COGNITIVE PREDICTORS OF READING ACHIEVEMENT IN CHINESE ENGLISH IMMERSION STUDENTS

by

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Abstract

The cognitive processes underlying reading achievement in Chinese English immersion students are not yet clear. This study investigated the effects of phonological awareness (PA) and naming speed (NS) on reading achievement and explored the evidence for cross-linguistic transfer in Chinese English immersion students. In addition, the differences between immersion and non-immersion students on Chinese measures were examined. The participants were 135 English immersion students and 103 non-immersion students from Grades 2, 4, and 6 in mainland China. For English immersion students, English predictors proved to be strong predictors of English reading achievement at the three grade levels. However, the unique predictors of English reading achievement were English PA in Grades 2 and 4, but English NS in Grade 6. Chinese PA was a significant predictor of Chinese achievement, but only in Grade 2. There was little evidence of cross-linguistic transfer. With regards to the Chinese performance of the two groups of students, English immersion students demonstrated an advantage over non-immersion students in Grade 6, but no significant differences were found in Grades 2 and 4; these results suggest either the long-term effect of a bilingual program or a selection effect. Results are discussed in terms of theories of reading development, and suggestions are offered for overcoming the limitations of the present study in future research.

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CHAPTER 1: INTRODUCTION

English is widely regarded today as the main language of international communication. English as a Second or Foreign Language instruction for children at an early age is becoming more common worldwide. Under such circumstances, it is imperative to have innovative and advanced methods of teaching English to students in their early years, which is particularly true for a country like China in which English is not the first language.

Research has demonstrated that bilingual education, which involves teaching all subjects in school through two different languages with varying amounts of each language used in accordance with the program model, has advantages in students' literacy development both in the mother tongue and target language (Bialystok, Luk, & Kwan, 2005). The goals of bilingual education can be achieved in many ways, immersion education being one of them (Swain, 2000). French immersion programs have prospered in Canada for over three decades and demonstrated that immersion is a feasible method of assisting preschool and primary school students to advance their language proficiency, literacy, and other subjects without eliminating competence in their first language (Cummins, 1999; Lapkin, Hart, & Swain, 1991; Swain, 1996). French Immersion programs in Canada have been adopted as a model of second language learning in China, yet few research studies have investigated the differences between immersion students and non-immersion students on their L1 achievement and the cognitive processes involved in early English immersion programs in China.

For many years, research on early reading ability mainly focused on the predictive power of phonological skills. These skills include phonological awareness, which refers to the ability to manipulate the sounds in words and the awareness of the sound structure of words, and phonological decoding, which enables the reader to convert written words into oral language by analyzing individual graphemes into their corresponding phonemes (Adams, 1990; Wagner, Torgesen, & Rashotte, 1994). Therefore, these two provide a solid foundation for word reading. However, researchers recently have found that phonological processes are not sufficient to explain all of the variance in reading ability. In particular, naming speed and orthographic processing come to the forefront. Some researchers (e.g., Wolf & Bowers, 1999; Johnston & Kirby, 2006) have argued that naming speed is a precursor of orthographic processing and makes a unique contribution to reading performance independent of phonological awareness. A specific important issue is whether phonological awareness and naming speed are associated with different aspects of reading, with phonological awareness being more related to phonological decoding (Wagner et al., 1994; Wagner, et al., 1997) and naming speed being more related to orthographic processing (e.g. Bowers & Wolf, 1993; Bowers & Newby-Clark, 2002; Manis, Seidenberg, & Doi, 1999). Although there is considerable evidence that phonological awareness and naming speed are crucial to word reading (Scarborough, 1998; Share & Stanovich, 1995; Wagner et al., 1994; Wagner et al., 1997), several studies (e.g. Kirby, Parrila, & Pfeiffer, 2003; Torgesen, Wagner, Rashotte, Burgess, & Hecht, 1997) have shown that phonological awareness and naming speed predict both word reading and reading comprehension. In addition, word reading is highly correlated with reading comprehension because the meaning of text must depend on accurately apprehending the individual words of the text. Poor reading comprehension can be expected as a result of deficiencies in word reading (Shankweiler et al., 1999). This study used reading comprehension as the outcome measure.

Recently, the relationship of cross-linguistic transfer between L1 and L2 in terms of phonological awareness and naming speed has been paid more attention by some researchers (Cisero & Royer, 1995; Comeau, Cormier, Gottardo, Yan, Siegel, & Wade-Woolley, 2001; Grandmaison, & Lacroix, 1999; Durgunoglu, Nagy, & Hancin-Bhatt, 1993; McBride-Chang & Ho, 2005; Wade-Woolley & Geva, 2000). They argued that phonological awareness and naming speed in L1 and L2 correlated with each other, transferred cross-linguistically, and could predict reading development in children's L1 and L2.

Hence, the primary purpose of the current study was to investigate the relations between cognitive processes, i.e., phonological awareness and naming speed both in English and Chinese, and English or Chinese reading achievement in Chinese English immersion students and explore the cross-linguistic transfer. The secondary purpose was to examine the differences in Chinese acquisition (Chinese cognitive skills, Chinese achievement, and Chinese mathematics achievement) between immersion students and non-immersion students.

CHAPTER 2: LITERATURE REVIEW

English Immersion Program

Bilingual education has been defined as “schooling provided fully or partly in a second language with the object in view of making students proficient in the second language while, at the same time, maintaining and developing their proficiency in the first language and fully guaranteeing their educational development” (Stern, 1972). Depending on the social, linguistic, educational, and political contexts, these goals of bilingual education can be achieved in many ways, immersion education being one of them (Swain, 2000).

The purpose of immersion is to allow children who speak the language of the majority at home to achieve proficiency in another language (Swain, 1996). Immersion is distinct from traditional approaches to bilingual education because the second language is not only explicitly taught but is also the medium of curriculum instruction (Genesee, 1985). The French immersion programs in Canada vary in form (Qiang & Siegel, 2004). They can start once the child in kindergarten or Grade 1 (early immersion) or after a number of years of schooling in the mother tongue (late immersion). They can also vary in the quantity of teaching time in the second language (total vs. partial immersion) (Comeau, Cormier, Grandmaison, & Lacroix, 1999). French immersion programs have prospered in Canada for over three decades, fostered by the educational, political, and economic motives of those involved. They take several forms, but the underlying common element is that students study for at least 50 percent of the content material such as mathematics, history, geography, and science using French (Swain, 2000). Originally, parents, school administrators, and researchers paid attention to whether immersion was feasible at all and whether it was detrimental to learning to read in the mother tongue and to academic achievement in general. However, research in French immersion programs has shown that immersion is an effective means of facilitating preschool and primary school students' language proficiency and literacy without any detrimental effects to their first language (Cummins & Carson, 1997; Lapkin, Hart & Turnbull, 2003; Swain, 1996; Turnbull, Lapkin, & Hart, 2001). For example, in a study with Grade 3 French immersion students, Turnbull et al. (2001) found that French immersion students performed equal to their monolingual peers on English language arts and mathematics when the formal instruction in English language arts started since Grade 3 although immersion students demonstrated a certain lag in English literacy skills in Grades 1 and 2. Moreover, Lapkin et al. (2003) indicated that at Grade 6, immersion students' literacy and mathematics test scores were better than their peers' in English-only programs.

Recent studies have also focused on the cognitive predictors of reading ability in French and English. MacCoubrey, Wade-Woolley, Klinger, and Kirby (2004) indicated that phonological awareness and naming speed in English (L1) could predict reading performance in French (L2) for French immersion students in the primary grades. In Bruck and Genesee's (1995) study, an advantage was found for the kindergarten children in the French programs over monolingual English-speaking kindergarten children on phonological awareness.

Although there is an abundance of research on French immersion programs in Canada, only limited studies of immersion programs in the Chinese context have been investigated. The result from Singapore showed that Singaporean students, who have

English as the primary language of instruction in most schools (which could be considered as total early immersion because the children begin instruction through the medium of English beginning in kindergarten), scored higher than any other students from English-speaking countries on tests of math and science (Gupta, 1994).

Although the majority of published studies have reported an advantage for early immersion programs, there has been some research on late immersion programs showing negative effects on content subjects. Marsh, Hau, and Kong (2000) evaluated the effectiveness of late English immersion in Hong Kong in terms of the English and Chinese performance with 12,784 middle school students. They argued that late immersion in English as the language of instruction had large negative effects on non-language subjects (mathematics, science, geography, and history). This result challenged the generality of previous findings for positive effects of early immersion programs to high schools in Hong Kong.

In 1998, early English immersion programs, modeled after French immersion programs in Canada, were carried out in elementary schools in several major Chinese cities, such as Beijing, Shanghai, Guangzhou, and Xi'an, attempting to expose students to more English input at an earlier age. Early immersion leads to early acquisition of the second language (Genesee, 1991) and attainment of high levels of proficiency in that language (Genesee, 1995). At the present time, almost 30,000 students are enrolled in English immersion programs in both public and private schools in China (Cheng, Li, Kirby, Wade-Woolley, & Qiang, 2008).

Chinese children in English immersion programs learn to read in a language different from the one spoken at home. Little is known about the cognitive mechanisms involved in this learning. The present study mainly investigated the relations of cognitive processes underlying reading achievement in Chinese English immersion students. The following sections will give an overview of the literature regarding the two critical cognitive predictors (phonological awareness and naming speed) of reading development to English-speaking children, children speaking different languages learning to read in their first language (L1) and children learning to read concurrently in their L1 and/or in an L2.

Cognitive Processes in Reading in English

An abundance of research literature on English reading development has shown that learning to read English requires mastering the processes of manipulating the sounds in words and mapping graphemes onto phonemes (Adams, 1990). This mastery contains a variety of related skills such as establishing various phonological processing skills (Adams, 1990; Wagner et al., 1994). Phonological processing skills are usually assessed by measuring how individuals can manipulate sub-lexical elements (e.g., phonemes, syllables, onsets, and rimes) by deleting, counting, detecting, segmenting, or substituting elements (Shankweiler, 1999). Wagner and Torgesen (1987) identified three major types of phonological processing skills: phonological awareness, phonological recoding in lexical access (further to be denoted as rapid naming), and short-term verbal memory. There is substantial evidence that the relationships between phonological processing and reading are mutually enhancing (e.g., Goswami & Bryant, 1990; Wagner et al., 1994). The purpose of the current study is mainly to investigate the power of phonological awareness and naming speed to predict reading performance in the Chinese English immersion program.

Phonological Awareness

Phonological awareness (PA) refers to the ability to recognize that spoken words can be broken down into syllables, intra-syllabic units, and phonemes as well as the ability to talk about, reflect upon, and manipulate these components (Adams, 1990; Goswami & Bryant, 1990; Kirby et al., 2003; Wagner, Torgesen, Laughon, Simmons, & Rashotte, 1993). It can be measured using tasks that involve identification and manipulation of speech sounds, such as detecting the initial or final sound in a word, saying a word with the deletion of one phoneme, or putting sounds together to form a word.

An extensive body of research has established a relationship between phonological awareness and early reading acquisition (for reviews, see Adams, 1990; Goswami & Bryant, 1990; Kirby et al., 2003; Scarborough, 1998; Share & Stanovich, 1995; Torgesen et al., 1997; Wagner et al., 1993; Wagner et al., 1994; Wagner et al., 1997). There is a reasonable agreement among the researchers that phonological awareness is the most prominent and powerful concurrent and longitudinal predictor of word decoding in early reading development. For example, in a 5-year longitudinal study, Wagner and his colleagues (1997) demonstrated different relations between phonological processing abilities and English word reading among 216 children assessed annually from kindergarten through fourth grade. They provided evidence that phonological awareness was related to word-level reading and the individual differences in phonological awareness are important in explaining variability in the growth of early word-reading skills at least through fourth grade which is consistent with their previous finding that strong causal influences of phonological awareness on word decoding (Wagner, et al., 1994). Later, Burgess and Lonigan (1998) conducted a 1-year study on bidirectional relations of phonological awareness and pre-reading abilities with 97 children aged 4 to 5. They showed that phonological awareness predicted growth in letter knowledge and letter knowledge contributed to growth in phonological awareness when controlling for children's age and oral language abilities (Burgess & Lonigan, 1998). Evidence cited above showed that phonological awareness is a significant predictor of word reading ability.

However, phonological awareness is not only related to word reading, but is also associated with reading comprehension. For example, Torgesen et al. (1997) demonstrated that individual differences in phonological awareness in both Grades 2 and 3 did uniquely explain word-reading development and reading comprehension two years later. In another longitudinal study, Kirby, Parrila, and Pfeiffer (2003) followed 79 children from kindergarten to Grade 5. After controlling for general mental ability and letter recognition, kindergarten PA was a strong individual predictor of both word reading and reading comprehension from kindergarten to Grade 5 (Kirby et al., 2003). In addition, Ehri et al. (2001) summarized the effects of PA instruction on learning to read from 52 studies published in peer-reviewed journals showing that PA instruction benefits not only word reading but also reading comprehension because reading comprehension depends on effective word reading. However, the effects of PA instruction on reading comprehension are not as strong as on word reading because the relationship between PA and reading comprehension is indirect.

Naming Speed

There is considerable evidence that naming speed (NS), also known as rapid automatized naming (RAN) or speed of lexical access, the speed at which children can name a set of stimuli, such as digits, letters, colors, or pictured objects is a unique and strong predictor of reading development (e.g., Bowers & Wolf, 1993; Bowers & Newby-Clark, 2002; Bowers, Sunseth, & Golden, 1999; Johnston & Kirby, 2006; Kirby et al., 2003; Manis, Seidenberg, & Doi, 1999; Scarborough, 1998; Wagner et al., 1997; Wolf & Bowers, 1999). In NS tasks, participants must verbally name the items as quickly as possible. It has been used in many research studies as a marker and longitudinal predictor of reading ability (e.g., Kirby et al., 2003; Schatschneider, Fletcher, Francis, Carlson, & Foorman, 2004).

