”). Correct answer: “螞蟻網” (“ant web”). The items, given orally, were 2 to 4 sentences long and arranged in ascending order of difficulty, from concrete to more abstract concepts. We showed the children pictures to illustrate 2 sample items and 2 trial items, but not for the actual test items. Children earned one point for each correct response, and the maximum score was 27. The internal consistency reliability coefficient reported by McBride-Chang et al. (2003) was .84. We obtained a coefficient of .79 for our sample.

English morphological construction. To test morphological awareness in English we selected and modified some test items used by McBride-Chang et al. (2005). At Times 1 and 2, we presented 9 scenarios verbally in three-sentence descriptions, with pictures accompanying each scenario. Children came up with words for the objects or concepts described in each item, through morpheme compounding. One example: “See this tree. These are apples. We call it an apple tree. Now see this tree. These are donuts. What do we call it?” The correct response was “donut tree”. At Times 3 and 4 we included additional items involving more abstract concepts, and with no picture illustrations. One point was given for each correct answer, and the maximum scores were 9 and 13, respectively, for the easier and harder versions of the task. McBride-Chang et al. (2005) obtained internal consistency reliabilities averaging to .71 for this test. Cronbach’s alpha coefficients were .72 and .76 respectively for the easier and harder versions of this task in the current study.

Results

Correlations between Chinese and English Tasks

Descriptive statistics for all measures are presented in Table 1. Table 2 shows the Pearson correlation coefficients between all Chinese tasks and English literacy measures. English word reading across all four time points (Times 1 to 4) correlated moderately with four of the Chinese tasks administered at Time 1—namely, Chinese word reading, one-minute word reading, rapid digit naming, and rhyme detection (ps<.01). Among them, Chinese rapid digit naming was negatively associated with English word reading since shorter average time taken in this task signified better performance in RAN. English word reading at both Times 1 and 2 also correlated with Chinese morphological construction at Time 1 (rs>.26, ps<.05). English reading and writing abilities at the text level—including untimed and timed reading comprehension, and writing fluency—were assessed at the last two time points (i.e., Times 3 and 4). Similar to English word reading, all these higher-order English literacy measures at both Times 3 and 4 correlated significantly with Chinese word reading, one-minute word reading, rapid digit naming, and rhyme detection at Time 1 (*p*s<.05). In addition, the English test of writing fluency at both Times 3 and 4 also correlated with the Chinese morphological task at Time 1 (*r*s>.28, *p*s<.01).

Correlations between reading-related cognitive tasks in Chinese and English were examined to explore cross-language relationships (Table 3). Chinese rhyme detection at Time 1 correlated moderately with phonological awareness in English both at the rhyme and phoneme levels across Times 1 to 4 (*r*s ranging from .42 to .63, *p*s<.001). Similarly, rapid digit naming (*r*s>.39, *p*s<.001) and morphological construction (*r*s>.27, *p*s<.05) in Chinese at Time 1 correlated significantly with their analogous tasks in English at all four time points.

Prediction of English Literacy across Time 1 to Time 4 using Chinese Reading and Reading-Related Cognitive Tasks at Time 1

To see if L1 Chinese reading abilities in Grade 1 predict later development of literacy skills in L2 English, a series of hierarchical regression analyses were performed. In all the regressions, demographic variables including children's age, gender, nonverbal IQ measured by Raven's Matrices, and parents' self-reported education level and English proficiency level were entered as controlled variables in the first step of the equations. Separate analyses were conducted for the various English literacy measures: English word reading, untimed reading comprehension, timed reading comprehension, and writing fluency at each time point assessed. Relevant diagnostic tests were conducted to ensure that the assumptions of linear regression were satisfied. The results are presented in Tables 4 and 5.

All Chinese Tasks as Predictors after Controlling for the Demographic Variables

To evaluate the relative contribution of the Chinese measures to English literacy, all Chinese tasks were entered simultaneously into the second step of the regression equations after the controlled variables. In the prediction of English word reading, all the Chinese tasks together accounted for over 20% of unique variance in the outcome measure at each time point (Table 4). Between the two Chinese word reading measures at Time 1, the timed task—Chinese one-minute word reading—predicted English word reading accuracy more strongly across time than did the untimed task. Among all Chinese tasks, it was also the strongest predictor of English word reading accuracy at all four time points.

