RUNNING HEAD: Second language learning difficulties in Chinese dyslexic children

Title: Second language learning difficulties in Chinese dyslexic children: what are the reading-related cognitive skills that contribute to English and Chinese word reading?

Kevin K. H. Chung

The Hong Kong Institute of Education

Connie Suk-Han Ho

The University of Hong Kong

This paper is accepted in Journal of Learning Disabilities for publication.

Address for correspondence:
Kevin K. H. Chung
Department of Educational Psychology, Counselling & Learning Needs
The Hong Kong Institute of Education
10 Lo Ping Road
Tai Po, NT
HONG KONG SAR China
E-mail: kevin@ied.edu.hk
Fax : (852) 29487983

Abstract

The study examined the relations between reading-related cognitive skills and word reading development of Chinese dyslexic children in their Chinese language (L1) and in English (L2). A total of 84 bilingual children who were 28 dyslexic, 28 chronological age (CA) controls and 28 reading level (RL) controls participated and were administered measures of word reading, rapid naming, visual-orthographic skills, phonological and morphological awareness in both L1 and L2. Children with dyslexia showed weaker performance than CA controls in both languages, and found more difficulties in phonological awareness in English but not in Chinese. In addition, reading-related cognitive skills in Chinese contributed significantly to the ability to read English words, suggesting cross-linguistic transfer from L1 to L2. Results found evidence for different phonological units of awareness related to the characteristics of the different languages being learned, supporting the Psycholinguistic Grain Size and Linguistic Coding Differences Hypothesis.

Dyslexia or reading difficulty is one of the most common problems that severely affect academic performance. It shows as a difficulty in learning to read and spell that cannot be attributed to low intelligence or inadequate educational and social opportunities (Seymour, 1998). Much of the research has investigated developmental dyslexia in children learning to read and spell in their first language, but recently research on dyslexia in bilingual or multilingual readers has aroused growing interest. It is generally believed that dyslexic readers with relative weakness in their L1 are prone to similar difficulties in their second language (L2) based on the transfer from one language to the other. Research into this has focused only on dyslexic readers learning to read English whose L1 is another Roman alphabetic system, such as Spanish, French, or Italian (e.g., Comeau, Cormier, Grandmaison, & Lacroix, 1999; D'Angiulli, Siegel, & Serra, 2001; Durgunoglu, Nagy, & Hancin-Bhatt, 1993). However, research into L2 learners who are dyslexic readers in their non-alphabetic first language, particularly when that language is Chinese, has been less extensive. The present study is concerned with Chinese dyslexic children learning to read English as L2 in a Chinese-speaking environment. We are particularly interested to examine cross-linguistic transfer of visual-orthographic knowledge, of rapid naming skills, and of phonological and morphological awareness in bi-literacy acquisition as well as the relationship between the reading-related cognitive skills and reading ability in a group of Chinese-English bilingual dyslexic children. Bilingual children provide a unique opportunity to examine reading acquisition in two different writing systems simultaneously. Before the discussion of dyslexia in the English and Chinese languages, an introduction is given to the cross-linguistic transfer in bilingual dyslexic readers as well as to English and Chinese orthography.

Cross-Linguistic Transfer in Bilingual Dyslexic Children

Research into bilingual learners who are dyslexic learners in their L1 and who have to learn an additional foreign language has been scant (Cline, 2000; Frederickson & Frith, 1998). The Psycholinguistic Grain Size Hypothesis (PGSH) and Linguistic Coding Differences Hypothesis (LCDH) could be used to inform the understanding of how individual differences and linguistic features interact to contribute to the reading performance of individuals with dyslexia. According to the PGSH (Ziegler & Goswami, 2005), different languages vary in the orthographic consistency and grain size of the orthography–phonology correspondences that play important roles in the acquisition of reading (Goswami & Bryant, 1990; Ziegler & Goswami, 2005). The hypothesis rests on the assumption that reading in consistent orthographies involves small linguistic units, whereas reading in inconsistent orthographies requires the use of larger units as well. In consistent orthographies with strong letter-sound correspondence like English, small grain size units of processing such as single letters and phonemes are favoured, even when large unit information is available. English seems to be more inconsistent and unreliable when larger units such as syllables and rimes are utilized. However, inconsistent languages, such as Chinese, favor larger grain size units because of the linguistic properties of a morphosyllabic script (also called logographic). There have been some recent demonstrations that, as predicted by the PGSH, the awareness of phonemes tends to be strongly associated with word recognition in English (Adams, 1990; Castles & Coltheart, 2004; Perfetti, Beck, Bell, & Hughes, 1987). In contrast, syllable awareness seems to be important for reading of Chinese and English (McBride-Chang, Bialystok, Chong, & Li, 2004) as well as Greek (Adinis & Nunes, 2001). These findings are in line with part psycholinguistic grain size theory (Ziegler & Goswami, 2005), which suggests that the way in which speech is represented in orthography influences the importance of different psycholinguistic units for word recognition in that script. Hence, the relevance of different-sized phonological units for reading different orthographies may have various implications for dyslexic bilinguals.

In addition to the PGSH, the Foreign Language Linguistic Coding Differences Hypothesis (LCDH) developed by researchers (Sparks & Ganschow, 1991; Sparks, Ganschow, & Pohlman, 1989) could be used to explain the problems and variations in foreign language acquisition. This posits L1 difficulties as the cause and predictor of L2 difficulties. Therefore, individuals who have learning difficulties in L1 will show similar problems in L2 (da Fontoura & Siegel, 1995). Several studies (e.g. Ganschow, Sparks & Schmeider, 1995; Sparks & Ganschow, 1991) strongly suggest that individuals who fail to reach a high level of proficiency in a foreign language may display a range of linguistic coding deficits founded upon phonological, orthographic and syntactic skills resulting from their weak L1 skills as is seen in the work of Sparks, Ganschow and Pohlman (1989). van der Leij and Morfidi (2006) found further evidence to support the transferability of difficulties in L1 Dutch phonological skills to L2 English as well as showing a low level of orthographic competence and rapid naming for both languages among poor bilingual readers. This suggests that the problem of dyslexic readers in foreign language learning may be phonologically-based, like the core cause of their difficulties in native language learning. If this is the case, this may imply cross-linguistic transfer and general processing skills, specifically phonology, morphology, orthography and naming speed across different languages.

Emerging research evidence in support of the LCDH also comes from cross-linguistic research showing L1 phonological knowledge might influence L2 reading. Increasing evidence from biliteracy acquisition of children learning to read in French-English (Comeau et al., 1999), Spanish–English (Durgunoglu, Nagy, & Hancin-Bhatt, 1993) and Portuguese–English (da Fontoura & Siegel, 1995) has been found for cross-language transfer of phonological processing skills which contributes to phonological skills and reading in both L1 and L2. More recently this facilitation from L1 to L2 phonology has also been shown in research on two different writing systems like L1 Chinese and L2 English. A few studies of bilingual Chinese-English children (e.g., Gottardo, Yan, Siegel, & Wade-Woolley, 2001) found cross-linguistic contribution of phonological awareness. The bi-directional transfer of phonological skills appears to be found across different orthographic systems and this supports the notion of a universal phonological core across different writing systems (Perfetti, Zhang, & Berent, 1992). This transfer suggests that dyslexic bilinguals, who have phonological deficits in one language, may fail to transfer necessary phonological skills to another language, thus resulting in reading difficulties in both languages.

Apart from the cross-language transfer of phonological skills, morphological and visual-orthographic skills may transfer from one language to reading in another language. For example, a study conducted by Deacon, Wade-Woolley and Kirby (2007) investigated the cross-linguistic transfer of morphological awareness in French and English reading for bilingual French-English readers with French as L1. They found bi-directionality in the relationship between morphological awareness and reading. Further, Wang, Cheng, & Chen (2006) found among a group of Chinese–English bilingual readers living in an English-speaking environment that English morphological skills were associated with Chinese reading, suggesting transfer of morphological skills from English L2 to Chinese L1. However, the relationship was not bidirectional as Chinese morphological awareness was not related to English reading. In a study of Korean-English bi-literacy acquisition (Wang, Park, & Lee 2006), limited orthographic transfer across the two orthographic systems that share alphabetic principles but differ in visual forms was found. Korean and English orthographic skills were not related to each other and did not predict word reading. This may reflect the differences in the orthographic features between two writing systems and possibly the correspondence between graphemes and phonemes of languages that cause different learning and reading problems. According to this account, individuals can be dyslexic in one language and not in other, since various languages produce visual, phonological and semantic differences which entail different demands on word reading. Of greatest interest, is perhaps the degree that underlying L1 deficits contribute to L2 differentially and how these deficits associate with L2 typology given the differences between the demands of cognitive processes and orthographic features of the two writing systems. It is plausible that the underlying causes of dyslexia may vary within the two different scripts.