The best known measures of NS are the Rapid Automatized Naming Tests (RAN; Denckla & Rudel, 1976), in which participants are asked to name a set of visual stimuli (digits, letters, colors, or objects), presented in random order, as quickly as possible. Torgesen et al. (1997) argued that RAN contributed a unique variance to word reading and reading comprehension but when the autoregressive effects of prior reading skills were factored out, RAN no longer accounted for any variance in any of the reading outcome measures. However, Manis et al.'s (1999) study indicated that when vocabulary and prior word-reading skill was factored out, RAN still accounted for variance in later word reading and reading comprehension. Some researchers have found that RAN tasks containing alphanumeric stimuli (i.e., letters or digits) have a stronger relationship with reading than RAN tasks involving non-alphanumeric stimuli (i.e., colors or objects) (e.g., Bowey, McGuigan, & Ruschena, 2005; Cardoso-Martins & Pennington, 2004; Savage & Frederickson, 2005). Van den Bos, Zijlstra, and lutje Spelberg (2002) examined the relations between naming speed of 4 stimulus types (letters, numbers, pictures, and colors) and word reading speed at the various age levels. They found that the increase of the relation between word reading speed and naming speed applies to alphanumeric naming stimuli only and not to non-alphanumeric stimuli. Meyer, Wood, Hart, and Felton (1998) stated that "number-letter scores are, on their face, more likely to reflect the impact of early learning to read, including alphabet mastery, whereas color-object scores are less obviously related to prior alphabet or reading mastery itself" (p. 96). The differentiation between NS stimuli appears because in the course of elementary education both reading and arithmetic practices interact with naming speed development of letters and numbers in particular.

However, two issues remain controversial in the reading literature with regards to phonological awareness and naming speed. One issue has to do with the disagreement as to the extent to which rapid automatized naming is seen as a phonological construct or is independent of phonological processing skills. Wagner, Torgesen, and their colleagues have argued that RAN tasks assess the rate of access to and retrieval of stored phonological information in long-term memory (or speed of lexical access). Wagner et al. (1997) explained that with increasing skill and practice beginner readers become more fluent and their word recognition skills become automatized, resulting in a decrease in variability in naming speed and therefore in a decrease in the role of rapid automatized naming in explaining variance in word recognition. Therefore, they see RAN as part of the phonological processing construct along with phonological awareness and phonological memory.

On the other hand, rapid automatized naming seems to be associated more with orthographic processing skills than with phonological processing skills (e.g., Manis et al., 1999; Uhry, 2002). Researchers such as Bowers and Wolf and their colleagues (Bowers & Wolf, 1993; Bowers, et al., 1999; Wolf & Bowers, 1999) acknowledge the importance of phonological processes in word recognition, but argue that naming speed makes a unique contribution to reading comprehension, independent of phonological awareness, and slow naming speed is also an important characteristic of some poor readers. Further, these researchers proposed the double deficit hypothesis, according to which some readers are poor at phonological processing, others are primarily poor in naming speed, and some have a deficit in phonological processing as well as in naming speed. They came to the conclusion that naming speed contributes to reading development, independent of phonological awareness. For example, Manis et al. (1999) demonstrated in their computational model that rapid automatized naming accounts for independent, distinct variance in predicting reading performance over and above phonemic awareness.

The second issue has to do with the separate roles of phonological and orthographic processing skills in reading. In general, reading literature has confirmed the role of phonological processing skill as an essential factor for word reading and reading comprehension. Orthographic processing has been defined as the ability to use the visual-orthographic information in the orthographic structure of words when processing written code (Levy, Gong, Hessels, Evans, & Jared, 2006; Wagner & Barker, 1994). Based on the methodological problems (Berninger, 1994), it is difficult to devise orthographic tasks without a phonological component because they are highly integrated in reading. Despite this problem, recent studies have shown that orthographic processing skills explained variance in reading independent of phonological processing skills (Barker, Torgesen, & Wagner, 1992; Bowers & Newby-Clark, 2002; Cunningham, Perry, & Stanovich, 2001).

Phonological and Orthographic Processing Skills

With respect to the relation between phonological processing skill and orthographic processing skill, Ehri (1997) classified the development of English word learning into five phases. They are: (1) the pre-alphabetic phase, (2) the partial-alphabetic phase, (3) the full-alphabetic phase, (4) the consolidated-alphabetic phase, and (5) the automatic-alphabetic phase. The pre-alphabetic phase, which is also called the logographic phase, describes the period of preschoolers who have little working knowledge of the alphabetic system, in which words are treated as pictures. The partial-alphabetic phase refers to the time of kindergartners and first graders who have basic working knowledge of the alphabetic system but lack full knowledge. The full-alphabetic phase characterizes students in first grade and beyond who have working knowledge of the major grapheme-phoneme units in English (Ehri & McCormick, 1998). The partial-alphabetic and the full-alphabetic phase are very dependent upon phonological processing skill. The consolidated-alphabetic phase and the automatic-alphabetic phase belonging to orthographic processing skill characterize students in the second grade or above, who are mature readers, possessing decoding and recognizing most words in text automatically; these phases are dependent upon orthographic processing skill. These phases describe the development of word learning and provide a framework for the investigation of phonological processing and orthographic processing skills in children learning English.

With regard to the impact of PA and NS in early reading development, Kirby and his colleagues (2003) indicated that the effect of PA is greatest in early grades, declining thereafter. The initial relationship between naming speed and reading ability is weaker but increased with grade level (Kirby et al., 2003).

The following section includes studies comparing children speaking different languages learning to read in their first language (L1) and studies concerned with children learning to read concurrently in their L1 and/or in an L2.

Cognitive Processes in Reading across Languages

L1-Based Cognitive Processes in Reading Research

Dozens of studies have indicated that phonological awareness and naming speed are significant predictors of English early reading achievement (for reviews, see Adams, 1990; Kirby et al., 2003; Scarborough, 1998; Wagner et al., 1993; Wolf & Bowers, 1999). Some studies also suggest that the role of phonological processing skills in learning to read may be universal. Phonological awareness is not only related to learning to read in English, but evidence indicates that it is an important factor in learning to read in various alphabetic languages such as French, Italian, Spanish, Dutch, Turkish, Hebrew, and Swedish (e.g., Durgunoglu & Oney, 1999; Sprenger- Charolles, Siegel, & Bonnet, 1998; de Jong & van der Leij, 1999; Wimmer, Mayringer, & Landerl, 2000, respectively). For example, in a longitudinal study of Dutch children from kindergarten through the second grade, de Jong and van der Leij (1999) found that Grade 1 phonological awareness contributed to the subsequent reading achievement after several months' reading instruction. In another study comparing Turkish and American 5-7 year old children, Durgunoglu and Oney (1999) found that the children's abilities to segment and delete phonemes in words were of the same importance for word recognition accuracy in Turkish and English. The knowledge of phonological awareness correlated with the word decoding ability of children in both countries. Moreover, both groups' children in Grade 1 performed better on the phonological awareness tasks than children in kindergarten.

There is not too much research available on the role of rapid naming in different alphabetic languages. However, research on German (Wimmer, Mayringer, & Landerl, 2000) and Dutch (de Jong & van der Leij, 1999) suggests that rapid naming may play a more prominent role than phonological awareness in predicting reading achievement in children who learn to read shallow orthographies in which there is a relatively simple one to one correspondence between letters and sounds. For example, in a longitudinal study of German children, Wimmer et al. (2000) indicated that naming-speed deficits measured in Grade 1 did affect reading fluency in Grade 3 but phonological awareness deficits did not. Similarly, in another longitudinal study of Dutch children, de Jong & van der Leij (1999) found that small but nonspecific effects of rapid naming ability on subsequent reading achievement were revealed in kindergarten but rapid naming ability appeared to be independent of phonological awareness to reading achievement in Grade 1.

It seems clear that phonological awareness and naming speed are two important parts of learning to read, at least for alphabetic languages. However, their importance to reading is not specific to alphabetic orthographies. Rather, there is some evidence that phonological processing skills extend as well to nonalphabetic scripts, such as Chinese (Chan & Siegel, 2001; Hu & Catts, 1998). Learning to read Chinese characters was thought to be achieved primarily by visual-orthographic process (Huang & Hanley, 1994; Wang & Geva, 2003) because Chinese is considered a logographic system, visual skills are said to be crucial for learning to read in Chinese (Huang & Hanley, 1994). However, there is now strong evidence for phonological skills not only in alphabetic languages but also in other writing systems. Research has shown that early phonological skills are useful in predicting accurate word recognition in Chinese primary level children (Ho & Bryant, 1997a, b; Hu & Catts, 1998; McBride-Chang, & Kail, 2002; McBride-Chang & Ho, 2000; Shu, Anderson, & Wu, 2000). For example, Ho and Bryant (1997a) examined the development of phonological awareness of Chinese children and its relationship with their success in reading. They found that Chinese children, like English-speaking children, are able to detect relatively large sound segments when they begin to acquire reading skills and that they gradually develop the ability to manipulate smaller units (Ho & Bryant, 1997a) which is consistent with the results showing that phonological processing skills were important in understanding variability in reading Chinese characters (Hu & Catts, 1998). In another study, Ho and Bryant (1997b) found that pre-reading phonological skills predicted children's reading performance in Chinese significantly two and three years later, even after controlling for the effects of age, IQ, and mother's education. The authors suggest that the main reason for this relationship is that phonological knowledge helps children to use the phonetic components in Chinese characters. Furthermore, in a study comparing Chinese and American kindergarten students, McBride-Chang and Kail (2002) reported the strongest predictor of reading was phonological awareness and naming speed was weakly associated with reading in each group. The result of the model that predicted reading in a Chinese child's native language (Chinese) was remarkably similar to the model that predicted reading in an American child's native language (English). They argued that despite diversities of culture, language, and orthography, models of early reading development were similar across cultures (McBride-Chang & Kail, 2002).

As to the relationship between rapid naming speed and Chinese character recognition accuracy and fluency, Liao, Georgiou, and Parrila (2008) administered four RAN tasks (colors, digits, Zhu-Yin-Fu-Hao, characters) (Zhu-Yin-Fu-Hao is an auxiliary system used in Taiwan to represent the sounds of the Chinese characters), and two character recognition tasks to 63 Grade 2 and 54 Grade 4 Taiwanese children and they found that graphological stimuli (RAN digits, RAN Zhu-Yin-Fu-Hao, and RAN Characters) were better predictors than the nongraphological stimuli (RAN colors) in Chinese children of this age. The importance of rapid naming in reading Chinese increases as children advance in grade level since RAN tasks accounted for more reading variance in Grade 4 than in Grade 2. Eventually, Liao et al. (2008) concluded that RAN tasks were significant predictors of character recognition fluency in Grade 2, and of both accuracy and fluency in Grade 4 after controlling for age, nonverbal intelligence, phonological sensitivity, short-term memory, and orthographic processing.

There is also evidence that both phonological awareness and naming speed in Chinese predict children's Chinese reading performance. McBride-Chang and Ho (2000) administered measures of phonological processing, speech perception, and Chinese character recognition to 109 Hong Kong Chinese 3 and 4 year old children. They indicated that both Chinese phonological awareness and naming speed predicted unique variance in Chinese character recognition after controlling for other phonological processing and vocabulary skills, which is similar to the studies of English-speaking children. They specifically posited that naming speed was a unique predictor of Chinese character recognition (McBride-Chang & Ho, 2000).

L2 and Bilingual Cross-linguistic Cognitive Processes in Reading Research

One of the first research areas that proposed advantages for bilingual children over their monolingual peers in reading was the domain of metalinguistics awareness (Bialystok, 2001). Clark (1978, p. 36) speculated that "learning two languages at once, for instance, might heighten one's awareness of specific linguistic devices in both." The most metalinguistic task used to compare monolingual and bilingual children was phonological awareness, by reason of its special status which has been highly correlated with the acquisition of alphabetic literacy. Research studies focusing on bilingual learners (Bruck & Genesee, 1995; Cisero & Royer, 1995; Comeau, Cormier, Grandmaison, & Lacroix, 1999; Durgunoglu, Nagy, & Hancin-Bhatt, 1993; Geva & Wang, 2001; Wade-Woolley, 1999; Wade-Woolley & Geva, 2000) show that phonological awareness skills in L1 and L2 correlate with each other, transfer cross-linguistically, and can predict word reading development in children's L1 and L2. In other words, individual differences in phonological awareness measured in the L1 or the L2 predict individual differences in the development of accurate word recognition and word decoding in the L1 or the L2 (Geva, Yaghoub-Zadeh, & Schuster, 2000; Geva, Wade-Woolley, & Shany, 1997; Wade-Woolley & Siegel, 1997). For example, Durgunoglu et al. (1993) indicated that phonological awareness in the first grade children's Spanish (L1) predicted word and pseudoword recognition in English (L2). Similarly, Cisero and Royer (1995) found a similar developmental order in acquiring phonological awareness skills in English and Spanish for Spanish-speaking children. Likewise, Wade-Woolley and Siegel (1997) found that phonological processing skills in English predicted L1 and ESL children's English spelling performance. In Comeau et al.'s (1999) study of English-speaking children in a French immersion program, they indicated that phonological awareness in English (L1) strongly predicted word decoding in English as well as French (L2) and phonological awareness in French (L2) significantly predicted word decoding in French and English (L1). These studies provided evidence for cross language transfer of phonological awareness and its impact on word decoding.

Another emerging line of research exploring cognitive processes in learning to read focuses on the role of rapid automatized naming in explaining basic reading processes of children learning to read concurrently in two languages, and children learning to read in L2. Since second language learners are less proficient in their L2, it is possible to expect that they will be slower at naming speed tasks than their L1 counterparts. For example, in a study of bilingual Farsi-English elementary school students, Gholamain and Geva (1999) indicated that naming speed in Farsi significantly explained variance in English reading tasks, and naming speed in English significantly predicted reading tasks in Farsi.

Therefore, a growing body of research on reading performance in children learning ESL points to concurrent transfer of phonological awareness and naming speed across alphabetic languages. However, the degree of similarity between L1 and L2 phonology and orthography may affect the reading acquisition process (Geva & Wade-Woolley, 1998; Wade-Woolley & Geva, 1999). For example, Cheung, Chen, Lai, Wong, and Hills (2001) demonstrated that, prior to literacy training, Chinese children tended to be poorer in phonemic awareness relative to New Zealand children. They suggested that the explanation for this phenomenon lies in the differences across languages used by the children because English has relatively many consonant clusters and Chinese has virtually none. English-speaking children may be exposed to phonemic units in their language to a greater extent than Chinese-speaking children (Cheung et al., 2001).