With respect to the reading-related cognitive skills, Chinese rapid digit naming at Time 1 was a unique predictor of English word reading at Times 2 and 3 (βs=-.22, ps$<$.05), after controlling for the effects of other Chinese tasks. Chinese rhyme detection was the second strongest predictor of English word reading at Time 1 (β=.28, $p<.01$). Chinese morphological awareness, by contrast, showed a significant negative relationship with English word reading at Time 3 (β=-.24, $p<.05$).

For English text-level reading and writing measures (Table 5), Chinese one-minute word reading at Time 1 contributed uniquely in predicting timed reading comprehension at both Times 3 and 4 (βs$>$.41, ps$<$.01), and writing fluency at Time 3 (β=.35, $p<.05$) over and above other Chinese tasks and controlled variables. Chinese rapid digit naming at Time 1 significantly predicted timed English reading comprehension at Time 3 (β=-.23, $p<.05$) and untimed reading comprehension at Time 4 (β=-.26, $p<.05$). Chinese rhyme detection was a significant predictor of English writing fluency at Time 3 (β=.24, $p<.05$). Chinese morphological construction did not predict any of the text-level literacy skills across time.

HKT-P(II) Subtests as Predictors after Controlling for the Demographic Variables

We further explored the feasibility of using Chinese subtests in HKT-P(II) as proxy indicators of later reading abilities in L2 English. Three of the HKT-P(II) subtests administered at Time 1—Chinese one-minute word reading, rapid digit naming, rhyme detection—each made unique contribution in predicting English word reading and text-level literacy skills across time. To determine how much variance in English reading abilities could be explained by these three tasks collectively, we entered them together in the second step of regressions; they accounted for 18-25% (ps<.001) of additional variance in English word reading (Table 4) and 16-28% (ps<.01) of variance in higher-order literacy abilities (Table 5), after controlling for the demographic variables.

Predictive Power of the HKT-P(II) Subtests Beyond English Word Reading at Time 1

For an even more stringent test of the contribution of the three HKT-P(II) subtests, we added Time 1 English word reading in step 2 of the regression equations. The change in variance explained by the three HKT-P(II) subtests in the third step remained significant for timed English reading comprehension at both Time 3 and Time 4 (ΔR^2>.04, ps<.05). Moreover, Chinese one-minute word reading at Time 1 emerged as a unique predictor of timed English reading comprehension at Times 3 and 4 (βs=.20, ps<.05) and writing fluency at Time 4 (β=.21, p<.05), beyond Time 1 English word reading and the other two HKT-P(II) tasks. When timed reading comprehension at Time 3 was entered as an autoregressor in predicting timed reading comprehension at Time 4, the unique contribution of Chinese one-minute word reading no longer held. Nonetheless, this reading fluency subtest in Chinese administered at Time 1 remained marginally significant (β=.16, p<.10) predicting Time 4 English writing fluency, even after controlling for the effects of English word reading at Time 1 and English writing fluency at Time 3.

Prediction of School Performance in English Reading and Writing across Grade 2 to Grade 4, using Chinese Reading and Reading-Related Cognitive Tasks in Grade 1

Hierarchical regressions analogous to those just described were conducted on ecologically significant measures, namely, school performance in English reading and writing. Children's school-examination results from the first semester of Grade 2 to the first semester of Grade 4 were obtained from the school with written parental consent. The school examinations required children to identify main ideas, locate specific information, make inferences from written passages, and complete writing tasks. The maximum score of every examination was 100.

The results of the regression analyses are shown in Table 6. When all predictors were entered simultaneously into the equations in step 2 after the controlled variables, Chinese rhyme detection in Grade 1 showed significant unique contribution to English reading and writing examination results in Grades 2 and 3 (βs>.22, *p*s<.05). Chinese rapid digit naming in Grade 1 also predicted school performance in English in Grade 3 (β=-.22, $p<.05$). Analogous to our results using experimental English literacy measures, Chinese one-minute word reading, rapid digit naming, and rhyme detection at Time 1 again emerged as the strongest predictors among the Chinese subtests in explaining school performance in English reading and writing. These three tests together accounted for 20-26% (*p*s<.001) of the variance in school results over and above the controlled variables. They explained a significant proportion of additional variance (ΔR^2=.03, $p<.05$) in Grade 3 examination results even after Time 1 English word reading and Grade 2 school performance were controlled for.