Naming speed or rapid automatized naming (RAN) is also an important general processing skill in learning to read for a variety scripts including, English (Wagner, et al. 1997), German (Wimmer, Mayringer, & Raberger, 1999), Dutch (de Jong & van der Leij, 1999) and Chinese (Ho & Lai, 1999). Typically, RAN tasks require individuals to name orally a series of numbers, letters, colors, or objects as quickly as possible and the average time taken for all the stimuli is measured. If an individual takes much longer than average to name all the stimuli, that individual is said to have a rapid naming deficit and this is associated with reading difficulties in monolingual speakers of various languages (Bowers & Wolf, 1993). Rapid naming is usually subsumed under phonological processing, while others believe that rapid naming deficits are independent of phonology and contribute uniquely to reading deficits in some poor readers. There is clear consensus that naming speed is a core cognitive skill which could be useful in distinguishing individual variability in reading acquisition across different orthographies. Recent work has extended this to demonstrate the importance of naming speed in development of L2 word reading for Korean-English and Chinese-English speakers (Cho & McBride Chang, 2005; Gottardo, Chiappe, Yan, Siegel, & Gu, 2006). Across these studies, there is some evidence for transferability of naming speed from one language to another, giving rise to the question whether dyslexic bilinguals, who have a naming speed deficit in one language, may also suffer a naming speed deficit in another language.

Differences between English and Chinese orthographies

The Chinese writing system differs substantially in both linguistic and structural features from English which is an alphabetic system in which each graphic unit represents sound at the phonemic level. It is speech-based in that mappings between orthography and phonology are relatively transparent but mappings between orthography and meaning are usually arbitrary. In contrast, Chinese orthography is considered logographic in that the great majority of characters represent morphemes. Each basic graphic unit of Chinese is a character which is associated with a morpheme (meaning unit) and represents a syllable of spoken Chinese (DeFrancis, 1989; Mattingly, 1992; Perfetti & Zhang, 1995). It is meaning-based in that mappings between orthography and meaning are often systematic but mappings between orthography and phonology tend to be opaque. As compared to English, Chinese has a simpler phonological structure than English, with no consonant clusters (Wong & Stokes, 2001). For example, Cantonese has a simple syllabic structure of (C)V(C) with around 98% of CVC and CV structures (Wong, 1984). English script is also atonal, synthetic and inflected and contains many consonant clusters whereas Chinese is analytic, tonal and non-inflected (McBride-Chang & Kail, 2002). Moreover, unlike English, most Chinese words consist of two or more morphosyllables. More than 80% of all Chinese characters are constructed of a phonetic radical giving a clue to the sound and a semantic radical providing a clue to the character's meaning (Kang, 1993).

In English, derivational morphology and inflectional morphology are important in distinguishing and manipulating morphemes at the structure of words. Derivational morphology includes knowledge of prefixes, suffixes, and compounding (e.g., *cowboy* and *sunlight* are both compound words). In contrast, inflectional morphology is used to indicate grammatical changes in words (e.g., the *s* in *cats* or the *ed* in *asked* are both grammatical inflections). Lexical compounding is more common and important in Chinese than it is in English. The majority of Chinese words are built and compounded from two or more morphemes. Many words sharing the same morpheme such as *柳樹 [lau5 syu6] "willow", 松樹[cung4 syu6] "pine", 棕櫚樹[zung1 leoi3 syu6] "palm" with the morpheme 樹[syu6] "tree"*, are semantically related because the semantic radical of a Chinese character often provides some indication of its meaning. Also, there are many syllables that share the same homophones. Many syllables have two or more homophones which provide different meaning (Zhou, Zhuang, & Yu, 2002). For example, *身[sai1] "body"、新 [sai1] "new" and 伸 [sai1] "extend"*. Therefore the ability to identify and distinguish among these syllables with identical sounds is helpful for mapping them on to new characters in learning Chinese. Moreover, knowing the compounding of the word formation or morphological structural awareness is particularly important for learning Chinese words.

Another marked difference between Chinese and English with respect to orthographic features is that Chinese is visually more complex than English. There are only 26 letters in English but around 620 stroke-patterns (sometimes called radicals) that make up different Chinese characters. The amount of visual information contained within a Chinese character is greater than in an English word (Hoosain, 1991). In particular, the visual-spatial configuration of Chinese is in contrast with the linear structure of English. Each character is a salient perceptual unit which differs from all others in terms of the number of strokes, the number of radicals and the spatial configuration. Thus, in contrast to English where word length is a visual cue, only individual strokes of a character distinguish it visually, the space it occupies is constant. Therefore, visual-orthographic skills may be more important in learning Chinese characters than words written in an alphabetic system (Huang & Hanley, 1995; Leck, Weekes, & Chen, 1995; Tzeng & Wang, 1983).

Given the different linguistic and structural features of English and Chinese language, it is likely that there are different manifestations for dyslexia in the two writing systems, and thus further work to determine what kinds of specific cognitive deficits may be more affected in English as compared with Chinese and which deficits could be a common cause of reading difficulties in both languages is needed.

Cognitive deficits in English and Chinese developmental dyslexia

Besides the differences between English and Chinese script, there appear to be different cognitive causations for developmental dyslexia in English and Chinese. Research conducted with monolingual English-speakers with dyslexia has shown that phonological processing deficits are associated with their reading difficulties and appear to be one of the major deficient cognitive determinants of developmental dyslexia (Bradley & Bryant, 1983; Torgesen, Wagner, & Rashotte, 1994). Later, Eden et al.,(1996) have pointed out that reading difficulties may not be the result of one processing problem but of multiple problems. Also important, and perhaps a separate issue, is a deficiency in name retrieval processes, measured by a rapid automatized naming (RAN) procedure (Wolf & Bowers, 1999). This deficit in rapid naming is thought to reflect the automatization of language subprocesses and is an important independent second core deficit associated with dyslexia. Other processing deficits beyond phonological and rapid naming domain are morphological awareness and visual-orthography processing (McBride-Chang, Manis, Seidenberg, Custodio, & Doi, 1993) and these deficits play a significant role in problem reading. Much of this research has been restricted to monolingual readers in English-speaking communities. This then leads to the question of whether and to what extent dyslexic readers are differentially affected by various cognitive deficits associated with reading difficulties in non-alphabetic languages like Chinese.

The study of developmental dyslexia in Chinese concerning reading-related cognitive skills of Chinese-speaking children is relatively recent. There is increasing evidence that a number of multiple cognitive deficits associated with reading difficulties have been identified in Chinese dyslexic readers. Recent studies in Hong Kong show that individual dyslexic children can have a variety of cognitive deficits, the most dominant being rapid naming and orthographic processing (Ho, Chan, Tsang, &Lee, 2002; Ho, Chan, Lee, Tsang, & Luan, 2004). Ho et al., (2004) reported that rapid naming and orthographic processing deficits were found in 57% and 42% whereas phonological awareness deficits and visual deficits were less common, at 29% and 27%. Apart from these deficits, Luan (2005) reported that many of the Chinese dyslexic children showed deficits in morphological awareness, in addition to the cognitive deficits found previously. It was found that the three most dominant deficits among dyslexic children in Hong Kong were rapid naming (52%), morphological awareness deficits (26%) and orthographic processing deficits (24%). Perhaps these children have difficulty in identifying and discriminating morphemes, manipulating the morphemic structure and generalizing morpheme meaning, all resulting in problems in learning to read Chinese. The current research suggests that the primary problem Chinese dyslexic children seem to have is in acquiring naming speed, visual-orthographic knowledge and morphological awareness. It is likely that deficits in phonological processing are of secondary importance due to the fact that Chinese has a morphosyllabic and not an alphabetic writing system. These dominant features may have important implications for Chinese dyslexic readers learning English as L2.