There are two methods to assess cross-linguistic transfer. One is a liberal method of hierarchical regression or correlation analysis. For example, Chow, McBride-Chang, and Burgess (2005) found that Chinese phonological awareness can predict English word reading abilities concurrently and longitudinally after accounting for variance due to age, Chinese vocabulary, and visual skills performance among 227 kindergarteners in Hong Kong. Recently, a study on cross-linguistic transfer for Chinese English immersion students from Knell et al. (2007) showed Chinese phonological awareness moderately predicted English word recognition for Grades 1 to 3 English immersion students after controlling for age and Chinese vocabulary. These two studies explored cross-linguistic transfer taking into account age and Chinese vocabulary, but without controlling for English phonological processing skills.

The other way to explore cross-linguistic transfer is more conservative. Not only are age and Chinese vocabulary controlled, but also the phonological processing skills in the other language are controlled. For example, McBride-Chang and Ho (2005) tested 90 Chinese children on phonological processing and other reading skills, once at age 4 and again 22 months later. They indicated that English letter-naming knowledge uniquely predicted Chinese word recognition and English word reading after controlling for Chinese vocabulary and Chinese phonological processing skills. Similarly, Gottardo, et al. (2001) administered parallel measures of phonological, syntactic, and orthographic processing skill and word reading in English and Chinese to 65 children whose L1 was Chinese and L2 was English. They found that L1 phonological awareness contributed unique variance to L2 word reading performance even if the children's L2 phonological awareness was controlled.

McBride-Chang et al. (2006), after accounting for Chinese character recognition and Chinese phonological awareness, found English phonological awareness only predicted English vocabulary knowledge but not Chinese vocabulary knowledge. There was no evidence in the study showing cross-linguistic transfer.

Previous studies demonstrate that phonological transfer is not restricted to languages with similar structures, but phonological processing skills in a nonalphabetic language can help the acquisition of an alphabetic language or vice versa. In other words, phonological awareness in Chinese can predict English word reading and phonological awareness in English can predict Chinese word recognition. However, until now, there is no research investigating the four relations between phonological awareness and naming speed in alphabetic language or nonalphabetic language, and the reading achievement in the same or other language together. The current study examines these four relationships between phonological awareness and naming speed in English and Chinese, and reading achievement in English and Chinese.

The Present Study

This study aimed to investigate the differences, if any, between English immersion students and non-immersion students in terms of Chinese cognitive skills (phonological awareness and naming speed), Chinese achievement, and Chinese mathematics achievement. Drawing on previous research concerning the prediction of English and Chinese reading development from phonological awareness and naming speed and cross-linguistic transfer (e.g., Gottardo et al., 2001; McBride-Chang & Ho, 2005; Chow et al., 2005), the different contributions of both English and Chinese cognitive predictors to Chinese and English reading achievement were examined in Chinese English immersion students. In other words, this study investigated four relations between phonological awareness and naming speed, and reading achievement: (a) phonological awareness and naming speed in English with reading achievement in English, (b) phonological awareness and naming speed in Chinese with Chinese achievement, (c) phonological awareness and naming speed in Chinese with reading achievement in English, (d) phonological awareness and naming speed in English with Chinese achievement. To our knowledge, this study is the first to detail the simultaneous contributions of these four relations in Chinese English immersion students.

Two issues on Chinese phonological awareness deserve mention in the present study. One issue is that this study mainly focused on onset-rime awareness of phonological awareness. Goswami and Bryant (1990) classified phonological awareness into three forms: syllable awareness, onset-rime awareness, and phoneme awareness. This developmental sequence reflects the degree of abstractness of different phonological units for children (Ho & Bryant, 1997b). Children are aware of relatively large sound elements when they start to learn reading and they gradually develop the ability to manipulate smaller phonological units. Chinese writing is a logographic system, more accurately, a morphosyllabic system. The basic unit of writing system in Chinese is the character. Each character represents a morpheme as well as a syllable. The basic unit of speech in Chinese is the syllable and the phonetic information in Chinese is defined at syllable level (Wang & Geva, 2003). McBride-Chang et al. (2006) argued that syllable awareness not phoneme awareness is strongly related to Chinese character recognition but phoneme awareness not syllable awareness is more associated with English reading. The phoneme level, which is crucial to read alphabetic languages, does not apply when reading a Chinese character because English words contain consonant clusters, perhaps sensitizing English speakers to phoneme awareness while Chinese language may sensitize speakers to syllables as Chinese syllable stress is relatively even across syllables (McBride-Chang et al., 2006). Chinese syllables, like English syllables, are divided into two parts: the initial sound segment and the final sound segment. The initial segment refers to the initial consonant (onset) and the final segment refers to the vowel plus the consonants that follow (rime) (Chan & Siegel, 2001). Based on the common sound features of English and Chinese, this study decided to evaluate onset-rime awareness as a component of phonological awareness in both English and Chinese.

The second issue is that this study assessed students' Chinese tone awareness in addition to Chinese onset-rime awareness as Chinese is a tonal language in which a change in tone always change the meaning of a syllable (Ho & Bryant, 1997a). Chen et al. (2004) also indicated that tone awareness was an additional facet of Chinese phonological awareness in Chinese character recognition. In Li, Anderson, Nagy, and Zhang's (2002) study, Chinese phonological awareness was assessed using measures of onset deletion and tone discrimination. According to Li et al. (2002), tone awareness is a phonological component which is unique in learning to read Chinese; therefore, phonological awareness in Chinese consists of the knowledge of onset, rime, syllable, and tone. It is decided to combine these two tasks together to a composite score as Chinese phonological awareness.

Research Questions

The following research questions were addressed in the present study:

1. Are there significant differences between the English immersion and non-immersion students in the measures of Chinese phonological awareness, Chinese naming speed, Chinese achievement, and Chinese mathematics achievement at three grade levels?
2. How well do English phonological awareness and naming speed predict English and Chinese reading achievement, and how well do Chinese phonological awareness and naming speed predict Chinese and English reading achievement for English immersion students at three grade levels?
3. How well do Chinese phonological awareness and naming speed predict Chinese and English reading achievement for non-immersion students at three grade levels?
4. Do English phonological awareness and naming speed have any effect on Chinese achievement, after controlling for Chinese phonological awareness and naming

speed, and do Chinese phonological awareness and naming speed contribute to English reading achievement, after controlling for English phonological awareness and naming speed for English immersion students at three grade levels?

Context of the Study

Before going into the method chapter, the instructional context of English immersion programs in the three schools which took part in the present study should be noted. Dongguan School[1] in Guangdong Province is a private boarding school where all students not only study but also live with their fellow students five days per week in academic terms. It has an English immersion program only which runs from elementary school to high school. Since Dongguan is a city full of people who engage in private business in the very southern part of China, many local children are sent to this school by their parents who have little education and not enough time to look after them because they are busy working in small companies. Thus, enrollment in the English immersion program is voluntary. Guangzhou School, also in Guangdong Province, is a public elementary school that includes both immersion and non-immersion programs. There are no entrance exams for students to be admitted into the immersion program and their parents can choose whether or not to enroll their children in the immersion program. Xi'an School in Shannxi Province is a public elementary school. It is a model school which ranks in the top five elementary schools in Xi'an city. The early English immersion program in China was first implemented in Xi'an School in 1998 and it has 10

[1] School names in the following sections are pseudonyms in this study.

years of immersion experience. Originally, enrollment in the English immersion program was voluntary (Knell et al., 2007). However, an entrance exam is now administered to all new students and those who scored higher can be accepted into the immersion program because many students wish to get into the immersion program. The entrance exam consists of tests in three key subjects (Chinese, mathematics, and English) tests. The Chinese test measures students' ability to recognize Chinese characters and the mathematics test assesses students' knowledge of numbers and addition. The English test includes saying words according to the pictures presented as well as responding in simple dialogues such as "What is your name?" or "How old are you"?

Although the three schools have their own unique features, the immersion program at each school is similar, in which 30-40% of the curriculum is taught in English and 60-70% in Chinese. Subjects taught in English include English language arts, English reading, and social studies. Chinese, mathematics, physical education, art, and music are still taught in Chinese. English immersion and non-immersion students spend the same amount of school time learning English in the class of English language arts. The only difference is that non-immersion students do not receive other subjects taught in English. With regards to the teacher resources in the English immersion programs, all the English teachers are native Chinese speakers and most of them obtained bachelor degrees. However, their English proficiency levels are not considered equal to those of native English speakers.

CHAPTER 3: METHOD

Participants

A total of 238 students with parental permission participated in this study, 135 students (48, 47, and 40 in each of Grades 2, 4, and 6) from English immersion programs and 103 students (30, 33, and 40 from each of Grades 2, 4, and 6) from non-immersion programs. Students were recruited from three schools--Dongguan, Guangzhou, and Xi'an in three different Chinese cities. It should be noted that only the Xi'an School included Grade 6 students and the Dongguan School had English immersion students only. Students were randomly selected from each school, with the only constraints being that approximately equal numbers of males and females were taken, and approximately equal numbers were taken from each class. The gender distribution is reported in Table 1.

Table 1

Gender Distribution by Program at Each Grade Level

	Grade 2		Grade 4		Grade 6	
Gender	EI	NI	EI	NI	EI	NI
Male	26	16	25	17	20	22
Female	23	14	22	16	20	18

Note. EI = English immersion program; NI = Non-immersion program.

Measures

This study included three English measures and five Chinese measures administered in Grades 2, 4, and 6.

English Measures

English Reading Measures (Cambridge YLE Reading & Writing)

The Cambridge English for Young Learners (YLE) test for Reading and Writing was employed to assess the general English language proficiency of all participants. It offers a comprehensive approach to testing the English of second language primary learners between the ages of 7 and 12. The YLE is the most popular test of English for speakers of other languages throughout the world; in 2002, it was taken by approximately 260,000 children in 55 countries, and these numbers are said to be growing rapidly (Cambridge ESOL, 2003). The YLE is a paper and pencil test which takes 20 minutes (*Starters* -- Grade 2), 30 minutes (*Movers* -- Grade 4) or 40 minutes (*Flyers* -- Grade 6) for Reading & Writing parts. Reading texts are short and constrained by a specified set of words and structures. Students perform operations such as selecting and coloring, writing words and phrases in gaps, or answering open-ended questions (Cambridge ESOL, 2007). At the *Starters* level, the test attempts to ensure the students can strengthen the knowledge of word spellings, different forms of nouns, present and present continuous tenses of verbs, and prepositions of place. At the *Movers* level, the students are expected to know comparative and superlative adjectives and adverbs, the function of modal verbs, grammatical function of past and past continuous tenses, and prepositions of time in addition to grammar and structures at the *Starters* level. At the *Flyers* level, besides the grammar and structures list in *Starters* and *Movers*, the students have to grasp the knowledge of present perfect tense, passive voice, tag questions, and if and where clauses. The score was the number of correct answers. Table 2 indicates the common characteristics and variations in the different levels of the tests.

Table 2

The Characteristics and Variations of Three Levels in Cambridge YLE Reading & Writing

	Cambridge Starters (Grade 2)		Cambridge Movers (Grade 4)		Cambridge Flyers (Grade 6)	
	N of sections	N of Items	N of sections	N of items	N of sections	N of items
Reading & Writing	5	25	6	40	7	50

English Sound Detection (James, 1996, adapted from Bryant & Bradley, 1985)

Two tests of initial sound detection and final sound detection in English (see Appendix A) developed by James, and adapted from Bryant and Bradley (1985), were administered to assess the onset-rime awareness of each student. There were two practice items and ten test items in each of initial sound detection and final sound detection. All the items had been recorded on a CD in English by a native English speaker, item by item, and the time interval between items was fixed at five seconds. During the testing, both the tester and the student had a pair of headphones so as not to be influenced by environmental noises. The tester asked each student to listen to the CD with headphones. In the English initial sound detection test, after listening to four words in one item, the student was asked to indicate which one of the four words began with a different sound from the other three words during the interval between two items. The student responded by pointing to one of four options on an answer sheet, which had the numerals, 1, 2, 3, and 4 in separate squares, each representing one of the four words in one item. For example, after listening to ***rot***, ***rod***, ***rock***, and ***box***, the student was expected to choose option 4 on the answer sheet, referring to the fourth word ***box***, which had a different initial sound than the other three. Similarly, in the English final sound detection test, the student was asked to choose which one of the four ended with a different sound from the other three words. The score was the number of correct answers. The total of the initial and final sound detection was termed English PA.

English Rapid Automatized Naming

We designed this measure for the present study, similar to those on the CTOPP – Comprehensive Test of Phonological Processing, Wagner, Torgesen, and Rashotte, 1999. Naming performance in English was measured using a continuous number-naming task. There were one practice task and one test task (see Appendix B). The practice task consisted of 5 randomly arranged digits (i.e., 1, 2, 4, 5, and 8) in one row, and the test stimuli consisted of 40 items, with five rows and eight columns of five randomly arranged digits (i.e., 1, 2, 4, 5, and 8) repeated in random order. The student was required to read all five digits in the practice task from left to right before starting the test. Once s/he was familiar with this rapid naming test style, the student was encouraged to sequentially read all the digits in English as fast as possible, from left to right, without making mistakes, starting at the top row and continuing to the bottom row. The student's responses were recorded on a digital MP3 recorder for verification at a later time. The number of seconds the student took to read all the digits in order and the number of uncorrected errors were recorded. The student's score was the number of digits named correctly divided by the time taken, that is, an efficiency score expressed in digits per second. This score was termed English NS.

Chinese Measures

Chinese Achievement

School-issued achievement tests in Chinese from three different schools were employed to measure Chinese reading achievement. Although there were different tests in different schools, the content of the tests was similar at each grade. Three school-issued Chinese achievement tests for Grade 2 consisted of pinyin identification (varied from 20% to 40%), writing Chinese characters and making up phrases (from 40% to 50%), and reading comprehension (from 20% to 30%). For Grade 4, besides the above three sections, making up sentences and writing were added to the test. The percentages of pinyin identification, writing characters and making phrases and sentences, reading comprehension, and writing were 10%, 20-40%, 20-40%, and 30%, respectively. Only the Xi'an School issued a Grade 6 test. On this test, there was no section for writing single characters. For Grade 6, the test consisted of pinyin identification (5%), making up phrases and sentences (15%), reading comprehension (40%), and writing (40%). All students' scores were marks of correct answers out of 100.