Comparison between Poor Readers of Chinese and Age-Matched Controls on Their Development of English Reading Abilities

We examined whether reading difficulties in Chinese as L1 early on predicted later reading deficiencies in English as L2 by comparing the test performance of children who were poor readers in Chinese at Time 1 to their age-matched controls in this study. Children were classified as poor readers in Chinese if: (1) their score on Time 1 Chinese word reading was at or below the 25th percentile based on local age norms established by the HKT-P(II) (Ho et al., 2007), and (2) their nonverbal IQ on *Raven's Standard Progressive Matrices* was 85 or above. The 25 children (13 boys and 12 girls) who met the above criteria comprised the reading at-risk group. Children in the control group were chosen from the rest of the participants, who all ranked above the 25th percentile in Chinese word reading based on HKT-P(II). Specifically, eligible matches for each child in the at-risk group were identified based on same gender, plus or minus 2 months in age, and standard scores on Raven's Matrices within a range of plus or minus 5. A match was then randomly selected from the eligible matches to form a group of 25 average readers. Independent-sample *t*-tests were conducted to compare the means of the two groups on all Chinese and English measures across Time 1 to Time 4.

As shown in Table 7, although children in the at-risk group were identified solely by their low scores on Chinese word reading in Grade 1, they also performed significantly worse than their age-matched counterparts on all the remaining Chinese tasks at Time 1, indicating that they were generally weak in cognitive skills related to Chinese reading. Compared to the controls, the at-risk group performed significantly worse in English word reading and rhyme awareness concurrently in Grade 1, and subsequently worse in English word reading, phoneme awareness, and rapid letter naming in Grade 2. More pronounced difficulties were seen in Grades 3 and 4: performance on all English literacy measures, both at the word and text levels, was significantly worse for the at-risk group. Phonological processing abilities—including rhyme and phoneme awareness—were also found to be weaker in the at-risk group in Grades 3 and 4.

Discussion

This longitudinal study investigated whether reading development in two languages with dramatically different orthographies can be predicted by common cognitive abilities. Specifically, we tested Cantonese-speaking children at age 7 to assess how well their Chinese reading-related cognitive abilities predicted literacy skills in English across ages 7 to 10. Moreover, we examined whether early manifestation of reading problems in L1 co-occurred with subsequent reading difficulties in L2 by comparing the cognitive profiles of children with word reading difficulties in Chinese at age 7 to the profiles of their typically developing peers.

Can L1 Abilities Predict Later Development in L2 Literacy?

Of all the Chinese tasks administered in Grade 1, Chinese one-minute word reading contributed uniquely in predicting untimed English word reading, timed reading comprehension, and writing fluency across time over and above other Chinese tasks and controlled variables. In addition, Chinese rhyme awareness and rapid digit naming each proved to be significant predictors of English literacy measures at some time points. By contrast, Chinese morphological construction did not predict any of the text-level reading and writing tasks in English.

To assess the ecological significance of the predictive power of L1 abilities for subsequent L2 literacy development, we explored how well Chinese reading skills in Grade 1 predicted school examination results in English reading and writing in subsequent years. Chinese rapid digit naming and rhyme detection proved to be significant longitudinal predictors of examination performance in English reading and writing across Grades 2 and 3 after controlling for age, IQ, and parent background. Hence, the converging evidence from both experimental literacy measures and academic performance suggests that early abilities in Chinese rapid naming and phonological awareness are good cross-language predictors of later reading development in L2 English, with these effects likely mediated by English word reading.

These results support the view that some reading-related cognitive abilities are language-general, while others such as morphological awareness are more language-specific. Our findings also support the possibility of cross-language transfer of reading-related skills from L1 Chinese to L2 English, despite their marked differences in orthographic, phonological, and morphological structures.

Phonological Awareness

The transfer of phonological skills between Chinese and English has been well studied in the past (Chen et al., 2010; Chow et al., 2005; Chung & Ho, 2010; Gottardo et al., 2001; Keung & Ho, 2009; McBride-Chang & Ho, 2005). Importantly, we also found significant relationships between Chinese phonological awareness and English literacy measures, as well as moderately strong correlations between Chinese rhyme awareness and English phonological awareness of rhymes and phonemes. Hence, although grapheme mapping occurs at the syllable level instead of phoneme level in Chinese, phonological sensitivity at the rhyme level—in between the syllable level and phoneme level—in L1 Chinese nonetheless correlated significantly with the development of sensitivity at the more fine-grained phoneme level in L2 English.