Given the current research in developmental dyslexia for English and Chinese language, there appears to be both language-specific and common causes to dyslexia in both orthographies. Perhaps phonological deficit is more specific to reading difficulties in English than Chinese In support of this view, a recent study conducted by Ho & Fong (2005) found that Chinese dyslexic children in Hong Kong encountered difficulties in learning English as a second language (L2) and these children are generally weak in phonological processing both in Chinese and English. Phonological difficulties at the levels of phonemic awareness in English were found to contribute to reading difficulties in English, but this was not the case in Chinese. Perhaps the most interesting finding of this study demonstrated that different phonological units of awareness vary in their importance for reading across different orthographies as predicted by PGSH (Ziegler & Goswami, 2005). Although this research showed sign of cross-linguistic transfer of phonological skills and specific causes of reading difficulties in the two languages among Chinese-English bilingual readers, it is worthwhile to explore further whether and to what extent Chinese dyslexic children who have difficulties not just in L1 phonological processing but also in morphological awareness, visual-orthographic knowledge and rapid naming show similar difficulties in L2 English acquisition. In summary, the findings of the aforementioned research suggest that the transferability of naming speed, phonological and morphological awareness from L1 to L2 is possible while evidence of transfer of visual-orthographic knowledge skills have been found to a lesser extent. In the present study we design comparable measures to tap into both common and reading-related cognitive skills of the two writing systems.

Research aims

The present study aimed to examine the degree of concomitance in reading difficulties in L1 Chinese and L2 English for Chinese–English bilinguals in Hong Kong and explore cross-linguistic transfer of reading-related cognitive skills in acquiring two very different writing systems. Our study was the first of its kind to investigate whether the cross-linguistic transfer of reading-related cognitive skills in bilingual reading acquisition could occur not only at the phonological-processing level but also at the orthographic, meaning, and speed processing level. We focused on Chinese children who were in the process of learning L1 Chinese and L2 English in Hong Kong primary schools. We tested children's L1 Chinese and L2 English phonological awareness, visual-orthographic knowledge, morphological awareness, naming speed and word reading. This study addressed four primary research questions: (a) Whether the severity of reading difficulties in Chinese related to the severity of reading difficulties in English among bilingual children? (b) How different processing deficits of visual-orthographic knowledge, rapid naming, phonological and morphological awareness manifested in L1 and L2 among bilingual dyslexic children? (c) Whether visual-orthographic knowledge, rapid naming phonological and morphological awareness assessed in L1 transferred to reading in L2 and (d) Whether and to what extent basic reading-related cognitive skills could predict word reading in L1 and L2? According to the PGSH, we expected that all tasks of phonological awareness would be related to reading in both Chinese and English and in turn common deficiencies in the phonological domain would be found in both languages among dyslexic bilinguals. At the same time, deficits in phonological awareness (especially at the phonemic level) were hypothesized to be more specific to reading problems in English than in Chinese given the constraints of each orthography

(Ziegler & Goswami, 2005). Based on the LCDH, we also argued that individuals who had difficulties in acquiring literacy in L1 would encounter difficulties when they learned to read L2. When transferability was assumed, we expected that Chinese-English bilingual children who had low performance on the measures of L1 phonological awareness, morphological awareness, visual-orthographic knowledge and rapid naming would exhibit similarly low performance on the same tasks in English as L2. We also predicted that these reading-related cognitive skills would be related to reading in the L1 and L2 and these skills could be transferred across two languages. We therefore examined within- and cross-linguistic contributions of reading-related cognitive skills to word reading among Chinese-English bilingual children.

Method

Participants

The participants, 84 Cantonese-speaking Chinese primary school students in Hong Kong, were divided into 3 groups. Details of the characteristics of the children are described in Table 1. All of these children had Chinese as their native language and had attended local primary schools where Cantonese was the teaching medium. Cantonese is a tonal dialect without formal written representation. There is no equivalent phonic system like Pinyin for Cantonese, and phonic instructions for Chinese are not often introduced in kindergarten and primary schools in Hong Kong. Typically, Cantonese reading instruction proceeds by memorization of characters or the “look and say” method (Holm & Dodd, 1996). All of the children learned English as a second language in kindergartens starting from 3 or 4 years of age. They did not generally receive phonics training in their learning of English and learned to read English through a similar "look and say" method. Hence, the correspondence between letters and phonemes was not explicitly taught. English vocabularies, grammatical structures and written English have been the main focus in Hong Kong school curriculum across kindergarten and primary schools. Nevertheless, Hong Kong remains a monolingual community in that very little English is spoken outside of the classroom.

The Dyslexic group comprised 28 participants (16 boys and 12 girls) whose ages ranged from 9 to 11 years; mean age was 9 years 9 months. The children, who were referred by the local education authority, were diagnosed with developmental dyslexia by professional psychologists in accordance with the diagnostic criteria set out in the Hong Kong Test of Specific Learning Difficulties in Reading and Writing (HKT-SpLD) (Ho, Chan, Tsang, & Lee, 2000). This test battery is used to assess Cantonese-speaking Chinese children with dyslexia in Hong Kong, from Primary 1 to Primary 4. It is a standardized test consisting of 5 domains including 3 literacy (Chinese word reading, One-minute reading and Chinese word dictation), 1 rapid naming (Digit rapid naming), 2 phonological awareness (Rhyme detection and Onset detection), 3 phonological memory (Word repetition, Nonword repetition I, and Nonword repetition II) and 3 orthographic skills subtests (Left/right reversal, Lexical decision and Radical position). Together with four subtests (Visual discrimination, Visual closure, Visual-spatial relationship, and Visual memory) in the Gardner's (1996) Test of Visual-Perceptual Skills (Non-motor) Revised (TVPS-R), there were one composite score on literacy and six composite scores separately on naming speed, phonological awareness, phonological memory, orthographic knowledge, visual perception and visual memory. The seven composite scores provided a profile of literacy and cognitive skills for children. To be diagnosed as dyslexic in Chinese, the child’s literacy composite score and at least one cognitive composite score had to be at least one standard deviation below the means of their respective age in the HKT-SpLD and TVPS-R. Participants in the Dyslexic group fulfilled this diagnostic criterion and all of them had normal intelligence on Raven’s Standard Progressive Matrices (i.e., with IQs of 85 or above). The children were carefully screened to make sure that they had sufficient learning opportunities (e.g. new immigrants were excluded) and they did not have any suspected brain damage, uncorrected sensory impairment, or serious emotional or behavioural problems.

The comparison control group comprised 56 normally-achieving children who were recruited from the four representative primary schools in Hong Kong. These children were divided into the chronological age (CA) and the reading level (RL) control group. The CA group comprised 28 participants (12 boys and 16 girls), and the remaining 28 students were in the RL control group (15 boys and 13 girls). The ages in the CA group ranged from 9 to 11 years; mean age was 9 years 9 months. Ages of the RL group ranged from 6 to 10 years; mean age was 7 years 8 months. According to their class teachers and the school administrators, these children had no history of literacy problems, developmental dyslexia or any other type of learning difficulty or psychopathology in childhood. Neither had they been received in any special educational service. These 56 children who had grade-appropriate reading achievement and normal intelligence were carefully selected to match the Dyslexic group on age, IQ and word reading level. The raw scores of Chinese word reading subtest from the HKT-SpLD and Raven’s matrices were used to match the

Dyslexic and control groups. The mean age of RL group was lower than that of the Dyslexic group. The CA group performed better than the Dyslexic group in the Chinese word reading ($p<.001$). There was no significant difference between the IQ of the dyslexic and control groups, as shown in Table 1.

Materials and Procedures

The participants were administered 13 measures for both English and Chinese script including a standardized test of nonverbal intelligence, four phonological awareness tasks, two morphological awareness tasks, two visual-orthographic tasks, two rapid automatized naming (RAN) tasks and two word reading tasks. Except for the nonverbal intelligence test and visual-orthographic tests, all other tasks were administered individually. The parents' or guardians' consents for children participation were obtained before testing. Trained experimenters conducted all assessments.

Nonverbal Intelligence Measure

Raven's Standard Progressive Matrices. Raven's Standard Progressive Matrices is a standardized test of nonverbal intelligence. It consists of 60 matrices divided into 5 sets, and the participant is required to complete all questions in the test. Each matrix contains a missing part. They need to choose the best one to complete the matrix from 6 or 8 alternatives. The test is scored based on the local norm established by the Hong Kong Education Department in 1986.

Reading Measures

English Word Reading. Because there is no standardized English word reading test in Hong Kong, 80 English words were selected based on four sets of the most popular English reading textbooks used in primary school level arranged in ascending order of difficulty. These words were selected based on variety in length and their occurrence in graded textbooks from Grade 1 to 6. All items in this test were real words ranging in length from 2 letters to 9 letters (e.g. bus, ball, watch, delicious etc.). Words at the start of the test that were typically short and frequently used in early graded textbooks (Grade 1 - 3), whereas words later in the test were typically longer and found mainly in higher grade textbooks (Grade 4 – 6). To better utilize administration time, the children started with the set that was appropriate for their grade level in terms of difficulty. Basal and ceiling rules were applied: If the children erred in more than two-thirds of the items in a set, they did not progress to the next difficulty level (ceiling); if they erred in fewer than 11 items in a set, they progressed onto the next level (basal). The participants were required to read the words aloud one by one. The list of English word is showed in Appendix 1.