Chinese Mathematics Achievement

School-issued achievement tests in mathematics in three different schools were employed to assess and control the group differences. As with the Chinese achievement tests, the content of the mathematics tests was similar across schools at three different grades. All of the grades had two sections of addition and subtraction, and logic. For Grade 2, the percentages from three schools were varying from70% to 80% and 20% to 30%, respectively. For Grade 4, the section of multiplication and division was added as the main section. The percentages were 5-15% for addition and subtraction, 55-65% for multiplication and division, and 20-30% for logic. For Grade 6 (in the Xi'an School), sections on percentage and equations were added, which reduced the section on multiplication and division to 30% and gave 15% and 10%, respectively to the extra sections. All students' scores were marks of correct answers out of 100.

Chinese Sound Detection

The Chinese initial and final sound detection tests (see Appendix C) used to measure Chinese sound detection, developed by Liao et al. (2008) were adapted and administered to each student to assess the onset-rime awareness of Chinese syllables. We kept the original two practice items and changed the original 12 test items into 10 test items in order to have the same numbers as English sound detection tests in both Chinese initial and final sound detection tests. The Cronbach's alpha coefficients in Liao et al.'s study were .83 for Grade 2 and .62 for Grade 4. Monosyllabic Chinese words were used in the task. Tones of syllables were controlled so that all four syllables in each item were in the same tone. All the items were recorded on a CD in Mandarin[2] by a native Chinese speaker, and the interval between items was fixed again at five seconds. The same procedure used in English sound detection tests was used in Chinese sound detection

[2] Mandarin: The official national standard spoken language of China, which is based on the principal dialect spoken in and around Beijing.

tests. For example, after listening to the item of 通 **tōng,** 推 **tuī,** 多 **duō, and** 吞 **tūn**, the student was expected to choose option 3 on the answer sheet, referring to the third syllable 多 **duō**, which had a different initial sound than the other three. Similarly, in the Chinese final sound detection test, the student was asked to choose which one of the four ended with a different sound from the other three syllables. The score was the number of correct answers. The total of initial and final sound detection was termed Chinese PAIF.

Chinese Tone Detection

A tone detection test (see Appendix C) was administered to assess the child's ability to detect differences in tones of Chinese syllables, also adapted from the original test created by Liao et al (2008). Two practice items and 10 test items were given. The Cronbach's alpha coefficients in Liao et al.'s study were .71 for Grade 2 and .65 for Grade 4. All the items were recorded on a CD in Mandarin by a native Chinese speaker, item by item, and the interval of time for each item was fixed at five seconds. The same procedure used in the English and Chinese sound detection tests was used here. For example, after listening to 拔 **bá,** 鼻 **bí,** 被 **bèi, and** 甭 **béng**, the student was expected to choose option 3 on the answer sheet, referring to the third syllable 被 **bèi,** which had a different tone than the others. The score was the number of correct answers. This score was termed Chinese Tone; a further score, termed Chinese PA, was created by summing Chinese PAIF and Chinese Tone.

Chinese Rapid Automatized Naming

We designed this measure for the present study, similar to those on the CTOPP – Comprehensive Test of Phonological Processing, Wagner et al., 1999. Naming performance in Chinese was measured using a continuous number-naming task. There were one practice task and one test task (see Appendix B). The same practice digits (i.e., 1, 2, 4, 5, and 8) and test digits (i.e., 1, 2, 4, 5, and 8) used in the English version were used in the Chinese version but in a different order. The practice task consisted of five digits randomly arranged in a row and the test stimuli consisted of 40 items, with five rows and eight columns of five randomly arranged digits repeated in random order. Once the student had read five practice digits, s/he was encouraged to sequentially read all the test digits in Chinese as fast as possible, without making mistakes, from left to right, starting at the top row and continuing to the bottom row. The students' responses were recorded on a digital MP3 recorder for verification at a later time. The number of seconds the student took to read all the digits in order and the number of uncorrected errors were recorded. The student's score was the number of digits named correctly divided by the time taken, that is, an efficiency score expressed in digits per second; this was termed Chinese NS.

Procedure

The school-issued achievement tests in Chinese and mathematics in the three different schools were administered to the students at the end of the last term of the previous academic year, at the beginning of July, 2007. The other tests were administered in October, 2007. The Cambridge YLE for Reading & Writing was administered to all students (English immersion and Non-immersion) before the individual PA and NS tests. PA and NS tests in both English and Chinese were given to English immersion students, but non-immersion students were given PA and NS tests only in Chinese because we considered that their English language proficiency was much lower than that of English immersion students. The English testing sessions of PA and NS lasted approximately 15 minutes, and the Chinese sessions 20 minutes. Both were administered by four testers who were fluent in both English and Chinese. The two testing sessions were conducted consecutively with all English immersion students who took both. Half of the students received the English tests first and the Chinese tests second, whereas the other half of the students received the Chinese tests first and the English tests second.

CHAPTER 4: RESULTS

This chapter is divided into four parts. In part one, descriptive statistics, reliability, and correlations of the measures are reported for both English immersion and non-immersion groups. Part two presents the differences between English immersion and non-immersion students in terms of Chinese measures using two-way ANOVAs and *t*-tests. Part three explains the hierarchical regression analysis models employed to investigate the contribution of English and Chinese phonological awareness (PA) and naming speed (NS) to English and Chinese reading achievement for both groups and to examine the evidence for cross-linguistic transfer. Part four examines the cross-language comparison of cognitive processes for English immersion students.

Descriptive Statistics, Reliability, and Correlations

Descriptive Statistics

Tables 3 and 4 present the means and standard deviations of all predictor and outcome measures of both English immersion and non-immersion groups in Grade 2, Grade 4, and Grade 6. No cases had missing data. One outlier was deleted in Grade 2 English immersion students. The numbers of English immersion students are 48, 47, and 40 in Grades 2, 4, and 6 respectively; the numbers of non-immersion students are 30, 33, and 40 in Grades 2, 4, and 6 respectively. English phonological awareness scores of Grade 6 English immersion students reached ceiling level because the mean scores were greater than 19 out of 20.

Skewness and kurtosis values for measures of English immersion students and non-immersion students are reported in Appendix D. Measures whose skewness and kurtosis values fell outside of the acceptable range (i.e., the absolute value of Skewness/SE. >3.09) were transformed according to the guidelines in Tabachnick and Fidell (2007). Square root, logarithmic, inverse, and dichotomized transformations were applied as appropriate. The transformed distributions were checked once again for skewness and kurtosis and descriptive statistics of transformed data are presented in Appendix E. All transformed measures were within acceptable range. The hierarchical regression analyses were based upon the transformed data.

Table 3

Descriptive Statistics for English Immersion Students

	Grade 2 (N = 48)		Grade 4 (N = 47)		Grade 6 (N = 40)	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*
English Phonological Awareness	13.67	4.65	17.60	2.31	19.30	1.24
English Naming Speed	0.96	0.41	1.37	0.25	1.75	0.34
English Reading Achievement	7.76	3.67	12.11	6.24	31.84	7.51
Chinese PAIF	11.71	4.65	14.87	3.23	18.53	1.52
Chinese Tone Awareness	5.92	2.61	7.62	2.28	9.25	1.03
Chinese Phonological Awareness	17.63	6.75	22.50	4.62	27.78	1.98
Chinese Naming Speed	1.84	0.39	2.38	0.58	3.43	0.90
Chinese achievement	97.79	2.16	94.85	4.04	97.06	1.78
Mathematics Achievement	96.06	4.03	93.63	4.71	94.31	5.90

Table 4

Descriptive Statistics for Non-immersion Students

Variable	Grade 2 (N = 30)		Grade 4 (N = 33)		Grade 6 (N = 40)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Chinese PAIF	13.40	3.93	15.64	3.35	15.85	3.40
Chinese Tone Awareness	8.20	2.19	7.30	2.39	8.40	1.88
Chinese Phonological Awareness	21.60	5.22	22.94	4.69	24.25	4.28
Chinese Naming Speed	1.96	0.55	2.58	0.70	3.20	0.69
Chinese achievement	97.00	4.23	93.27	5.94	94.10	3.43
Mathematics Achievement	95.78	5.73	94.79	6.63	90.81	6.68
English Reading Achievement	7.50	1.84	11.59	4.71	18.60	6.81

Reliability

Cronbach's alpha was used to determine the measures' reliabilities. As shown in Table 5, the reliability coefficients of measures obtained from English immersion students reached the acceptable level (e.g., $\alpha > .5$, Kraayenoord & Schneider, 1999) except the measures of Chinese PAIF ($\alpha = .45$) and Chinese Tone Awareness ($\alpha = .43$) in Grade 6. A possible explanation for these lower alpha values is that these two measures were too easy for Grade 6 students, resulting in ceiling effects, since 35% and 53% of the students obtained the full scores in the measures of Chinese PAIF and Chinese Tone Awareness, respectively. For non-immersion students, Cronbach's alpha values ranged from .50 to .85 except the English reading achievement whose reliability coefficient was only 0.15, which may be because the Cambridge YLE test at Grade 2 Starter level consisted of English spelling and decoding items; however, non-immersion students in Grade 2 did not learn English decoding until they were in Grade 3 but English immersion students started to learn English decoding and spelling in Grade 2. Although both English immersion and non-immersion students acquire English skills using the same textbook in the course of English language arts, the process of learning English is slower for non-immersion students than immersion students.

Table 5

Reliability of Phonological Awareness and English Reading Achievement for All Students

Measure	Grade 2		Grade 4		Grade 6	
	EI (N=48)	NI (N=30)	EI (N=47)	NI (N=33)	EI (N=40)	NI (N=40)
English PA	.84		.64		.60	
Chinese PAIF	.82	.76	.69	.74	.45	.77
Chinese TA	.74	.78	.72	.74	.43	.70
Chinese PA	.88	.82	.78	.78	.51	.78
English Reading	.78	.15	.85	.74	.85	.83

Note. PA = Phonological awareness; PAIF = Initial and Final Sound Detection Phonological awareness; TA = Tone Awareness.

Correlations among English and Chinese Measures

English initial and final sound detection tests were treated as a single test to measure English immersion students' English phonological awareness; this variable will be termed English PA. The Chinese initial sound detection and final sound detection scores were also added; this variable is termed Chinese PAIF. The correlations between Chinese PAIF and Chinese tone detection, for the English immersion students in Grades 2, 4, and 6 were .71 ($p < .01$), .39 ($p < .01$), and .18 (*ns*). For non-immersion students, the equivalent correlations were .41 ($p < .05$), .31 (*ns*), and .25 (*ns*), respectively. In spite of the low correlations at the higher grades, it was decided to add Chinese PAIF and Chinese tone detection to form a single score, termed Chinese PA. The correlations among total English and Chinese measures for both groups at the three grade levels are reported in Tables 6, 7, and 8.

Of the four cognitive tasks, English PA, NS, and Chinese PA were significantly correlated with English reading, Chinese, and mathematics achievement for immersion students in Grade 2; Chinese NS did not appear to relate to any achievement. However, Chinese NS was significantly correlated with English reading and mathematics achievement for non-immersion students in Grade 2. Moreover, Chinese achievement of Grade 2 non-immersion students showed relatively stronger association ($r = .67$, $p < .01$) with mathematics achievement than did that of Grade 2 immersion students ($r = .30$, $p < .05$). In Grade 4, only English and Chinese PA were significantly correlated with English reading, Chinese, and mathematics achievement for immersion students, whereas Chinese PA and NS of Grade 4 non-immersion students were significantly correlated with Chinese and mathematics achievement but only Chinese PA was correlated with English reading achievement. For Grade 6 immersion students, there was only significant correlation between English NS and English reading achievement. No significant correlations were found between Chinese or English predictors and Chinese achievement, or between Chinese predictors and English reading achievement for immersion students. However, for non-immersion students, there was a strong correlation between Chinese and mathematics achievement ($r = .80$, $p < .01$). In addition, different from immersion students, there was a significant correlation between Chinese PA and NS for non-immersion students; Chinese NS of non-immersion students was also significantly correlated with English reading achievement. Chinese PA was significantly correlated with mathematics achievement for both groups.

Several noteworthy features of the correlations can be observed. First, the correlation between cognitive predictors and outcome achievement varies across grades for immersion students: in Grade 2, English PA, NS, and Chinese PA were strongly correlated with English and Chinese achievement; in Grade 4, English and Chinese PA but not English NS were significantly correlated with English and Chinese achievement; in Grade 6, in contrast, there was only powerful association between English NS and English reading achievement. Second, the situation of non-immersion students turns out differently from immersion students and the associations between Chinese predictors and outcome measures were quite unstable across grades: in Grade 2, only Chinese NS was significantly correlated with English reading achievement; in Grade 4, Chinese PA and NS were moderately correlated with Chinese achievement; in Grade 6, there was a significant association between Chinese PA and Chinese achievement and a moderate correlation between Chinese NS and English reading achievement. Third, the relation of English reading and Chinese achievement was fairly low for both groups, perhaps indicating first and second language knowledge develops independently when the first language has a nonalphabetic script but the second language has an alphabetic script.

Table 6

Correlations Among English and Chinese Measures in Grade 2 English Immersion and Non-immersion Students

Variable	1 [a]	2 [a]	3	4	5	6	7
1. English Phonological Awareness	--						
2. English Naming Speed	.43**	--					
3. Chinese Phonological Awareness	.81**	.55**	--	.48**	.01	.18	.21
4. Chinese Naming Speed	.09	.51**	.29*	--	.40*	.34	.44*
5. English Reading Achievement	.53**	.49**	.53**	.21	--	.34	.35
6. Chinese achievement	.35*	.30*	.55**	.10	.16	--	.67**
7. Math Achievement	.44**	.30*	.53**	.21	.39**	.30*	--

Note. English immersion correlations are below diagonal; Non-immersion correlations are above diagonal

N = 48 for Grade 2 English immersion students; N = 30 for Grade 2 non-immersion students

[a] These measures were not administered to the non-immersion students.