Our data revealed phonological transfer between L1 and L2 regardless of disparities in orthographic form or phonological mapping, consolidating empirical support for Cummins' (1981) proposition that language-general processes such as phonological awareness contribute to the development of a CUP that facilitates language growth in both L1 and L2. More specifically, the ability that a child acquires in one language to detect and manipulate sounds facilitates performance of such tasks in other languages as well. In addition, differences in orthographic depth or psycholinguistic grain-size between languages do not appear to deter this transfer. Our findings on phonological awareness thus argue against the script-dependent hypothesis which presumably predicts minimal phonological transfer between Chinese and English.

Phonological measures in Chinese and English were significantly correlated probably because both reflected how well underlying phonological representations were structured in the mental lexicons. High quality phonological representations, in general, facilitates manipulation and processing of speech sounds, which in turn enables better mapping of speech sounds to graphemes, and consequently better decoding. This can plausibly explain the link between Chinese phonological awareness and English literacy, and why this relationship is likely mediated by English word reading.

Rapid Naming and Word Reading Fluency

Prior research was far less clear on whether RAN in Chinese would predict reading in English. Our findings converged with Chung and Ho's (2010) finding that Chinese rapid digit naming uniquely predicted concurrent English word reading of L2 English learners. Furthermore, naming speed—measured by Chinese rapid digit naming and one-minute word reading here—predicted English reading ability in the present study, not only concurrently as revealed in prior studies, but also prospectively and longitudinally as seen here.

Although past research has highlighted the role of naming speed in reading, few studies have addressed this in a cross-language context. According to Wolf, Bowers, and Biddle (2000), rapid naming involves a number of concerted skills, including general attentional and perceptual processes, visual processing of patterns, lexical access of mental representations, access and integration of orthographic, semantic and phonological information, and motoric activation that leads to articulation. RAN also reflects the long-term learning ability of visual-verbal associations. Many, if not all, of these cognitive processes are presumably needed in reading irrespective of orthography. Our results support the view that these underlying skills contributing to automaticity in reading are common across languages, be it encoded in a logographic orthography such as Chinese, or an alphabetic script such as English. Aligning this with Cummins' theory (1981), rapid naming skills are readily transferable across languages probably because they, apart from phonological awareness, constitute part of the underlying language-learning capacity that subserves literacy development across languages. Again, this finding does not fit well with the script-dependent hypothesis given the disparities between the two orthographic systems.

An important point to highlight is that past research mostly focused on the relations between Chinese rapid naming and English reading at the word level (Chung & Ho, 2010; Keung & Ho, 2009), whereas this study went beyond word-level reading. Chinese rapid digit naming in Grade 1 was found to predict English reading comprehension longitudinally, and this relationship was likely mediated by English word reading. Chinese word reading fluency, on the other hand, predicted English timed reading comprehension and writing fluency even when English word reading was controlled for. Global processing speed might partially account for the relations between these timed measures. Alternatively, these findings can be conceptualized within the framework of interactive models of reading, which assume that lower- and higher-level skills are interactively used to process text (Grabe, 1988). LaBerge and Samuel's automaticity model (1974), for instance, posits that fast word recognition frees up cognitive resources for higher-level processes such as text comprehension and interpretation. Combining this with the notion of CUP, the automaticity that supports fluent word reading in Chinese may also promote rapid word processing in English, and in turn enhance text-level reading comprehension and writing.

Morphological Awareness

Cross-language transfer of morphological awareness in Chinese-English bilinguals has been demonstrated in the past, more commonly between English (L2) compound awareness and Chinese (L1) reading (e.g., Pasquarella et al., 2011; Wang et al., 2006), and less frequently reported between Chinese morphological skills and English reading (Chung & Ho, 2010). In our study, Chinese morphological construction in Grade 1 correlated weakly but positively with concurrent English word reading, and longitudinally with timed reading comprehension and writing fluency in Grades 3 and 4.

However, when the effects of all other Chinese reading and cognitive measures were controlled for, Chinese morphological construction did not significantly predict any of the

English literacy tasks, except English word reading in Grade 3 for which a significant negative association was observed. Chung and Ho (2010) have provided evidence for the concurrent cross-language transfer of morphological awareness from L1 Chinese to L2 English, where Chinese morphological construction contributed significantly to English word reading after controlling for Chinese phonological awareness and orthographic tasks. By contrast, morphological awareness did not reveal to be a unique predictor in this study when Chinese word reading, one-minute word reading, rapid digit naming, and rhyme awareness were simultaneously accounted for. This discrepancy could be because a larger common variance was shared among the various Chinese tasks used here as compared to that in Chung and Ho's study (2010). Our data suggest that some metacognitive skills, such as morphological awareness, are more language-specific than others, and their transfer might be reduced by the linguistic differences between the languages involved. Our findings overall support the postulation that the two theoretical perspectives—central processing hypothesis and script-dependent hypothesis—may indeed complement each other, accounting for the cross-language transfer of some skills but not the others.