Chinese Word Reading. This word reading subtest was from the HKT-SpLD. The participants were asked to read the 150 two-character words aloud in ascending order of difficulty. The test was discontinued when the children failed to read 15 words consecutively.

Rapid Naming Measures

English Rapid Letter Naming. This task was originally conceptualized by Denckla and Rudel (1974) to measure serial rapid automatised naming (RAN). English letters were used because these were familiar to the children. These letters were taught at kindergarten. Eight rows of 26 lowercase letters (e.g. a, c, f, i, etc) were printed on a piece of white A4 paper in a random order. The children were asked to read from left and right and line to line and to name the letters as quickly as possible without making mistakes. The task was repeated twice, and the average time was taken.

Chinese Rapid Digit Naming. This was measured by using the Digit Naming subtest from the HKT-SpLD. Eight rows of five Arabic digits (2, 4, 6, 7, and 9) were printed on a piece of white A4 paper in a random order. The children were instructed to say the number names aloud in order on the sheet from beginning to end as accurately and quickly as possible. Each child named each list twice, and the score was the average naming latency across the two trials.

Phonological Awareness Measures

English Phoneme Deletion. The idea for developing this test was taken from Muter and Snowling (1997). This task, which consisted of 14 items with 7 initial and 7 final phoneme deletion from single real English words,was presented orally in a randomized order. The participants heard a word first and then were asked how this word would sound without a certain sound. The children were asked to produce a new word by deleting the initial or final phoneme. For example, for initial phoneme deletion, the children were asked to say “back” without the sound /b/. The answer was /ack/; for final phoneme deletion, the participants were asked to say “half” without the sound /lf/. The answer was /ha/. The test ended when the children failed to answer three consecutive items.

English Rhyme Detection. For the 12 trials of this task, the participants were instructed to listen while a cassette player repeated three monosyllabic words twice.The children were asked to indicate among the three items which two sounded similar. An example for this task is “toy, boy, cold”. The answer was “toy and boy”. This task was similar to those tasks from Muter and Snowling (1997).

Chinese Rhyme Detection and Onset Detection. For both tasks, the participants heard three Chinese syllables presented through a cassette player, similar to the English Rhyme Detection task described above. There were 15 trials for each task. The children were asked to indicate among the three syllables which two sounded similar (e.g., [sau]1, [fo]1, [fung]1 in onset detection and [gaam]1, [bing]1, [daam]1 in rhyme detection). The answers were “fo and fung” and “gaam and daam”. This task was similar to those used in analyzing Chinese syllable into rhyme and onset (Ho & Bryant, 1997).

Morphological Awareness Measures

English Morphological Construction. In this task, 14 scenarios were presented in two- to four-sentence stories. This task was modified from those used by McBride-Chang, Wagner, Muse, Chow & Shu, (2005). The participants were then asked to come up with words for the objects or concepts presented by each scenario. One example of the items is this: A tree that grows "apples" is called an "apple tree". What do we call a tree that grows "donuts"? The correct response item was "donut tree".

.

Chinese Morphological Construction. The procedure was the same as for the English Morphological Construction but the items used were different. The stimuli set included 20 items, similar to those used by McBride-Chang, Shu, Zhou, Wat, & Wagner (2003). One example was: "朝頭早既時候日頭出嚟，我哋叫佢做日出。咁夜晚既時候月亮出嚟，我哋會點叫佢呀？" which means "Early in the morning, we can see the sun coming up. This is called a sunrise. At night, we might also see the moon coming up. What could we call this?" The correct response item was "moonrise".

Visual-Orthographic Knowledge Measures

English Orthographic Choice. This task contained 20 single real English words and 20 single homophonic pseudowords with similar word shape to the real word. Each pseudoword was constructed by combining different illegal vowels and illegal letter positions at the beginning and ending of this word. Examples consisted of the following: slow, slou and dlow. The children were then asked to cross out all the nonwords. This task was based on the concept originated from Olson, Kliegl, Davidson, and Foltz (1985).

Chinese Orthographic Choice. This subtest was from the HKT-SpLD. There were 30 rare characters and 30 noncharacters. These items were two-radical characters and non-characters of left-right structure. Each non-character was constructed by forming a semantic radical and a phonetic radical from different characters in their illegal positions (e.g. 蒦亻), two semantic radicals (e.g. 虫氵), or two phonetic radicals(e.g. 甬亥) . The children were then asked to cross out all the noncharacters.

Results

Firstly, the means, standard deviations (S.D.) and F-values for all tests were calculated in both Chinese and English languages for the Dyslexic, CA and RL control group. Secondly, intercorrelations among all measures for three groups were presented. Thirdly, the analyses of partial correlation were calculated for both languages for bilingual dyslexic children. Fourthly, a series of multiple regression analyses were conducted to examine within-language relationships between phonological awareness, visual-orthographic knowledge, morphological awareness and rapid naming performance, and reading performance in Chinese and English. Finally, regression analyses investigated cross-language transfer of the four reading-related cognitive variables across these languages.

Coefficients alpha were calculated for each of the measures in the present sample. For the rapid naming tasks, the reliability estimates were test–retest reliabilities. For all other tasks in both Chinese first (L1) and English second (L2) language, the internal consistency reliabilities were presented in Table 2. The tasks provided adequate reliability generally and did not show any apparent floor or ceiling effects.

Comparisons of the three groups for reading Chinese as L1

A multivariate analysis of variance was conducted to examine group differences in the various Chinese word reading and cognitive measures including rhyme detection, onset detection, orthographic choice, morphological construction and rapid digit naming. The effect of group was significant, Wilks' Λ = 0.13, F (12, 152) = 22.39, p < .001, partial η^2 = .64 and separate analyses of variance were used to examine each task (see Table 2). Follow up with the post hoc comparisons were Bonferroni-adjusted using a significance level (*p* =0.02) to account for multiple comparisons, resulting in the overall probability of making a type I error rate or experiment-wise error rate of 5% (*p* = .05). Bonferroni-adjusted post hoc comparisons revealed that the dyslexic group was significantly worse than the CA group but similar to the RL group on most of the measures. The only area where the dyslexic group performed significantly worse than the RL control group, was orthographic choice and rapid digit naming. This suggests that on average the Chinese dyslexic children seemed to have a serious problem in rapid naming and visual-orthographic knowledge in reading Chinese.

Comparisons of the three groups for reading English as L2

A multivariate analysis of variance showed that overall group differences were significant for all English measures in word reading, phoneme deletion, rhyme detection, orthographic choice, morphological construction and rapid letter naming, Wilks' Λ = 0.11, *F* (12, 152) = 25.49, *p* < .001, partial η^2 = .67. For each task an analysis of variance and post hoc contrasts were conducted to pinpoint differences among the groups. Bonferroni-adjusted post hoc analyses indicated that Chinese dyslexic children had significantly more difficulties in all the tasks as compared with the CA control group (see Table 2). They performed even worse than the RL control group in the rapid letter naming.

Correlations between reading-related cognitive and word reading skills for the three groups

Table 3 shows the correlations for all variables with children's age and IQ statistically controlled. Several features of the correlations are noteworthy. Correlations between the measures of rapid naming, visual-orthographic knowledge, phonological and morphological awareness were modest to strong within each Chinese and English language. Apart from this, it is also interesting to note correlations in tasks purportedly measuring similar constructs across languages. The cross-language correlations of rapid naming, visual-orthographic knowledge, phonological and morphological awareness in L1 and L2 word reading were strongly associated. These results provided initial evidence indicating the possible cross-linguistic transfer. Also, the Chinese and English word reading were strongly associated, perhaps suggesting that learning to read in a first and second language develops dependently in Hong Kong children.