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

Table 7

Correlations Among English and Chinese Measures in Grade 4 English Immersion and Non-immersion Students

Variable	1 [a]	2 [a]	3	4	5	6	7
1. English Phonological Awareness	--						
2. English Naming Speed	-.06	--					
3. Chinese Phonological Awareness	.46**	.26	--	.34	.39*	.38*	.46**
4. Chinese Naming Speed	.22	.45**	.16	--	.08	.38*	.40*
5. English Reading Achievement	.50**	.14	.34*	.31*	--	.11	.06
6. Chinese achievement	.33*	.14	.43**	.10	.09	--	.60**
7. Math Achievement	.38**	.12	.38**	.15	.38**	.59**	--

Note. English immersion correlations are below diagonal; Non-immersion correlations are above diagonal.

N = 47 for English immersion students; N = 33 for non-immersion students.

[a] These measures were not administered to the non-immersion students.

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

Table 8

Correlations Among English and Chinese Measures in Grade 6 English Immersion and Non-immersion Students

Variable	1 [a]	2 [a]	3	4	5	6	7
1. English Phonological Awareness	--						
2. English Naming Speed	-.09	--					
3. Chinese Phonological Awareness	.35*	-.09	--	.31*	.27	.44**	.57**
4. Chinese Naming Speed	.25	.34*	-.10	--	.32*	.27	.16
5. English Reading Achievement	.06	.37*	.17	.16	--	.31*	.23
6. Chinese achievement	-.08	-.00	-.05	-.19	.38*	--	.80**
7. Math Achievement	.54**	.05	.50**	.09	.30	.07	--

Note. English immersion Grade 6 correlations are below diagonal; Non-immersion Grade 6 correlations are above diagonal.

N = 40 for English immersion students and the same N for non-immersion students.

[a] These measures were not administered to the non-immersion students.

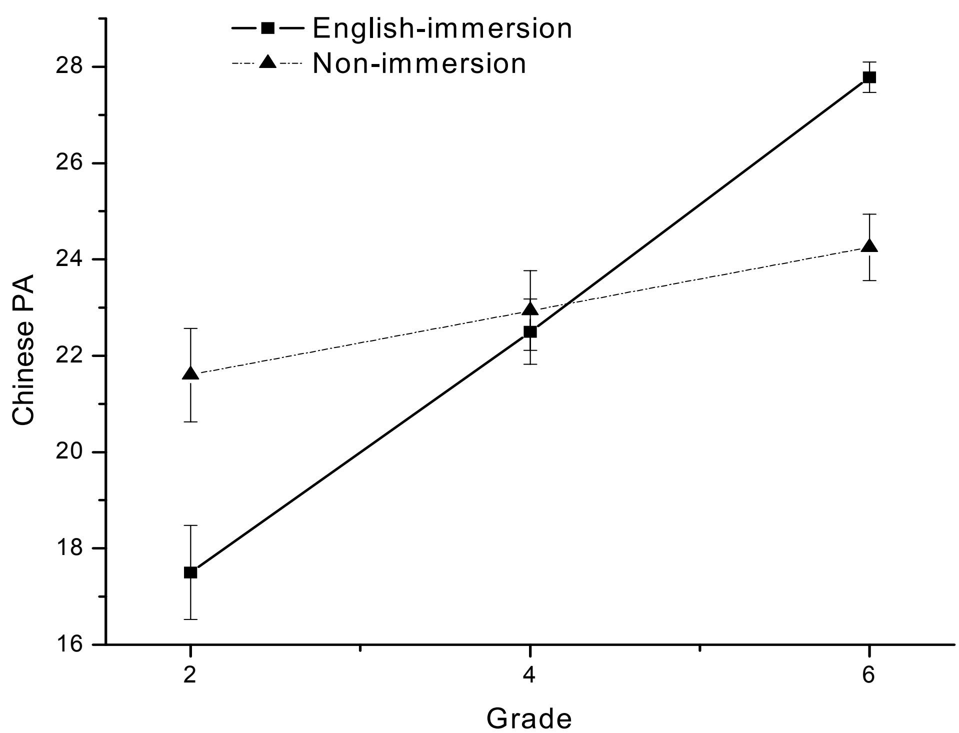
*p< .05. **p< .01

Differences on Chinese Measures between Two Groups

In order to answer the first research question about the differences between English immersion and non-immersion students in terms of Chinese PA, Chinese NS, Chinese achievement, and Chinese mathematics achievement, 3 (Grade) x 2 (Program) ANOVAs and *t*-tests were conducted to compare the mean differences.

For Chinese PA, the grade effect, F (2, 232) = 33.30, $p < .001$, partial $\eta^2 = .22$, and the Grade x Program effect, F (2, 232) = 11.45, $p < .001$, partial $\eta^2 = .09$, were both significant (the full analysis is presented in Appendix F). The interaction is illustrated in Figure 1. To explore this interaction further, *t*-tests were carried out between programs at each Grade. The non-immersion students performed higher in Grade 2, t (76) = -2.75, $p < .01$, and lower in Grade 6, t (54.988) = 4.73, $p < .001$; the groups were not different in Grade 4, t (78) = -.43.

Figure 1 *Mean performance on Chinese PA of English immersion and non-immersion students at three grade levels (error bars are SEs -- Standard Errors)*

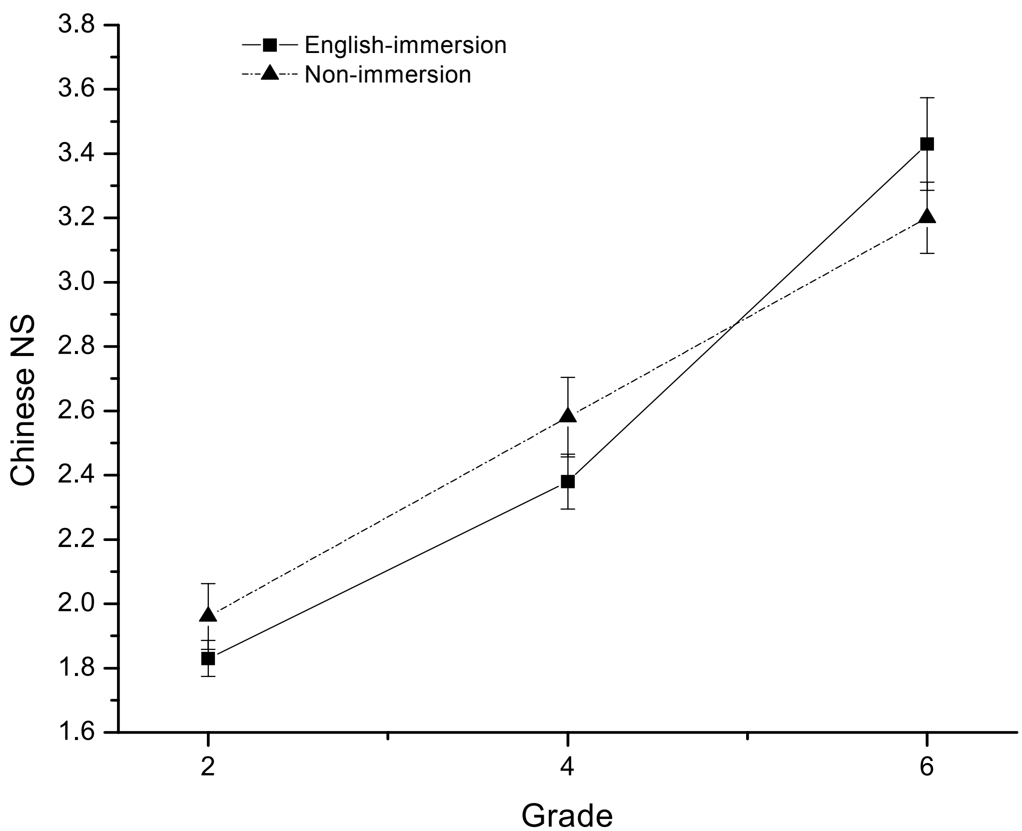


The finding with Chinese PA may reflect a conflict between English and Chinese at the beginning level for English immersion students. But by Grade 6, the Chinese PA of

English immersion students was higher than that of non-immersion students. Both groups' Chinese PA develops as their grade level increases.

For Chinese NS, there was a grade effect, F (2, 232) = 93.77, $p < .001$, partial $\eta^2 = .45$, but there was no difference between programs and no interaction (the full analysis is reported in Appendix F). Figure 2 displays the mean performance on Chinese NS between two groups at three Grade levels. Both groups' Chinese NS develops as their Grade level increases.

Figure 2. *Mean performance on Chinese NS of English immersion and non-immersion students at three grade levels (error bars are SEs)*



Because the Chinese achievement tests from the three grade levels were different, two-way ANOVA was not employed but three *t*-tests were used to show the differences. The results from three *t*-tests showed there were no significant differences between immersion and non-immersion students in Grades 2 and 4, $t\ (38.585) = .95$, $p > .05$, for Grade 2; $t\ (78) = 1.42$, $p > .05$, for Grade 4. However, a large difference favoring immersion students was found in Grade 6, $t\ (58.716) = 4.84$, $p < .001$.

A similar situation was also found in Chinese mathematics achievement between English immersion and non-immersion students at Grades 2, 4, and 6. There were no differences between the two groups in Grades 2 and 4 on mathematics achievement but Grade 6 English immersion students scored higher than Grade 6 non-immersion students, $t\ (78) = 2.49$, $p < .05$.

Why were significant differences found only in Grade 6 rather than in Grades 2 and 4? Were they caused by the selection process of Xi'an School because all Grade 6 students were from Xi'an School only? In order to address our concerns, we employed *t*-tests to compare Chinese and English measures in immersion and non-immersion programs between Xi'an School's Grade 2 and 4 students and those in the other two schools. If the Grade 6 differences were due to the selection process, then differences should be apparent in the earlier grades. The means of Xi'an School and the other two schools in Grades 2 and 4 on all measures are reported in Table 9 and *t* values are reported in Table 10.

Table 9

The Means and SDs of Xi'an School and the Other Two School Students in Grades 2 and 4 on All Measures

	Grade 2				Grade 4			
	EI		NI		EI		NI	
	D+G	X	D+G	X	D+G	X	D+G	X
	N=39	N=9	N=12	N=18	N=37	N=10	N=15	N=18
Chinese PA	15.51	26.78	20.17	22.56	21.97	24.40	22.27	23.50
	(5.57)	(2.17)	(4.51)	(5.57)	(4.65)	(4.20)	(5.46)	(4.02)
Chinese NS	1.79	2.07	1.68	2.15	2.31	2.65	2.32	2.78
	(0.38)	(0.38)	(0.47)	(0.54)	(0.60)	(0.46)	(0.69)	(0.65)
Chinese Ach	97.44	99.33	95.00	98.33	94.89	94.70	90.43	95.64
	(2.21)	(1.00)	(5.17)	(2.93)	(3.62)	(5.58)	(6.77)	(3.95)
Mathematics	95.26	99.56	90.79	99.11	93.50	94.15	91.60	97.44
	(4.06)	(0.58)	(6.14)	(1.50)	(4.78)	(4.67)	(8.75)	(1.84)
English PA	12.28	19.67			17.35	18.50		
	(3.91)	(0.50)			(2.48)	(1.27)		
English NS	0.83	1.50			1.39	1.30		
	(0.31)	(0.35)			(0.24)	(0.30)		
English R	12.46	25.50	11.67	15.83	17.18	29.60	18.67	18.36
	(2.13)	(6.94)	(1.50)	(3.51)	(7.27)	(12.72)	(5.32)	(8.33)

Note. D+G = Dongguan and Guangzhou schools; X = Xi'an School; EI = English Immersion; NI = Non-immersion; PA = Phonological Awareness; NS = Naming Speed; R = Reading Achievement; Ach = Achievement.
SDs are in parentheses.

Table 10

The T Values of Xi'an School and the Other Two School Students in Grades 2 and 4 on All Measures

	Grade 2		Grade 4	
	EI	NI	EI	NI
Chinese PA	*t* (34.22) = -9.82 (p<.001)	no sig.	no sig.	no sig.
Chinese NS	no sig.	*t* (28) = -2.48 (p<.05)	no sig.	no sig.
Chinese Ach	*t* (46) = -2.50 (p<.05)	*t* (28) = -2.26 (p<.05)	no sig.	*t* (31) = -2.76 (p<.01)
Mathematics	*t* (43.45) = -6.34 (p<.001)	*t* (11.87) = -4.61 (p<.01)	no sig.	*t* (15.03) = -2.54 (p<.05)
English PA	*t* (42.57) = -11.41 (p<.001)		no sig.	
English NS	*t* (46) = -5.75 (p<.001)		no sig.	
English R	*t* (8.35) = -5.57 (p<.001)	*t* (24.70) = -4.46 (p<.001)	*t* (10.64) = -2.96 (p<.05)	no sig.

Note. EI = English immersion NI = Non-immersion; PA = Phonological Awareness; NS = Naming Speed; R = Reading Achievement; Ach = Achievement.

T-tests results in Table 10 showed that Grade 2 immersion students from Xi'an School performed better than those from the other two schools on all Chinese and English measures except Chinese NS. However, there were no significant differences between Xi'an School's immersion students and those of the other two schools on all Chinese measures in Grade 4. On English measures, Xi'an School's Grade 4 immersion students did perform better than did the students of the other two schools only on English reading achievement. For non-immersion students, Xi'an School's Grade 2 students excelled at all Chinese measures except at Chinese PA, while Xi'an School's Grade 4 students excelled at Chinese and mathematics achievements only. The superior performance of the non-immersion students at Xi'an School does not support the selection interpretation. Although Xi'an Grade 2 immersion students outperformed the Grade 2 immersion students in the other two schools, which could have been a result of selection process, no significant differences were found between Xi'an Grade 4 and the other two schools' Grade 4 immersion students. The inconsistent findings across variables do not provide much support for the selection factor. We cannot conclude that the higher performance of Xi'an Grade 6 immersion students over non-immersion students was due to selection.