With respect to the counter-intuitive result of a negative contribution from Grade 1 Chinese morphological construction to Grade 3 English word reading, we can only speculate that the rather holistic approach in combining morphemes in Chinese, when applied to reading English, may sometimes hinder rather than facilitate the process, since word decoding in English often demands a more analytical approach than what is required in lexical compounding in Chinese.

Can Early Reading Difficulties in L1 Predict Later Reading Problems in L2?

We also focused on poor Chinese readers in Grade 1 (children with Chinese word reading performance in the bottom 25% according to local age norms). Their performance on all other Chinese tasks was significantly lower than that of a control group of average readers matched on gender, age, and nonverbal IQ. That is, they seemed to have problems in multiple reading-related cognitive abilities in L1, including phonological awareness, rapid naming, and morphological awareness.

Previous research has revealed that Chinese-speaking children who are dyslexic in their L1 also have reading difficulties in their L2 English (Chung & Ho, 2010). We too found that poor readers of Chinese (L1) showed significant difficulties in English (L2) word reading as well as more advanced English reading and writing tasks, both concurrently and in subsequent years. These results support our hypothesis that early reading difficulties in Chinese are associated with later problems in English reading development. This relationship between L1 and L2 reading difficulties may well be at least partially mediated by poor language-general skills such as phonological awareness and rapid naming, which are likely constituents of the CUP as postulated by the central processing hypothesis and Cummins' model (1981).

To explore this, we examined the cross-language profiles of these children. Indeed, young poor readers of Chinese already displayed significant weakness in English rhyme detection in Grade 1, and their deficits in phonological skills persisted from Grade 1 through at least Grade 4. Our findings are consistent with those from McBride-Chang et al.'s retrospective study (2012), which found that deficits in phonological awareness were associated with poor reading in Chinese, in English, or in both. The results here, again concurring with the conceptualization of a CUP, indicate a possible universal phonological core intrinsic to language development across different orthographies. Our examination of the first graders at risk for poor reading—identified by their word learning difficulties in Chinese—uncovered more second-language deficits concurrently and in later years, including poor rapid naming.

Clinical and Educational Implications

A question of clinical interest is whether the widely used Chinese subtests in the HKT-P(II) can serve as convenient proxy indicators for early detection of reading difficulties not only in L1 Chinese but also later in L2 English. Since among the HKT-P(II) tasks, Chinese one-minute word reading, rapid digit naming, and rhyme detection were relatively strong longitudinal predictors of English literacy measures and school achievement in English reading and writing, we combined the three HKT-P(II) subtests to see how well they predicted English reading performance. Together, these three subtests accounted for 18-25% of additional variance in English word reading over and above nonverbal IQ and demographic variables, and 16-28% of unique variance in higher-order literacy abilities across the first three years in elementary school. They remained significant predictors of timed reading comprehension even when English word reading in Grade 1 was also controlled for. Analogous results were obtained for the prediction of school achievement, where 20-26% of the variance in English reading-and-writing examination results was uniquely contributed by the three subtests, and they still significantly predicted Grade 3 performance after controlling for Grade 1 English word reading and Grade 2 school results.

McBride-Chang et al. (2012) argued that Chinese-speaking children learning English as an L2 should be tested separately for reading difficulties in their L1 and L2, since markers of each may be different. Nevertheless, they found that poor readers of L1 Chinese and poor readers of L2 English both displayed early difficulties in phonological awareness, though only the former showed deficits in morphological awareness. Hence from another perspective, their findings indeed lend support to the idea that phonological awareness is a common marker underlying poor reading in Chinese and English. Our present study further suggests that RAN in L1 Chinese, in addition to phonological skills, may also serve as an early indicator of possible reading problems in L2 English later. Therefore, our findings actually corroborate McBride-Chang et al.’s (2012) observation of some common cognitive abilities underlying the acquisition of L1 and L2. However, we are drawing a somewhat different conclusion. Specifically, these L1 markers can help educators tentatively identify L2 learners at risk of later reading problems, especially when their L2 proficiency is still too limited to render proper identification through comprehensive assessment.