Analyses of reading performance among dyslexic children

Partial correlation analysis was also conducted to examine whether the severity of reading difficulties in Chinese related to the severity of reading difficulties in English among the bilingual dyslexic children. Partial Pearson's correlations were therefore computed separately for L1 and L2. The correlations among word reading and reading-related cognitive skills with children's age and IQ statistically controlled are presented in Table 4. Correlations between Chinese word reading and Chinese phonological awareness were not significant, with the exception of moderate to strong correlations between Chinese word reading, visual-orthographic knowledge, rapid naming and morphological awareness. In contrast, English word reading was moderately to strongly associated with English phonological awareness. These results suggest that difficulties in phonological awareness may contribute to reading difficulties in English, but this may not be the case in Chinese. Also, English word reading was correlated with rapid naming, visual-orthographic knowledge and morphological awareness. In addition to this, rapid naming was related to both L1 and L2 word reading, indicating that the retrieval of phonological and orthographic information from lexical memory is an important processor in L1 and L2 reading. Furthermore, the measures of Chinese word reading were moderately associated with English word reading as shown in Table 4. It is evident that there are both common and specific causes of reading difficulties in Chinese and English. These results suggest that if children have severe difficulties in learning to read Chinese, they tend to have similarly great difficulties in learning English as a second language.

Within-language contributions of L1 and L2 word reading for the three groups

Separate hierarchical regression analyses were performed for Chinese and English word reading, as shown in Table 5. A series of multiple hierarchical regression analyses for the three groups of children were conducted using the Chinese and English reading measure as the dependent variable. Control measures including age and IQ were included in the regression equations. We examined the extent to which phonological awareness, morphological awareness, visual-orthographic skills and rapid naming would explain unique variance in word reading for both Chinese and English. These reading-related cognitive measures were entered with phonological awareness first because it is best established as a strong correlate of reading across orthographies (e.g., Bryant & Bradley, 1985; Ho, Law, & Ng, 2000), visual-orthographic skills and morphological awareness were second and third, because they have been shown to be strongly related to Chinese and English reading more recently (e.g., McBride-Chang et al., 2003; Shu, McBride-Chang, Wu, & Liu, 2006), and finally rapid naming. We included rapid naming as the final cognitive correlate because it is a powerful correlate of reading ability and strong predictor of both concurrent and future reading development in Chinese and English (e.g., Georgiou, Parrila, & Kirby, 2006; Ho & Lai, 1999). Bowers and Newby-Clark (2002) have also suggested that rapid naming plays a crucial role in lexical or whole word processing. Therefore, the control variables of age of children and Raven's matrices measure were entered as the first block into each regression analysis. The measures of phonological awareness, visual-orthographic skills, morphological awareness and rapid naming were then entered in the second, third, fourth and fifth block respectively.

With respect to reading Chinese, regression analysis was conducted to examine whether phonological awareness, visual-orthographic knowledge, morphological awareness and rapid naming would explain unique variance in word reading. As shown in Table 5, the regression analysis indicated that the four Chinese cognitive skills explained significant variables in Chinese word reading ability: age, IQ (R^2 = 0.183), rhyme and onset detection (additional variance explained = 0.195), orthographic choice (additional variance explained = 0.197), morphological construction (additional variance explained = 0.130) and rapid digit naming (additional variance explained = 0.020). Table 5 shows that the four English reading-related cognitive skills contributed significant variables to English word reading ability: age, IQ (R^2 = 0.130), rhyme detection and phoneme deletion (additional variance explained = 0.328), orthographic choice (additional variance explained = 0.235), morphological construction (additional variance explained = 0.032) and rapid letter naming (additional variance explained = 0.120). This pattern was similar to the Chinese word reading. Table 5 shows that the four reading-related cognitive skills are important predictors of reading ability in both languages.

Cross-linguistic contributions of L1 and L2 word reading for the three groups

To assess the predictions further, a final series of hierarchical regression analyses examined cross-language predictors as displayed in Table 6. These analyses were conducted to investigate whether the four reading-related cognitive skills could be transferred from one language to the other in learning to read. In order to examine the cross-transfer of metalinguistic skills from L2 to L1, the unique effect of the four English cognitive skills on Chinese word reading was investigated. For predicting Chinese word reading, the order of entry was age and IQ as the first block. Next, the four Chinese cognitive tasks were entered in the second block as control measures. This was then followed by the English measures of rhyme detection and phoneme deletion, orthographic choice, morphological construction and rapid letter naming as entered in the third, fourth, fifth and sixth block respectively. As shown in Table 6, the English cognitive skills explained no unique variance in Chinese word reading. Thus cross-linguistic transfer did not occur for Chinese word reading.

Similarly, in analyses of cross-linguistic skills from L1 to L2, we examined whether the unique variance in English word reading could be accounted for by the Chinese cognitive skills. The Chinese cognitive skills were unique and significant predictors of English word reading even after the four English cognitive tasks were taken into consideration (see Table 6). For predicting English word reading, the results of regression analysis showed the age, IQ (R^2 = 0.130), the four English cognitive tasks as control variables (additional variance explained = 0.716), rhyme and onset detection (additional variance explained = 0.22), orthographic choice (additional variance explained = 0.024), morphological construction (additional variance explained = 0.027) and rapid digit naming (additional variance explained = 0.029). The cross-language results indicate the influence from L1 to L2 and suggest that Chinese meta-linguistic skills facilitate in learning to read English.

Discussion

The present study investigated the degree of concomitance of reading difficulties between the L1 Chinese and L2 English and also cross-linguistic transfer of reading-related cognitive skills, specifically in visual-orthographic knowledge, phonological and morphological awareness and rapid naming, between L1 and L2 among Chinese-English bilinguals. Despite the differences between the Chinese and English writing system, common underlying abilities affecting L1 reading could also have an impact on L2 reading. Our study provides evidence indicating that this group of Chinese-English dyslexic children has difficulties learning English as L2. These children are generally weak in rapid naming, visual-orthographic knowledge, phonological and morphological awareness in both languages. The present results are consistent with the Linguistic Coding Differences Hypothesis (LCDH), which argues for language base consisting of various orthographic, phonological and morphological features in explaining linguistic ability. Difficulties in one or more of these features could affect the acquisition of L2 reading. Thus, Chinese dyslexic children would have difficulties with learning L2 resulting from deficient linguistic coding and general processing problems in their L1 and the cross-linguistic transfer deficits from L1 to L2, which subsequently interfere with their L2 learning. Apart from some evidence of cross-language transfer, our study also demonstrates that the relative importance of psycholinguistic units for reading acquisition depends on the languages to be learned (Goswami, 1999; Ziegler & Goswami, 2005).

Our results indicated that the concomitance rate of reading problems in the two languages was high despite the fact that Chinese and English are very distinctive scripts. It appears that Chinese dyslexic children have a high risk of learning difficulty for L2. Similarly, the dyslexic children's severity of reading difficulties in L1 is reflected in the severity of their reading difficulties in L2. These children also perform poorly in visual-orthographic knowledge, rapid naming, phonological and morphological awareness for both Chinese and English. This finding adds to our existing knowledge of cross-linguistic transfer from L1 to L2. We provide further evidence for cross-language transfer of deficits in reading-related cognitive skills between two languages. Previous research evidence has shown that visual-orthographic knowledge, phonological and morphological awareness skills are important in learning to read both English and Chinese (e.g., Hu & Catts, 1998; McBride-Chang & Ho, 2000) and deficits in rapid naming are also common among both English and Chinese dyslexic readers (Ho & Lai, 1999; Ho et al., 2002, 2004). These data support the notion of a universal phonological core (Perfetti, Zhang, & Berent, 1992) and the LCDH's view that individuals with impairments in such skills would have difficulties learning to read both L1 and L2.

Although deficits in phonological skills were found among this group of dyslexic children, phonological difficulties in Chinese were not associated with the problems in Chinese reading. In contrast, English phonological difficulties at the phonemic level were strongly related to reading in English script which is represented at the level of the phoneme. Chinese script is represented by the large grain size or linguistic units at the level of the syllable, onset and rime and as such does not require access to the more fine-grained units of language at the phonemic level (Wydell & Butterworth, 1999). Consequently, it seems that Chinese dyslexic children have difficulties learning L2 English because of their phonological difficulties at the phonemic level, whereas this difficulty is not a main cause of their dyslexia problem in Chinese. This supports the notion that phonemic awareness is crucial for learning alphabetic English, but not for non-alphabetic Chinese. Findings in the present study underscore the importance of different phonological units for reading different orthographies as predicted by the Psycholinguistic Grain Size Hypothesis (PGSH) (Ziegler & Goswami, 2005). Furthermore, these data are compatible with the findings that phonological difficulties are less related to reading in Chinese but more in English for Chinese-English dyslexic children (Ho & Fong, 2005). While phonological deficit seems to be more specific to reading problems in English, rapid naming deficit may be a common cause of reading difficulties in both languages. This suggests that naming speed is a general form of processing skills that is common for learning any script, while other specific meta-linguistic processes may need to be acquired for each language.