Hierarchical Regression Analyses

Prediction of English Reading and Chinese Achievement in English Immersion Students

A series of hierarchical regression analyses was conducted for English immersion students to assess the contribution of English and Chinese PA and NS to English reading and Chinese achievement and look for cross-linguistic transfer. Different from the previous studies on cross-linguistic transfer of cognitive processes among Chinese children who learned English as a second language, the data in the current study were analyzed separately at three grade levels because the dependent measures (i.e., English Reading achievement and Chinese achievement) were different across grades.

The regression analyses examining the prediction of English reading achievement from English or Chinese PA and NS for English immersion students are summarized in Table 11. To control for the variance accounted for by the students' first language achievement and various other factors that contribute to reading achievement (such as general mental ability), Chinese and mathematics achievement were entered first into the regression equation as step 1. In step 2, English PA and NS were entered in the equation. Chinese PA and NS were forced into the regression equation at the final step 3. English reading achievement was the dependent variable. In a second analysis, the order of steps 2 and 3 was reversed.

Table 11

Hierarchical Regression Analyses Predicting English Reading Achievement from English and Chinese Cognitive Tasks for English Immersion Students at Three Grade Levels

	English Reading								
Step	Grade 2			Grade 4			Grade 6		
predictor	β [a]	β [b]	ΔR^2	β [a]	β [b]	ΔR^2	β [a]	β [b]	ΔR^2
1.Chinese	.17	.05		-.13	-.21		.35**	.40**	
Math	.39**	.23	.22**	.48**	.33†	.17**	.24	.16	.20**
2. Eng PA	.29*	.33†		.43**	.38**		-.17	-.28†	
Eng NS	.22	.20	.13**	.15	.11	.16**	.34**	.29*	.15**
3. Chi PA	-.06	-.06		.09	.09		.25	.25	
Chi NS	.04	.04	.00	.04	.04	.01	.23	.23	.07
2A.Chi PA	.33	-.06		.32*	.17		.09	.20	
Chi NS	.07	.04	.07	.10	.01	.10	.16	.11	.03
3A.Eng PA	.33†	.33†		.38*	.38*		-.28†	-.28†	
Eng NS	.20	.20	.06	.11	.11	.09†	.29*	.29*	.16**

Note. PA = Phonological Awareness; NS = Naming Speed; Chinese = Chinese achievement; Math = Mathematics Achievement.
[a] Standardized beta coefficient for the step at which the predictor first entered the model.
[b] Standardized beta coefficient for the final step of the model.
**$p< .01$, *$p< .05$, † $p< .10$

The results indicate that English PA and NS significantly predicted English reading achievement after Chinese and mathematics achievement were considered in Grades 2, 4, and 6. The unique contributions of English reading achievement are from English PA in Grades 2 and 4, and English NS in Grade 6. It should be noted that there is no effect of English PA in Grade 6, which may be due to a ceiling effect in English PA. The Grade 6 English NS effect, therefore, may be due to the absence of the PA effect, leaving more variance to be explained. Thus, the following regression analysis (see Table 13 and associated description) with English PA and NS entered into equation separately examines whether the significant effect on English reading achievement from English NS is due to the absence of English PA or not. Table 11 also shows that Chinese PA and NS did not explain additional variance in English reading achievement after English predictors were included in the equation at each grade level, indicating no cross-linguistic transfer. This result might not be surprising because English and Chinese belong to two very different orthographic categories and the numbers of our participants are limited. When Chinese PA and NS were entered into the equation to predict English reading achievement before English predictors; they still failed to contribute unique variance to English reading achievement at all grade levels. Furthermore, English PA and NS still add extra variance to English reading achievement beyond that contributed by Chinese predictors in Grades 4 and 6. The results indicate that English predictors are strong predictors of English reading achievement for English immersion students even if Chinese achievement and Chinese predictors are controlled. Chinese predictors did not add further significant variance to English reading achievement.

A similar set of hierarchical regression analyses (Table 12) examined the two Chinese predictors and two English predictors in relation to Chinese achievement for English immersion students in Grades 2, 4, and 6. These analyses allowed us to investigate the contributions of L1 and L2 PA and NS to L1 achievement. In the first step, the measure of mathematics achievement was entered to control individual differences in background and general mental ability. At step 2, Chinese PA and NS were forced into the regression equation. In the last step, English PA and NS were entered. The order of steps 2 and 3 was reversed for a second analysis. The outcome measure was the Chinese achievement test.

Table 12

Hierarchical Regression Analyses Predicting Chinese achievement tests from English and Chinese Cognitive Tasks for English Immersion Students at Three Grade Levels

	Chinese Achievement								
Step	Grade 2			Grade 4			Grade 6		
predictor	β^a	β^b	ΔR^2	β^a	β^b	ΔR^2	β^a	β^b	ΔR^2
1. Math	.29*	-.03	.09*	.59**	.51**	.35**	.13	.22	.02
2. Chi PA	.59**	.80**		.20	.18		-.18	-.17	
Chi NS	-.04	-.13	.24**	-.04	-.07	.04	-.22	-.24	.06
3.Eng PA	-.31†	-.31†		.06	.06		.00	.00	
Eng NS	.13	.13	.04	.04	.04	.00	.04	.04	.00
2A.EngPA	.21	-.31†		.11	.06		-.10	.00	
Eng NS	.22	.13	.11	.05	.04	.01	-.02	.04	.01
3A.ChiPA	.80**	.80**		.18	.18		-.17	-.17	
ChiNS	-.13	-.13	.17*	-.07	-.07	.03	.17	.17	.06

Note. Eng PA = English Phonological Awareness; Eng NS = English Naming Speed; Chi PA = Chinese Phonological Awareness; Chi NS = Chinese Naming Speed; Math = Math Achievement.

[a] Standardized beta coefficient for the step at which the predictor first entered the model.

[b] Standardized beta coefficient for the final step of the model.

**p< .01, *p< .05, † p< .10

As shown in Table 12, Chinese PA and NS together explained a significant 24% of the variance in Grade 2 the only unique effect being for Chinese PA, but did not account for significant variance in later grades. However, at all grade levels, neither English PA nor NS had any additional effect on Chinese achievement after controlling Chinese PA and NS. They also could not predict Chinese achievement at any grade level before Chinese predictors, but Chinese PA significantly predicted Chinese achievement even after English predictors were controlled in Grade 2. The results suggest that Chinese PA is a solid predictor of Chinese achievement for Chinese English immersion students in the early grade.

Finally, a set of hierarchical regression analyses (Table 13) was conducted to examine the individual effect of English PA or English NS on English reading achievement for immersion students at the three grade levels in order to solve the problem posed in Table 11. Chinese and mathematics achievement were entered first into the regression equation as step 1 to control students' first language proficiency and general mental ability. English PA was entered in step 2 and English NS in step 3. The English reading achievement test was the outcome measure. English PA provides unique predictions of English reading achievement in Grades 2 and 4. The effect of English NS on English reading achievement in Grade 6 shows that the significant effect of English NS in Grade 6 is not simply due to the absence of an English PA effect as we suspected. When the English PA and NS measures were entered in reverse order, a similar pattern of results was found but English NS explained unique variance in English reading achievement in Grade 2.

Table 13

Hierarchical Regression Analyses Predicting English Reading Achievement from English Phonological Awareness and from English Naming Speed for English Immersion Students at Three Grade Levels

	English Reading								
Step	Grade 2			Grade 4			Grade 6		
predictor	β [a]	β [b]	ΔR^2	β [a]	β [b]	ΔR^2	β [a]	β [b]	ΔR^2
1.Chinese	.17	.04		-.13	-.20		.35*	.34*	
Math	.39**	.23	.22**	.48**	.33**	.17*	.24	.26†	.20*
2. Eng PA	.36*	.29†	.09*	.41**	.43**	.14**	-.20	-.17	.04
3. Eng NS	.22	.22	.04	.15	.15	.02	.40**	.34*	.12*
2A. Eng NS	.29*	.22	.07*	.10	.15	.01	.36*	.34*	.13*
3A. Eng PA	.29†	.29†	.06†	.43**	.43**	.15**	-.17	-.17	.03

Note. Eng PA = English Phonological Awareness; Eng NS = English Naming Speed; Chinese = Chinese achievement; Math = Mathematics Achievement.
[a] Standardized beta coefficient for the step at which the predictor first entered the model.
[b] Standardized beta coefficient for the final step of the model.
**$p < .01$, *$p < .05$, † $p < .10$

Prediction of English and Chinese Achievement in Non-immersion Students

Tables 14 and 15 report the contribution of Chinese PA and NS to English and Chinese achievement for non-immersion students at the three grade levels.

In Table 14, English reading achievement was the outcome measure. After controlling Chinese and mathematics achievement, Chinese predictors did not significantly predict English reading achievement at all the three grade levels except for a unique variance from Chinese PA in English reading achievement in Grade 4.

Table 14

Hierarchical Regression Analyses Predicting English Reading Achievement from Chinese Cognitive Tasks for Non-immersion Students at Three Grade Levels

	English Reading Achievement								
Step	Grade 2			Grade 4			Grade 6		
predictor	β [a]	β [b]	ΔR^2	β [a]	β [b]	ΔR^2	β [a]	β [b]	ΔR^2
1.Chinese	.23	.23		.11	.02		.33	.26	
Math	.21	.10	.16†	.03	-.08	.02	-.04	-.10	.09
2. Chi PA	-.24	-.24		.42*	.42*		.15	.15	
Chi NS	.34	.34	.08	-.03	-.03	.14	.21	.21	.07

Note. Chi PA = Chinese Phonological Awareness; Chi NS = Chinese Naming Speed; Chinese = Chinese Achievement; Math = Math Achievement.

[a] Standardized beta coefficient for the step at which the predictor first entered the model.
[b] Standardized beta coefficient for the final step of the model.
***p*< .01, **p*< .05, † *p*< .10

In Table 15, when Chinese achievement was the outcome measure, mathematics achievement was entered as the first step to control background and mental ability. Chinese PA and NS were forced into the equation as the second step, but they did not add any further variance in Chinese achievement at the three grade levels.

Table 15

Hierarchical Regression Analyses Predicting Chinese Achievement tests from Chinese Cognitive Tasks for Non-immersion Students at Three Grade Levels

Step predictor	Chinese achievement								
	Grade 2			Grade 4			Grade 6		
	β [a]	β [b]	ΔR^2	β [a]	β [b]	ΔR^2	β [a]	β [b]	ΔR^2
1. Math	.61**	.55**	.37**	.50**	.31	.25**	.80**	.82**	.64**
2. Chi PA	.07	.07		.17	.17		-.09	-.09	
3. Chi NS	.10	.10	.02	.23	.23	.07	.17	.17	.03

Note. Chi PA = Chinese Phonological Awareness; Chi NS = Chinese Naming Speed; Math = Math Achievement.

[a] Standardized beta coefficient for the step at which the predictor first entered the model.
[b] Standardized beta coefficient for the final step of the model.
**p*< .05. ***p*< .01

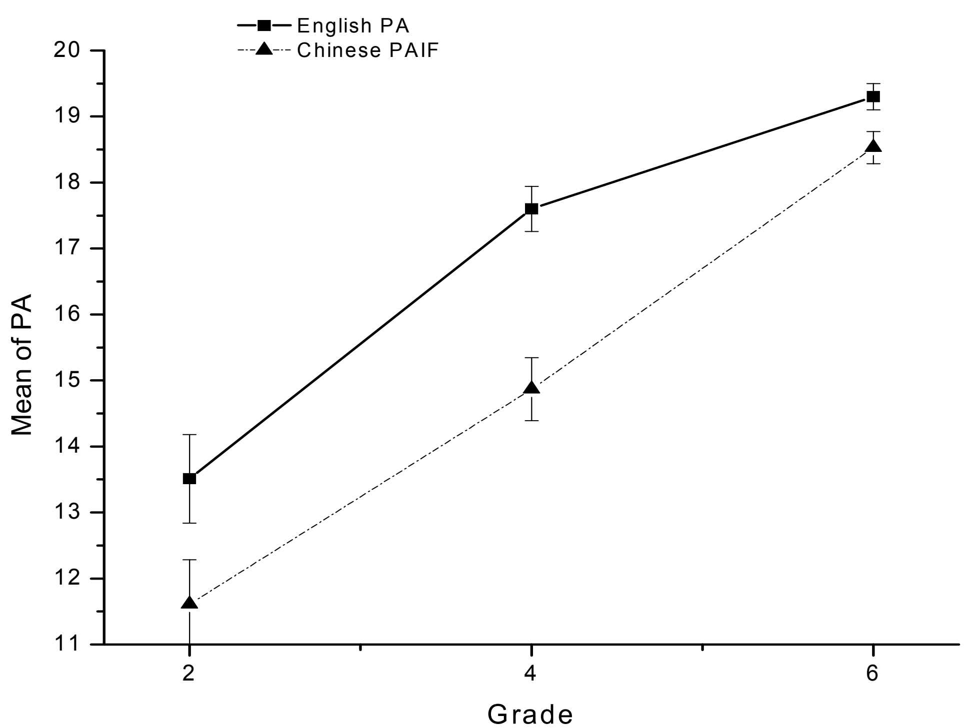
The above results indicate that, for non-immersion students, there is no effect on English and Chinese achievement from Chinese predictors.

Cross-language Comparison on Phonological Awareness and Naming Speed

In order to explore cognitive development further, cross-language comparison on phonological awareness and naming speed was performed for English immersion students.

Since English PA and Chinese PAIF had the same number of items, they were analyzed in a 3 (Grade) x 2 (Language) ANOVA with repeated measures on the second factor, which showed a language effect $F(1, 132) = 56.85$, $p < .001$. There were also grade $F(2, 132) = 48.20$, $p < .001$ and interaction effects $F(2, 132) = 5.29$, $p < .01$ (the full analysis is reported in Appendix G). The interaction results are shown in Figure 3. To examine the interaction further, paired-samples *t*-tests were conducted between languages at the three grade levels. Immersion students scored higher on English PA than on Chinese PAIF in Grade 2, $t\ (47) = 4.34$, $p < .001$; in Grade 4, $t\ (46) = 5.80$, $p < .001$; in Grade 6, $t\ (39) = 3.18$, $p < .001$. These results indicate that the English PA test is easier than Chinese PAIF test to the immersion students at all grade levels. The interaction would appear to be due to the greater difference between languages at Grade 4, or the smaller difference at Grades 2 and 6.