Not all children who are poor readers in Chinese are at risk for reading problems in English, and parents, teachers and educational psychologists should be aware of this. Our findings here do not obviate the ultimate need for dual-language testing, as we believe that comprehensive assessment in the respective L1 and L2 will indubitably provide a more accurate indication of a child's language performance in each. Nonetheless, by providing evidence to show that phonological awareness, RAN, and word reading speed in an L1 can predict longitudinal literacy development in an L2, when the orthographic distance between the two languages is as wide as that between Chinese and English, the results in this study underscore the important role of these cognitive components in predicting reading proficiency in any other language as well.

We hypothesize that the findings of this study can likely be extrapolated to other combinations of L1 and L2 beyond Chinese and English. In other words, the relationship between other L1 and L2 may also be mediated by these underlying components, presumably forming part of the CUP. Therefore, it is important to include measures to test phonological awareness, rapid naming, and word reading speed in any language assessment. Test on word reading accuracy without any evaluation of speed may sometimes lead to an inaccurate impression of a child's reading proficiency. Moreover, subpar performance on phonological awareness, RAN, and reading fluency should raise concern for teachers and parents, as such deficits may foretell reading difficulties in learning another language too.

Our findings on cross-language relationships do point to certain directions in terms of future research and educational practice, but the current results should not be interpreted as direct evidence for specific instructional recommendations, as further testing is needed to verify them. Nonetheless, there are several educational implications that can be extrapolated from the present findings. First from the broadest perspective, given the strong relation between L1 and L2 even for languages as different as Chinese and English, laying a good foundation in an L1 should benefit the acquisition of an L2 in general, regardless of language type. The language-general skills developed in L1 should facilitate the learning of a second or third language. Hence teachers will do well to focus on students' phonological awareness and reading speed in learning a language, assuming that these cognitive skills will prove amenable to instruction.

In light of the potentially important role of phonological awareness as a core component of the CUP, incorporating a phonics approach into teaching and learning L1 may help strengthen this underlying language-learning capacity, and consequently benefit reading acquisition in both L1 and L2. This might be easier for an alphabetic language, but not as common for a non-alphabetic orthography such as Chinese, for which a "look-and-say" method is traditionally employed in classroom learning. Nonetheless, the use of auxiliary symbols (e.g. Pinyin—alphabetic coding of character pronunciation in Mandarin) to aid reading of Chinese characters is widely practiced in Mainland China, and children exposed to Pinyin performed better than those that were not in terms of English word segmentation and pseudoword reading (Holm & Dodd, 1996). There is indeed a growing number of elementary schools in Hong Kong that start to use Mandarin instead of Cantonese as a medium of instruction for Chinese Language learning. The effects of this instructional practice on Hong Kong children's phonological skills and Chinese reading await further investigation.

For automaticity in reading, repeated oral reading has been consistently shown improve reading fluency (Chard, Vaughn, & Tyler, 2002; Meyer & Felton, 1999). This involves repetitive practice in reading words and passages for a predetermined number of times, or until a performance criterion is achieved in terms of number of words read per minute (Dahl, 1979; Samuels, 1979). Although effects of repeated oral reading have been well documented mostly in alphabetic languages, similar methods such as paired reading have been found to improve Chinese word recognition and reading fluency among preschoolers in Hong Kong (Lam, Chow-Yeung, Wong, Lau, & Tse, 2013). Thus, enhancing reading fluency can possibly be a teaching focus for teachers both in Hong Kong and around the world.

Limitation and Conclusion

Based on the design of this study, using early abilities in L1 to predict later literacy performance in L2, Chinese reading and related cognitive tasks were only administered in Grade 1 but not in subsequent years. This has restricted the possibility of tracking any developmental changes across the early elementary years in the cross-language relationships, and this remains a major limitation of this study.

In conclusion we have identified three potential cross-language markers—Chinese word reading fluency, Chinese rapid digit naming, and Chinese rhyme awareness—that contributed uniquely in predicting English reading and writing abilities longitudinally. Since the two languages tested are substantially different linguistically, they offer a good test case of possible common underlying mechanisms subserving reading development in different orthographies. The cognitive skills apparently common to reading development in both Chinese and English may also underlie literacy development in other languages. Educational implications of the present findings may well apply to other combinations of L1 and L2.

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