Significant correlations between rapid naming, visual-orthographic knowledge, phonological and morphological awareness were found to be related within both L1 Chinese and L2 English. These correlations suggest that there may be shared reading-related cognitive skills and this in turn helps to learn both scripts. Our results also demonstrated that in learning to read L1 and L2, rapid naming, visual-orthographic knowledge, phonological and morphological awareness predicted unique variance in word reading after controlling for age and IQ. This result highlights the important role of these reading-related cognitive skills in learning to read for both languages and is consistent with existing literature that links rapid naming, visual-orthographic, phonological and morphological skills and reading skills in monolingual speakers and Chinese-speaking ESL children (Siegel & Ryan, 1988; Stanovich & Siegel, 1994; Wagner & Torgesen, 1987). Furthermore, our study contributed additional evidence for cross-language transfer of rapid naming, visual-orthographic knowledge, phonological and morphological awareness among this group of Chinese-English speakers in Chinese-speaking environments. Although there was evidence for cross-language transfer showing that Chinese reading-related cognitive skills explained unique variance in English word reading, there was no additional cross-language contribution for Chinese word reading from English cognitive tasks. This transfer of meta-linguistics was only observed in the direction from L1 to L2, but not from L2 to L1. We argued that the children's L1 proficiency was likely to be higher than their L2 proficiency as they were mostly in early grades in primary schools and living in Chinese-speaking environments. Therefore these children who tended to rely on their L1 knowledge and strategies to process and learn L2 would transfer their reading-related cognitive skills from a strong L1 to the weak L2 language. These data are consistent with work on bilingual and biliteracy acquisition showing transfer of language and literacy skills from L1 to L2 (Durgunoglu et al., 1993). This cross-language transfer implies that specific meta-linguistic processes are universally relevant to any scripts.

Our study has limitations that should be taken into account. First, across all measures administered, the dyslexic children did not differ in performance levels from their reading level matched controls. Similar findings have been demonstrated in previous studies (e.g., Ho et al., 2002; Ransby & Swanson, 2003). However, this finding is somewhat problematic for arguing about causality in reading. It is likely that dyslexia implies a general lag, rather than a permanent deficit, in a variety of cognitive and perceptual skills among Chinese children. Support for this conclusion can only be obtained through longitudinal studies, some of which follow dyslexics into adulthood. It should be noted that the present study only reported correlational data where the language- and reading-related tasks were administered simultaneously. Therefore we cannot make any suggestion on directionality of the relationship between visual-orthographic knowledge, phonological and morphological awareness and bilingual literacy acquisition. To better understand this relationship, future research needs to address the issue of bidirectional relationships and examine the predictive power of reading-related cognitive skills in reading acquisition in biliteracy acquisition over time. Another limitation of this study was that there were differences in the format and number of stimuli used in rapid naming tasks (RAN) for letter and digit naming. Such differences between the English RAN task (all 26 letters, presented 5 times each) and the Chinese RAN task (5 Arabic digits, presented 8 times each) could have influenced performance. It might be that children were slower at naming the letters than digits. Although the children learned English language in kindergarten schools from age 3, not all of the children were familiar with all the 26 letters at that juncture, particularly those letters that occur less frequently (e.g., x, z, y, j, etc.) thus reducing the possibility of confounding letter knowledge with RAN abilities. Methodological differences in the present study may have affected the performance. Nevertheless, future studies should consider matching the design and format of both RAN tasks for letters and digits. Finally, both tasks of rapid digit naming and rapid letter naming are required to be administered in Chinese and English respectively. Also, further work may examine the role of rapid naming transfer across two scripts with a common measure of rapid naming such as the rapid picture naming task.

Despite these limitations, overall, the results of this study are meaningful both theoretically and practically. Theoretically, we have demonstrated that Chinese bilingual dyslexic children seem to have quite a high concomitance rate of reading difficulties in Chinese (L1) and English (L2). Our results also showed that these children are characterized by poorer reading-related cognitive processes: rapid naming, visual-orthographic knowledge, phonological and morphological awareness skills in L1 and L2. Poorer results for these cognitive processes may be indicative of a language "core" common to both Chinese and English. Results of our findings corroborate the premise of the LCDH. What is unique about this study is also the fact that the cross-language transfer is between the two different orthographies. Despite this transfer, however, we have also demonstrated the relative importance of different-sized phonological units in relation to word recognition in both L1 and L2 within the sample of dyslexic bilinguals. The current research provides evidence for basic underlying reading-related cognitive processes that influence L1 and L2 reading acquisition. Cross-linguistic transfer of cognitive processes across L1 to L2 transcends the linguistic differences that exist between them. The ability to apply strategic knowledge of processing one language to another language seems to occur irrespective of the two different writing systems. These basic underlying L1 processes are likely to be strong predictors of L2 word reading. Practically, such results suggest that early detection of poor L1 reading related skills could also help in identifying at-risk readers who may have difficulties in L2 skills. Therefore, researchers and educators might consider incorporating such L2 meta-linguistic awareness and general processing measures into their standard evaluation batteries. Carefully designed instructional programs taking into account these cognitive skills could enhance successful learning and teaching of Chinese and English as a second language acquisition.

Reference

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

Adinis, A., & Nunes, T. (2001). The role of different levels of phonological awareness in the development of reading and spelling in Greek. *Reading and Writing: An interdisciplinary Journal, 14*, 145-177.

Bowers, P.G., & Newby-Clark, E. (2002). The role of naming speed with a model of reading acquisition. *Reading and Writing: An Interdisciplinary Journal*,15,109–126.

Bowers, P., & Wolf, M. (1993). Theoretical links among naming speed, precise timing mechanisms and orthographic skill in dyslexia. *Reading and Writing: An Interdisciplinary Journal, 5*, 69-85.

Bradley, L., & Bryant, P. (1983). Categorizing sound and learning to read – a causal connection. *Nature, 301*, 419-421.

Bradley, L., & Bryant, P. (1985). Rhyme and reason in reading and spelling. Ann Arbor, MI.: The University of Michigan Press.

Castles, A., & Coltheart, M. (2004). Is there a causal link from phonological awareness to success in learning to read? *Cognition, 91*, 77-111.

Cho, J. R., & McBride-Chang, C. (2005). Levels of phonological awareness in Korean and English: A 1-year longitudinal study. *Journal of Educational Psychology, 97*, 580-590.

Cline, T. (2000). Multilingualism and dyslexia: Challenges for research and practice. *Dyslexia, 6*, 3-12.

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.

D' Angiullia, A., Siegel, L., & Serra, E. (2001). The development of reading in English and Italian in bilingual children. *Applied Psycholinguistics, 22(4)*, 479-507.

Da Fontoura, H. A., & Siegel, L. S. (1995). Reading, syntactic, and working memory skills of bilingual Portuguese-English Canadian children. *Reading & Writing, 7*, 139-153.

Deacon, S. H., Wade-Woolley, L., & Kirby, J. (2007). Crossover: The role of morphological awareness in French immersion children's reading. *Developmental Psychology, 43*(3), 732-746.

DeFrancis, J. (1989). *Visible speech: The diverse oneness of writing systems*. Honolulu, HI: University of Hawaii Press.

de Jong, P. F., & van der Leij, A. (1999). Specific contributions of phonological abilities to early reading acquisition: Results from a Dutch latent variable longitudinal study. *Journal of Educational Psychology, 91(3),* 450-476.

Denckla, M. B., & Rudel, R. (1974). Rapid "automatized" naming of pictured objects, colors, letters and numbers by normal children. *Cortex, 10*(2), 186-202.

Durgunoglu, A. Y., Nagy, W. E., & Hancin-Bhatt, B. J. (1993). Cross-language transfer of phonological awareness. *Journal of Educational Psychology, 85*(3), 453-485.

Eden, G., Vanmeter, J. W., Rumsey, J. M., Maisog, J. M., Woods, R. P., & Zeffro, T.A. (1996). Abnormal processing of visual motion in dyslexia revealed by functional brain imaging. *Nature , 382(6586),* 66-69.

Frederickson, N., & Frith, U. (1998). Identifying dyslexia in bilingual children: A phonological approach with inner London Sylheti speakers. *Dyslexia: An International Journal of Research and Practice, 4,* 119-131.

Ganschow, L., Sparks, R., & Schneider, E. (1995). Learning a foreign language: challenges for students with language learning difficulties. *Dyslexia: International Journal of Research and Practice, 1,* 75-95.