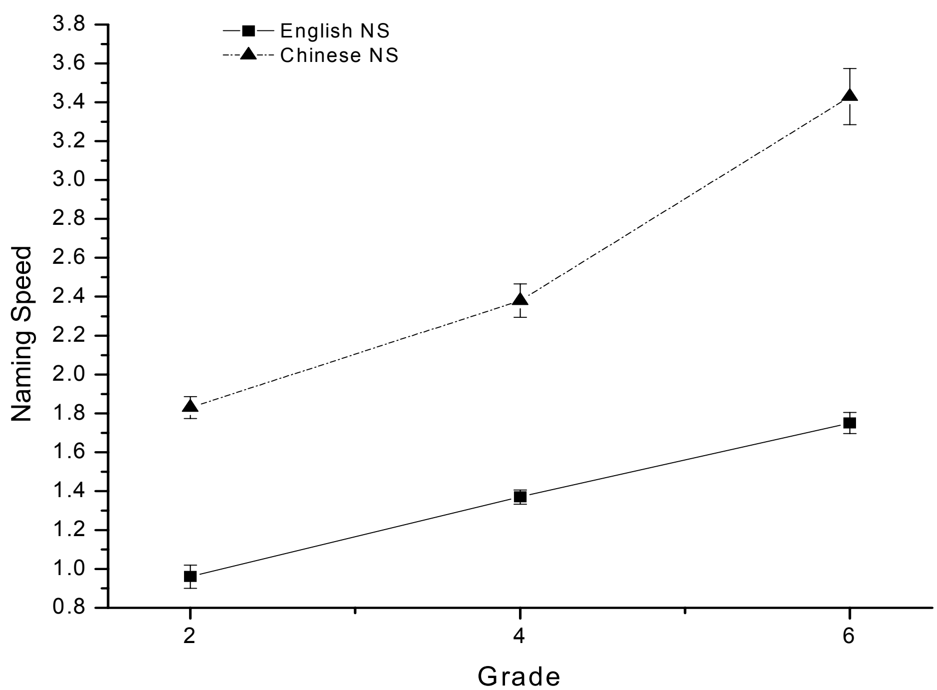
Figure 3. *Mean performances on English PA and Chinese PAIF of English immersion students*



Data from the English and Chinese naming speed tests were analyzed in a similar ANOVA, which showed language $F\ (1, 132) = 526.88$, $p < .001$, grade $F\ (2, 132) =$

90.50, $p < .001$, and interaction effects F (2, 132) = 21.58, $p < .001$ (the full analysis is reported in Appendix G). The paired-samples t-tests showed immersion students scored lower on English NS than on Chinese NS in Grade 2, t (47) = -15.43, $p < .001$; in Grade 4, t (46) = -13.27, $p < .001$; in Grade 6, t (39) = -12.60, $p < .001$. The interaction is due to the greater differences between languages with increasing grade. The results are illustrated in Figure 4. The situation is quite different from that of phonological awareness for immersion students. English naming speed efficiency of English immersion students is slower than their Chinese naming speed efficiency.

Figure 4. *Mean performances on English NS and Chinese NS of English immersion students*



The cross-language comparison on phonological awareness and naming speed in immersion students demonstrated that the students' L1 proficiency is higher than that of

L2, which can be seen from their faster Chinese naming speed efficiency. Their high scores on English PA rather than Chinese PA are mostly due to the easier English PA measure.

In this study, NS measures across language are more comparable than PA measures because NS measures share the similar stimuli and the results received from NS comparison are more convincing.

CHAPTER 5: DISCUSSION

This study investigated the effects of phonological awareness and naming speed on reading achievement and explored the evidence for cross-linguistic transfer for Chinese English immersion students. The differences in Chinese acquisition (Chinese cognitive skills, Chinese achievement, and Chinese mathematics achievement) between immersion students and non-immersion students were also investigated.

Is There an English Immersion Advantage?

The literature reviewed on bilingualism and immersion programs has claimed that immersion students achieve a remarkably high level of second language proficiency without any detrimental effects on their first language (Cummins & Carson, 1997; Lapkin et al., 2003; Swain & Johnson, 1997; Turnbull et al., 2001). With regard to cognitive processes underlying achievement, the majority of studies have reported an advantage for bilingual children (Bruck & Genesee, 1995; Campbell & Sais, 1995; Yelland, Pollard, & Mercuri, 1993). Therefore, knowing whether there are English immersion advantages in reading achievement and cognitive skills for Chinese English immersion students will contribute to our understanding of English immersion influences on language proficiency, literacy, and cognitive processes because these two orthographies vary substantially in their representation of phonology.

When exploring the differences in cognitive skills and reading achievement in students' first language between English immersion and non-immersion students, we discovered that there was no overall difference between the two groups in their Chinese NS at any grade level. Non-immersion students even performed better than immersion students on Chinese PA in Grade 2. No significant difference was found between the two groups in Chinese PA in Grade 4, nor in Chinese and mathematics achievement in Grades 2 and 4. However, immersion students performed better on Chinese PA, Chinese, and mathematics achievement in Grade 6 which is consistent with Lapkin et al.'s (2003) study that French immersion students had advantages over non-immersion students on English literacy and mathematics achievements in Grade 6. The superiority of French immersion students on achievement tests was not obvious until they were in Grade 3 when the formal instruction in English started, and the French immersion students even demonstrated a certain lag in English literacy skills in Grades 1 and 2. In our study, Chinese English immersion students seemed to have more advanced Chinese phonological awareness, Chinese achievement, and mathematics achievement than non-immersion students in Grade 6. However, the superior Chinese cognitive skills and literacy achievement of immersion students were not apparent in early grades, such as Grade 2 or 4.

There are two plausible explanations for the immersion students' superior performance on Chinese measures in Grade 6. The first explanation is that the difference is a result of bilingualism. During the early years of instruction, Chinese students learned pinyin, a Latin alphabetic system, to represent sounds and pronounce Chinese characters. Although Chinese is the students' first language, the English immersion students form a basic foundation of Chinese language but not a solid one due to the fact that they are exposed to more English than their non-immersion peers, which may cause confusion between the two languages during the earlier grades and negatively affect their Chinese phonological awareness in Grade 2. In addition, they may spend less time on Chinese subjects and more time on studying English because they are required to know more English than are non-immersion students.

However, as they progress in grade level, the advantages of bilingualism begin to appear due to cross-linguistic transfer (Gottardo et al., 2001; McBride-Chang & Kail, 2002; Wade-Woolley & Geva, 2000). The accumulated English phonological awareness of immersion students transfers to their Chinese phonological awareness, which may consolidate their Chinese PA and indirectly improve their Chinese achievement. Some researchers have also argued that bilingualism makes cognition more flexible as a natural consequence of learning two languages (Campbell & Sais, 1995; Rubin & Turner, 1989). The contrast between two languages makes bilingual children pay more attention to phonologies and orthographies of words. Thus, the Chinese phonological awareness and reading achievement of immersion students grows faster than that of non-immersion students, resulting in better performance in later grades. The benefits to Chinese achievement of English immersion programs, therefore, cannot be observed until students have reached the upper grade levels.

The second explanation of Grade 6 students' superiority on Chinese measures over non-immersion students is that all of the Grade 6 students in this study are from Xi'an School. English immersion students in Xi'an School were selected by means of an entrance exam to the English immersion program because more students wished to enroll in the Grade 1 program than there were spaces. The results from the comparison of Xi'an English immersion Grade 2 or Grade 4 students and English immersion Grade 2 or Grade 4 students at the other two schools were complicated because Xi'an English immersion students had an advantage in Grade 2 but not in Grade 4. It is difficult to conclude that

Xi'an School students at all the three grade levels went through the same selection process. We can only assume that Grade 6 students in the English immersion program may have superior average academic achievement compared to Grade 6 non-immersion students as they all had to perform well on the entrance exam to be accepted.

Research into how immersion programs influence students' cognitive development and language proficiency has produced inconsistent results. Although the majority of previous published studies have reported an advantage for immersion students (Bruck & Genesee, 1995; Yelland, et al., 1993), Bialystok and her colleagues (2003) found that bilingual children do not have an advantage over monolingual children in terms of phonological awareness (Bialystok et al., 2003). It is difficult to conclude from this current study that English immersion programs have ameliorative effects on Chinese students' cognitive development and achievement because there is no clear evidence that the advantage of Grade 6 immersion students over non-immersion students results directly from the effectiveness of the English immersion program or from the selection process of the English immersion program.

Prediction of English and Chinese Achievement for English Immersion Students

Consistent with previous studies which concluded that English phonological awareness and naming speed significantly predicted ESL children's English word recognition (de Jong & van der Leij, 1999; Durgunoglu & Oney, 1999), we found that Chinese English immersion students' English PA and NS explained unique variance in their English reading achievement, although not in Chinese. This result suggests that sensitivity to English phonology and NS may be predictive of reading success in English as a second language, as found in previous studies of children whose L1s were Dutch, Spanish, Turkish, and Hebrew (de Jong & van der Leij, 1999; Durgunoglu & Oney, 1999; Wimmer, et al., 2000). The result is also in line with McBride-Chang and her colleagues' (2006) finding that English PA uniquely predicted English vocabulary knowledge for Hong Kong kindergarteners. More importantly, the present result still holds even after statistically controlling for general mental ability (as represented by mathematics achievement), Chinese achievement, Chinese PA, and Chinese NS.

However, it is interesting to note that English PA has unique effects in Grades 2 and 4 and the effect of English PA increases in Grade 4. Furthermore, English NS provides a unique contribution to English reading achievement in Grade 6, but English PA does not. Chinese English immersion students' PA's moderate relationship in Grade 2, strong relationship in Grade 4, and weak relationship in Grade 6 to English achievement may be due to the students' relative levels of phonological processing skills. Ehri (1997) classified word learning into five phases. In the first pre-alphabetic phase or logographic phase, Grade 2 students begin to learn English with a holistic approach of recognizing English words but without having their attention directed to the internal details (e.g., spelling) of written words. By Grade 4, they have learned spelling and phonological decoding, and have paid more attention to sounds and letters in an analytic way, which may have increased their phonological awareness skill. They are in partial and full alphabetic phases. In Grade 6, in the consolidated and automatic alphabetic phases, the students recognize more words as whole orthographic units, rather than as individual letters, which may have weakened the effect of their phonological awareness.

The effect of English NS on English reading achievement, which is very moderate in Grade 2, but negligible in Grade 4 and strong in Grade 6, may also be attributed to Ehri's (1997) phonological and orthographic processing skills. In the first pre-alphabetic phase, Grade 2 students might rely mainly on a logographic "look and say" approach in early English language studies (McBride-Chang & Treiman, 2003). Using this method, the teacher presents an English word to students, reads it aloud, and asks the students to repeat the pronunciation. Little attention is paid to the individual sounds or letters. Rather, the teacher emphasizes the word's holistic visual configuration; this is what may be happening in the Grade 2 children. In the second and third phases, the students use more partial or full alphabetic skills by learning phonological decoding and phonemes and the effect of their phonological awareness increases; this is what appears to be happening in Grade 4. During these two phases, the students acquire the foundation for reading skills. In the final phases, as represented by the Grade 6 students of the present study, orthographic knowledge grows as a result of successful phonological decoding experiences (Share & Stanovich, 1995) and the students recognize more words as whole units rather than letter by letter.

The relationship between NS and reading achievement in Grade 6 may also be shaped by the processes of comprehension. Naming speed measures lexical access efficiency and it may be an index of how much and how quickly information can be processed in working memory (Kintsch, 1998); therefore, a certain level of reading speed is required for adequate reading comprehension.

It is worth noting that the results of our study showed that the cognitive processes of English learning in English immersion students seemed more delayed than those of native English-speaking children. English-speaking children in Grades 1 and 2 have been in the partial-alphabetic and the full-alphabetic phases (Ehri & McCormick, 1998) but Chinese English immersion children in Grade 4 would be moving into these two phases. Also, English-speaking second graders or above come into the orthographic phase, in which letters are processed in larger groups but Chinese children will not go through it until they are in Grade 6. This may explain the unique development of learning to read English in ESL children.

The third main finding, still related to the second research question, is that Chinese PA made a unique contribution to Chinese achievement in Grade 2. This is consistent with researchers' conclusions that phonological processing skills are important in reading Chinese (Ho & Bryant, 1997a, b; Hu & Catts, 1998; McBride-Chang & Kail, 2002). Every Chinese child spends the first 10 weeks of first grade learning pinyin, an alphabetic script, to help in pronouncing and identifying characters before Chinese character instruction begins. Research has indicated that the pinyin system can improve Chinese phonological awareness (Cheung et al., 2001; Siok & Fletcher, 2001). For example, Cheung et al. (2001) reported that children in mainland China, who had learned the pinyin system, performed better than their Hong Kong counterparts, who had not been taught pinyin, on an onset and coda matching task. Moreover, phonological awareness in Chinese can enhance students' ability to read Chinese characters (Ho & Bryant, 1997a, b; Hu & Catts, 1998).

However, previous studies on phonological processing skills of Chinese children have mainly focused on children aged 3 to 7 (Ho & Bryant, 1997a; McBride-Chang, & Ho, 2000; Chow et al., 2005). Few have examined Grade 2 children or older. Our study investigated Chinese students whose ages ranged from 8 to 12. The importance of Chinese PA diminishes with grade level just as when learning to read English (Kirby et al., 2003; Ehri, 1997). Because Chinese children experience more pinyin input in Grades 1 and 2 in order to become familiar with the pronunciation of Chinese characters, as soon as they grasp this phonetic system, training on the pinyin system is reduced in later grades and then the majority of Chinese literacy instruction would focus more on Chinese character recognition, writing, and reading comprehension, which may decrease the effect of their phonological awareness gained from the pinyin system.

Prediction of English and Chinese Achievement for Non-immersion Students

As far as we know, our study of the prediction of Chinese non-immersion student reading achievement is the first of its kind in using phonological awareness and naming speed as predictors. In answering the third research question, there is no evidence of the effectiveness of Chinese PA and NS as predictors of English and Chinese achievement for non-immersion students.