Gardner, M. F. (1996). *Test of visual-perceptual skills, (non-motor)*. U.S.A.: Psychological and Educational Publications, Inc.

Georgiou, G., Parrila, R., & Kirby, J. (2006). Rapid naming speed components and early reading acquisition. *Scientific Studies of Reading, 10,* 199–220.

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. In U. Goswami (Series Ed.), *Essays in development psychology series* (pp.151-158). Hillsdale, NJ: Lawrence Erlbaum Associates.

Gottarde, A., Chiappe, P., Yan, B., Siegel, L., & Gu, Y. (2006). Relationships between first and second language phonological processing skills and reading in Chinese-English speakers living in English-speaking contexts. *Educational Psychology*, *26*(3), 367-393.

Gottardo, A., Yan, B., Siegel, L. S., & Wade-Woodley, L. (2001). Factors related to English reading performance in children with Chinese as a first language: More evidence of cross-language transfer of phonological processing, *Journal of Educational Psychology*, *93*(3), 530-542.

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

Ho, C. S.-H., Chan, D. W.-O., Tsang, S.-M., & Lee, S.-H. (2000). *The Hong Kong Test of Specific Learning Difficulties in Reading and Writing.* Hong Kong: Hong Kong Specific Learning Difficulties Research Team.

Ho, C. S.-H., Chan, D. W.-O., Lee, S.-H., & Tsang, S.-M., Luan, V. H. (2004). Cognitive profiling and preliminary subtyping in Chinese developmental dyslexia. *Cognition, 91*, 43-75.

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

Ho, C. S.-H., & Fong, K. M. (2005). Do Chinese Dyslexic Children Have Difficulties Learning English as a Second Language? *Journal of Psycholinguistic Research, 34*(6), 603-618.

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.

Ho, C. S-H., Law, T. P-S., & Ng, P. M. (2000). The phonological deficit hypothesis in Chinese developmental dyslexia. *Reading and Writing*, *13*, 57-79.

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

Hoosain, R. (1991). *Psycholinguistic implications for linguistic relativity: A case study of Chinese*. Hillsdale, NJ, England: Lawrence Erlbaum Associates, Inc.

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.

Kang, J. S. (1993). Analysis of semantics of semantic-phonetics compound characters in modern Chinese. In Y. Chen (Ed.), *Information analysis of usage of characters in modern Chinese.* Shanghai: Shanghai Education Publisher.

Leck, K. J., Weekes, B. S., & Chen, M. J. (1995). Visual and phonological pathways to the lexicon: Evidence from Chinese readers. *Memory and Cognition, 23*(4), 468-476.

Luan, H. (2005). The role of morphological awareness among Mandarin-speaking and Cantonese specking children (Doctoral dissertation, The University of Hong Kong, 2006).

Mattingly, I. G. (1992). Linguistic awareness and orthographic form. In R. Frost & L. Katz (Eds.), *Orthography, phonology, morphology, and meaning: Advances in psychology* (pp. 11-26). Oxford, England: North-Holland.

McBride-Chang, C., Bialystok, E., Chong, K. K. Y., & Li. Y. P. (2004). Levels of phonological awareness in the three cultures. *Journal of Experimental Child Psychology*, *89*, 93-111.

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

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

McBride-Chang, C., Manis, F. R., Seidenberg, M. S., Custodio, R. G., & Doi, L. M. (1993). Print exposure as a predictor of word reading and reading comprehension in disabled and nondisabled readers. *Journal of Educational Psychology*, *85,* 230-238.

McBride-Chang, C., Shu, H., Zhou, A., Wat, C.-P., & Wagner, R. K. (2003). Morphological awareness uniquely predicts young children's Chinese character recognition. *Journal of Educational Psychology, 95*, 743-751.

McBride-Chang, C., Wagner, R. K., Muse, A., Chow, B. W.-Y., & Shu, H. (2005). The role of morphological awareness in children's vocabulary acquisition in English. *Applied Psycholinguistics, 26(3)*, 415-435.

Muter, V. & Snowling, M. (1997). Grammar and phonology predict spelling in middle childhood. *Reading and Writing, 9*(5-6), 407-425.

Olson, R. K., Kliegl, R., & Davidson, B. J., & Foltz, G. (1985). Individual and developmental differences in reading disability. In G. E. MacKinnon & T. G. Walker (Eds.), *Reading research: Advances in theory and practice* (pp. 1-64). New York: Academic Press.

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

Perfetti, C. A., & Zhang, S. (1995). Very early phonological activation in Chinese reading. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21*(1), 24-33.

Perfetti, C. A., Zhang, S., & Berent, I. (1992). Reading in English and Chinese: Evidence for a "universal" phonological principle. In R. Frost, & L. Katz, (Eds.), *Advances in* *psychology: Orthography, phonology, morphology, and meaning* (pp. 227-248). Oxford: North-Holland.

Ransby, M. J., & Swanson, H. L. (2003). Reading Comprehension Skills of Young Adults with Childhood Diagnoses of Dyslexia. *Journal of Learning Disabilities, 36(6)*, 538-555.

Seymour, P. H. K. (1998). Beyond the phonological deficit hypothesis. *Child Psychology & Psychiatry Review*, *3*(1), 22-23.

Shu, H., McBride-Chang, C., Wu, S., & Liu, H. (2006). Understanding Chinese developmental dyslexia: Morphological awareness as a core cognitive construct. *Journal of Educational Psychology 98*, 122-133.

Siegel, L. S., & Ryan, E. B. (1988). Development of grammatical-sensitivity, phonological, and short-term memory skills in normally achieving and learning disabled children. *Developmental Psychology*, *24*, 28-37.

Sparks, R. L., & Ganschow, L. (1991). Foreign language learning differences: Affective or native language aptitude differences? *Modern Language Journal*, *75*, 3-16.

Sparks, R., Ganschow, L., & Pohlman, J. (1989). Linguistic coding deficits in foreign language learners. *Annals of Dyslexia*, *39*, 179-195.

Stanovich, K. E., & Siegel, L. S. (1994). Phenotypic performance profile of children with reading disabilities: A regression-based test of the phonological-core variable-difference model. *Journal of Educational Psychology, 86(1),* 24-53.

Torgesen, J. K., Wagner, R. K., & Rashotte, C. A. (1994). Longitudinal studies of phonological processing and reading. *Journal of Learning Disabilities, 27*, 276-286.

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

van der Leij, A & Morfidi, E. (2006). Core Deficits and Variable Differences in Dutch Poor Readers Learning English. *Journal of Learning Disabilities, 39*, 74-90.

Wang, M., Cheng, C., & Chen, S.-W. (2006). Contribution of morphological awareness to Chinese-English biliteracy acquisition. *Journal of Educational Psychology, 98*, 542-553.

Wang, M., Park, Y., & Lee, K. R. (2006). Korean-English biliteracy acquisition: Cross-language phonological and orthographic transfer. *Journal of Educational Psychology*, *98*, 148-158.

Wanger, R. K., & Torgesen, J. K. (1987). The nature of phonological processing and its causal role in the acquisition of reading skills. *Psychological Bulletin, 101(2),* 192-212.

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(3),* 468-479.

Wimmer, H., Mayringer, H., & Raberger, T. (1999). Reading and dual-task balancing: Evidence against the automatization deficit explanation of developmental dyslexia. *Journal of Learning Disabilities, 32(5),* 473-478.

Wolf, M., & Bowers, P. G. (1999). The double-deficit hypothesis for the developmental dyslexia. *Journal of Educational Psychology, 91,* 415-438.

Wong, S. L. (1984). *A Chinese syllabary pronounced according to the Dialect of Canton*, Hong Kong: Chung Hwa Books.

Wong, W. W. Y., & Stokes, S. F. (2001). Cantonese consonantal development: Towards a nonlinear account. *Journal of Child Language*, *28*(1), 195-212.

Wydell, T. N. & Butterworth, B. L. (1999). A case study of an English-Japanese bilingual with monolingual dyslexia. *Cognition, 70,* 273-305.

Zhou, X., Zhuang, J., & Yu, M. (2002). Phonological activation of disyllabic compound words in the speech production of Chinese. *Acta Psychologica Sinica, 34*, 242-247.

Ziegler, J. C., & Goswami, U. (2005). Reading acquisition, developmental dyslexia, and skilled reading across languages: A psycholinguistic grain size theory. *Psychological Bulletin*, *131*(1), 3-29.

Table 1.

Characteristics of the Three Groups of Participants

Characteristics	Reliability	Dyslexics (*n* = 28)		CA controls (*n* = 28)		RL controls (*n* = 28)		*F(2,81)*	Post hoc comparison
		M	*SD*	*M*	*SD*	*M*	*SD*		
Age (years; months)		9:9	8.01	9:9	6.65	7:8	18.37	27.94***	D=CA, D>RL
Age range (years; months)		(8:8-10:8)		(8:9-11:0)		(5:9-9:5)			
Raven's matrices (raw score)		99.71	6.86	101.93	5.44	100.93	10.57	.55	D=CA, D=RL
Chinese Word Reading (raw score)	0.96	76.86	28.47	122.39	11.87	82.68	23.20	34.63***	D<CA, D=RL

Note. Split-half reliability is reported for Chinese word reading from subtests of HKT-SpLD (Ho, Chan, Tsang, & Lee, 2000).

**p*<.05. ***p*<.01. ****p*<.001.

Table 2.

Reliability Coefficients, Mean Scores, and Standard Deviations on Various Tasks for the Dyslexic Group, the CA Control Group, and the RL Control Group and F Values for Group Differences on Various Measures

Task	Reliability	Dyslexics (*n* = 28)		CA controls (*n* = 28)		RL controls (*n* = 28)			
		M	*SD*	*M*	*SD*	*M*	*SD*	*F(2,81)*	Post hoc comparison
Chinese									
Chinese Morphological Construction	0.83	9.18	2.55	13.18	2.31	9.61	3.68	15.97***	D<CA, D=RL
Chinese Rapid Digit Naming	0.91	27.73	8.92	14.44	2.44	19.09	4.53	36.02***	D>CA, D=RL
Chinese Rhyme Detection	0.75	11.43	2.67	14.68	2.21	12.00	2.92	12.30***	D<CA, D=RL
Chinese Onset Detection	0.69	7.39	2.39	10.68	3.12	8.64	2.92	9.64***	D<CA, D=RL
Chinese Orthographic Choice	0.74	24.93	4.78	45.61	3.94	32.32	4.79	150.49***	D<CA, D=RL
English									
English Word Reading	0.98	18.56	11.66	62.89	10.22	49.46	9.56	128.92***	D<CA, D<RL
English Morphological Construction	0.81	5.21	1.79	8.75	2.46	5.68	3.01	16.95***	D<CA, D=RL
English Letter Naming	0.88	37.54	15.79	19.06	3.97	25.98	8.07	22.16***	D>CA, D=RL
English Rhyme Detection	0.87	5.82	2.29	8.54	2.20	5.93	2.67	11.53***	D<CA, D=RL
English Phoneme Deletion	0.72	3.50	2.05	7.43	3.71	18.79	4.03	11.81***	D<CA, D=RL
English Orthographic Choice	0.70	12.54	3.72	28.68	5.89	10.93	2.83	85.88***	D<CA, D=RL

Note. Split-half reliability is reported for rapid naming and visual-orthographic knowledge which are tapped by subtests of HKT-SpLD (Ho, Chan, Tsang, & Lee, 2000).

$^*p<.05$. $^{**}p<.01$. $^{***}p<.001$.

Table 3.

Correlations among Variables Controlling for Ages and IQ

Variables	1	2	3	4	5	6	7	8	9	10	11	12
						Chinese tasks						
1. Chinese Word Reading	---											
2. Chinese Morphological Construction	.67***	---										
3. Chinese Rapid Digit Naming	-.64***	-.51***	---									
4. Chinese Rhyme Detection	.40***	.33**	-.45***	---								
5. Chinese Onset Detection	.40***	.19	-.42***	.43***	---							
6. Chinese Orthographic Choice	.65***	.45***	-.58***	.33***	.43***	---						
						English tasks						
7. English Word Reading	.69***	.63***	-.67***	.45***	.55***	.77***	---					
8. English Morphological Construction	.41***	.36***	-.41***	.25*	.35**	.50***	.55***	---				
9. English Rapid Letter Naming	-.58***	-.53***	.76***	-.38***	-.41***	-.53***	-.69***	-.45***	---		.	
10. English Rhyme Detection	.43***	.29**	-.37***	.42***	.44***	.36***	.50***	.36***	-.28**	---		
11. English Phoneme Deletion	.34**	.30**	-.36***	.22*	.39***	.39***	.50***	.34**	-.34**	.50***	---	
12. English Orthographic Choice	.58***	.51***	-.46***	.32**	.30**	.79***	.67***	.45***	-.39***	.37***	.29**	---

**p*<.05. ***p*<.01. ****p*<.001.

Table 4.

A Matrix of Partial Correlation Coefficients for the Dyslexics (n=28) after Controlling for the Differences in Age and IQ

	Chinese Word Reading	English Word Reading
Chinese Word Reading		0.53**
Chinese Rhyme Detection	0.16	0.38
Chinese Onset Detection	0.18	0.36
Chinese Rapid Digit Naming	-0.63***	-0.52**
Chinese Morphological Construction	0.59**	0.32
Chinese Orthographic Choice	0.54**	0.22
English Rhyme Detection	0.19	0.47*
English Phoneme Deletion	0.17	0.78***
English Rapid Letter Naming	-0.53**	-0.69***
English Morphological Construction	0.29	0.50*
English Orthographic Choice	0.23	0.44

*p<.05.**p<.01; ***p<.001

Table 5.

Within-Language Analysis: Hierarchical Regression Equations Predicting Chinese and English Word Reading

	Chinese Word Reading		English Word Reading	
Variable	R Square	R Square Change	R Square	R Square Change
Step 1: Age, Raven	.183	.183***	.130	.130*
Step 2: Phonological Awareness (Chinese Rhyme Detection; Chinese Onset Detection / English Rhyme Detection; English Phoneme Deletion)	.368	.195***	.341	.328***
Step 3: Visual-orthographic Knowledge	.565	.197***	.577	.235***
Step 4: Morphological Construction	.694	.130***	.609	.032*
Step 5: Rapid Naming (Rapid Digit Naming / Rapid Letter Naming)	.714	.020*	.729	.120***

*p<.05. **p<.01. ***p<.001.

Table 6.

Cross-Language Analysis: Hierarchical Regression Equations Predicting Chinese and English Word Reading

Variable	R Square	R Square Change
	Chinese Word Reading	
Step 1: Age, Raven	.183	.183***
Step 2: Chinese Orthographic Choice; Chinese Rapid Digit Naming; Chinese Rhyme Detection; Chinese Onset Detection and Morphological Construction	.714	.530***
Step 3: English Rhyme Detection and Phoneme Deletion	.723	.009
Step 4: English Orthographic Choice	.723	.000
Step 5: English Morphological Construction	.723	.001
Step 6: English Rapid Letter Naming	.723	.000
	English Word Reading	
Step 1: Age, Raven	.130	.130*
Step 2: English Orthographic Choice; English Rapid Letter Naming; English Rhyme Detection; English Phoneme Deletion and Morphological Construction	.729	.716***
Step 3: Chinese Rhyme Detection and Chinese Onset Detection	.752	.022*
Step 4: Chinese Orthographic Choice	.775	.024**
Step 5: Chinese Morphological Construction	.802	.027**
Step 6: Chinese Rapid Digit Naming	.830	.029*

*$p<.05$. **$p<.01$. ***$p<.001$.

Appendix 1 - English Word Reading

	Word		Word		Word		Word
Kindergarten 2 - Primary 1		22	sing	48	talk	71	delicious
		23	cold	49	pick	72	expensive
1	go	24	beautiful			73	invitation
2	boy	25	rain	**Primary 4 – Primary 6**		74	celebrate
3	egg	26	swim			75	huge
4	pencil	27	name	50	boat	76	patient
5	cat	28	listen	51	king	77	dessert
6	fish	29	eat	52	party	78	famous
7	pig	30	buy	53	tell	79	wardrobe
8	bus	31	watch	54	take	80	suggest
9	apple	32	family	55	show		
10	orange	33	walk	56	quiet		
11	monkey	34	put	57	enjoy		
12	tree	35	live	58	turn		
13	cook	36	water	59	stand		
14	big	37	make	60	visit		
		38	write	61	light		
Primary 2 – Primary 3		39	window	62	ear		
		40	short	63	favourite		
15	sun	41	give	64	kind		
16	school	42	feel	65	kite		
17	ball	43	clean	66	leave		
18	doctor	44	like	67	cross		
19	mouse	45	friend	68	tail		
20	hot	46	sit	69	weather		
21	long	47	draw	70	festival		