After controlling for mathematics achievement, the Chinese predictors for non-immersion students at the three grade levels did not effectively predict Chinese achievement. This may be due to the fact that the Chinese achievement measures were from three school-issued final term exams rather than a single standardized test with high reliability and validity or a word reading test. As most previous studies have shown that phonological awareness and naming speed are strong predictors of word reading in both alphabetic and non-alphabetic languages (Burgess & Lonigan, 1998; Wagner et al., 1997), but our study used achievement test rather than word reading test as outcome measure, which may explain why we obtained different results from those of previous studies. The relatively low number of subjects is the other explanation that Chinese predictors could not contribute to Chinese achievement for non-immersion students. With respect to the relation between Chinese predictors and English reading achievement for non-immersion students, Chinese PA and NS did not predict English reading achievement after Chinese reading and mathematics achievement were taken into consideration, which showed non-immersion students shared a similar pattern with immersion students, indicating no cross-linguistic transfer.

Is There Cross-linguistic Transfer?

The final research question concerns cross-linguistic transfer, asking whether or not Chinese PA and NS predict English reading achievement and English PA and NS predict Chinese achievement for immersion students. Several research studies have indicated phonological awareness can transfer across languages, no matter whether the two languages are classified in the same orthographic category or not (Gottardo et al., 2001; Knell et al., 2007; McBride-Chang & Ho, 2005; Chow et al., 2005).

There were two ways to address this issue. One is the liberal way, in which only background factors, such as Chinese vocabulary knowledge and general mental ability, are controlled. The other is a more conservative way, in which PA and NS in the language of the outcome achievement variable are also controlled. In our study, when we used the liberal method for English immersion students, after controlling for Chinese achievement and general mental ability, Chinese PA and NS did not explain a significant amount of the variance in English reading achievement at any of the three grade levels.

With regards to the prediction of Chinese achievement from English predictors, when mathematics achievement was controlled, English PA and NS also did not predict Chinese achievement at any grade level for immersion students. Moreover, when we use the conservative method, in other words, when we controlled for Chinese achievement and general mental ability in the first step, and English PA and NS in the second step, Chinese PA and NS still did not predict English reading achievement at any grade for immersion students. The possible reasons why we did not observe the cross-linguistic transfer are as follows: (1) the large distance between L1 and L2 phonology and orthography is an obstacle to cross-linguistic transfer; (2) most of the previous studies found cross-linguistic transfer using oral word reading measures as outcome measures but our study used silent reading comprehension as the outcome measure; (3) Chinese outcome measures in our study were from school-issued tests in the previous academic year for which reliability and validity could not be calculated without subscores and relevant measures.

It is worth noting that our study investigated the cognitive processes of the students in three Grades 2, 4, and 6, respectively. In contrast, in those previous studies which indicate a cross-linguistic transfer between English and Chinese (Gottardo et al., 2001; Knell et al., 2007; McBride-Chang & Ho, 2005; Chow et al., 2005), their samples were either an aggregation of participants of all grades or kindergarteners. There are two reasons why we separated the subjects. One is that the three school-issued Chinese achievement tests are not on the same scale for each grade. The other is that even if the researchers controlled confounding variables, such as age, the result is still difficult to interpret because reading related skills contribute to reading abilities differently across age (Wagner et al., 1997). Thus, our study explored the data separately at each grade.

A cross-language comparison of the development of PA and NS was also conducted for the immersion students. Because the English PA and Chinese PA tasks are different, although immersion students scored higher on English PA than on Chinese PA (see Figure 3), it is not possible to draw the conclusion that immersion students have more advanced English phonological awareness. A plausible explanation for the result shown in Figure 3 is that the English PA measure is easier than the Chinese one. With respect to NS, because the English NS and Chinese NS tasks showed the same number of stimuli but in different order to the students, these are more comparable than the English and Chinese PA tasks. The NS results in our study showed that the immersion students scored higher on Chinese NS than on English NS, which indicates the students' greater level of familiarity with their first language.

Limitations and Implications for Future Research

Some limitations should be noted why firm conclusions cannot be drawn from the present study. First, although the number of participants per group was adequate for the analyses, greater numbers would have provided more power and stability.

Second, previous research has most frequently been based on the relationship between oral word reading and PA and NS cognitive predictors. However, broader English and Chinese reading achievement scores rather than oral word reading scores were used in the present study, which may help to explain why the present results differ from those of the previous studies. Moreover, the raw scores of the Chinese and mathematics achievement tests from the three school-issued final term exams were used in this study even though the achievement tests across the three schools were different. In addition, the reliability and validity of school-issued achievement tests have not been calculated because we only had the total scores of each achievement test from schools, and there were no criterion measures to which the scores could be compared. Chinese and mathematics achievement scores at each grade level had very high means. Thus, the consistency and appropriateness of the measures could not be determined. Moreover, both Chinese and mathematics achievement tests from the three schools were administered to the students in June of the previous academic year, which was four months before the cognitive tasks and English achievement test were issued. It is possible that the time lapse between the collected measures may have influenced the results.

Third, the Grade 6 students were only from the Xi'an School and were selected by means of an English immersion entrance exam. Although we employed *t*-tests to compare Xi’an School students to the other two school students on all Chinese and English measures in Grades 2 and 4, the inconsistent results could neither confirm nor refute that the results were due to a selection process. We should be aware that the observed differences between the immersion and non-immersion groups may be spurious. In addition, English immersion students may also have been further exposed to English because they attended English tutoring schools on weekends so as to acquire more English language proficiency, which we did not track at all.

Fourth, phonological awareness consists of syllable awareness, onset-rime awareness, and phoneme awareness. The present study only measured onset-rime awareness using the task of sound detection. Grade 6 students showed a ceiling effect on that task in English, indicating that the task was too easy for them. In fact, we needed a PA task that is appropriate for all Grades 2, 4, and 6; but if we chose a more difficult task, it would have had a floor effect in Grade 2. Therefore, in future research, different levels of phonological awareness tasks, and more tasks, should be included to obtain a more complete understanding of how phonological awareness relates to reading development for Chinese students. Moreover, as learning to read involves converting the written language to its corresponding spoken language, the pre-eminence of phonological awareness in the early stages of reading acquisition is not surprising. However, reading is more than converting orthographic forms into phonological forms. Comprehension can only be achieved when the converted phonological forms are mapped onto semantic information. As children grow older, other aspects of metalinguistic awareness are critical to the development of word reading and reading comprehension (Bowey, 1994; Moats, 2000). Hence, future research should examine the role of factors such as morphological awareness and syntactic awareness in reading comprehension in both English and Chinese.

This study has shown that English phonological awareness is a significant predictor of English reading achievement in Grades 2 and 4 Chinese English immersion students. Educators may be able to use phonological awareness training or phonics skills; for example, classroom teachers could use perhaps 10 minutes at the beginning or at the end of each class to practice activities that build this knowledge, such as rhyming, segmenting, and blending sound units in early grades, thereby providing a stronger foundation for students to learn English phonics to enhance their reading ability in English (Adams, Foorman, Lundberg, & Beeler, 1998). Moreover, English naming speed uniquely predicted English reading achievement in Grade 6 students. Naming speed is related to fluent reading, which is also associated with orthographic knowledge because recognition of letter patterns in a word depends on seeing these letters in sufficient temporal contiguity (Adams, 1990). Rapid naming of symbols might be an index of this ability to recognize letters in time and thus be linked to orthographic knowledge and skill (Bowers & Wolf, 1993). The findings of Levy et al. (2006) suggested that basic orthographic skills are necessary for beginning reading and basic orthographic training should be incorporated into the program.

Conclusion

This study upholds the idea that English phonological awareness and naming speed are significant predictors of English reading comprehension in Chinese English immersion students. The findings also suggest that the importance of phonological awareness to early reading comprehension is not specific to alphabetic languages but also applies to Chinese. However, this study does not provide any evidence for cross-linguistic transfer, perhaps because of the large distance between Chinese and English, insufficient sample sizes, and the nature of the outcome measures. In addition, the result that English immersion students demonstrated an advantage over non-immersion students in Grade 6, but no significant differences were found in Grades 2 and 4 suggests either the long-term effect of a bilingual program or a selection effect.

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Appendices

Appendix A: English Sound Detection

English Initial Sound Detection:

Practice

rot	rod	rock	box
lick	lid	miss	lip

Test

1	**bud**	**bun**	**bus**	**rug**
2	**pip**	**pin**	**hill**	**pig**
3	**ham**	**tap**	**had**	**hat**
4	**peg**	**pen**	**well**	**pet**
5	**kid**	**kick**	**kiss**	**fill**
6	**lot**	**mop**	**lock**	**log**
7	**leap**	**mean**	**meal**	**meat**
8	**crack**	**crab**	**crag**	**trap**
9	**slim**	**flip**	**slick**	**slip**
10	**roof**	**room**	**food**	**root**

English Final Sound Detection:

Practice

fan	cat	hat	mat
leg	peg	hen	beg

Test

1	**pin**	**win**	**sit**	**fin**
2	**doll**	**hop**	**top**	**pop**
3	**bun**	**hut**	**gun**	**sun**
4	**map**	**cap**	**gap**	**pal**
5	**men**	**red**	**bed**	**fed**
6	**wig**	**fig**	**pin**	**dig**
7	**weed**	**peel**	**need**	**deed**
8	**pack**	**lack**	**sad**	**back**
9	**sand**	**hand**	**land**	**bank**
10	**sink**	**mint**	**pink**	**wink**

Appendix B: Naming Speed

English Digit Naming

4	**5**	**2**	**1**	**5**	**4**	**8**	**1**
2	**1**	**8**	**2**	**4**	**5**	**1**	**4**
8	**4**	**5**	**2**	**1**	**4**	**2**	**8**
5	**1**	**2**	**8**	**2**	**5**	**8**	**4**
1	**4**	**8**	**5**	**8**	**1**	**2**	**5**

Chinese Digit Naming

8	**2**	**5**	**4**	**2**	**8**	**1**	**4**
5	**4**	**1**	**5**	**8**	**2**	**4**	**8**
1	**8**	**2**	**5**	**4**	**8**	**5**	**1**
2	**4**	**5**	**1**	**5**	**2**	**1**	**8**
4	**8**	**1**	**2**	**1**	**4**	**5**	**2**

Appendix C: Chinese Sound Detection and Tone Awareness

Chinese Initial Sound Detection:

Practice:	包 bāo	帮 bāng	背 bēi	招 zhāo
	通 tōng	推 tuī	多 duō	吞 tūn
Test : 1	潘 pā n	乓 pā ng	发 fā	烹 pē ng
2	夫 fū	妈 mā	咪 mī	摸 mō
3	都 dō u	踢 tī	登 dē ng	当 dā ng
4	招 zhā o	张 zhā ng	朱 zhū	称 chē ng
5	咖 kā	哥 gē	估 gū	刚 gā ng
6	番 fā n	风 fē ng	分 fē n	刀 dā o
7	鳖 biē	拼 pī n	边 biā n	标 biā o
8	松 sō ng	村 cū n	缩 suō	虽 suī
9	爹 diē	癫 diā n	听 tī ng	丢 diū
10	聪 cō ng	搓 cuō	尊 zū n	蹿 cuā n

Chinese Final Sound Detection:

Practice:	呆dāi	拉 lā	胎tāi	开 kāi
	瞎xiā	家 jiā	边 biān	掐 qiā
Test: 1	**匡kuāng**	**酸suān**	**荒huāng**	**双shuāng**
2	昆 kū n	松 sō ng	充 chō ng	中 zhō ng
3	咧 liē	江 jiā ng	枪 qiā ng	乡 xiā ng
4	捐 juā n	宣 xuā n	缺 quē	圈 quā n
5	宽 kuā n	川 chuā n	欢 huā n	光 guā ng
6	沾 zhā n	三 sā n	当 dā ng	番 fā n
7	黑 hē i	勒 lē i	背 bē i	科 kē
8	巴 bā	趴 pā	妈 mā	掏 tā o
9	嗔 chē n	风 fē ng	身 shē n	针 zhē n
10	包 bā o	捞 lā o	闷 mē n	掏 tā o

Chinese Tone Awareness:

Practice:	拔 bá	鼻 bí	被 bèi	甭 béng
	滥 làn	郎 láng	漏 lòu	力 lì
Test: 1	非 fē i	番 fā n	否 fǒ u	分 fē n
2	岛 dǎ o	但 dàn	底 dǐ	斗 dǒ u
3	提 tí	谈 tán	逃 táo	胎 tā i
4	辣 là	太 tài	更 gèng	可 kě
5	帮 bā ng	猫 mā o	凡 fán	低 dī
6	桥 qiáo	夹 jiá	恐 kǒ ng	频 pín
7	顿 dùn	良 liáng	挂 guà	降 jiàng
8	春 chū n	岁 suì	俊 jùn	下 xià
9	扁 biǎ n	马 mǎ	朵 duǒ	收 shō u
10	晚 wǎn	停 tíng	捆 kǔn	养 yǎng

Appendix D: Skewness and Kurtosis Values of Raw Scores

Table 1

Measures with Skewness and Kurtosis Values of Raw Scores for English Immersion Students

	Grade 2 (N=48)		Grade 4 (N=47)		Grade 6 (N=40)	
Measure	S/SE	K/SE	S/SE	K/SE	S/SE	K/SE
English PA	-.38	-1.75	-3.31	1.59	-6.87	10.67
English NS	1.91	1.37	-.57	0.09	-.30	-1.30
English Reading	4.21	3.24	3.46	4.77	-.19	-0.81
Chinese PAIF	1.06	-1.39	-2.34	1.21	-2.62	0.71
Chinese PA	.97	-1.57	-1.83	0.19	-1.81	-0.73
Chinese NS	-1.15	-0.51	1.06	1.31	-1.60	0.16
Chinese Achievement	-4.29	5.67	4.20	3.43	-2.68	0.67
Math Achievement	-3.56	0.81	3.00	1.06	-3.43	1.19

Note. S = Skewness; K = Kurtosis; SE = Standard Error; PA = Phonological Awareness; NS = Naming Speed; PAIF = Phonological Awareness Initial and Final Sound Detection.

Table 2

Measures with Skewness and Kurtosis Values of Raw Scores for Non-immersion Students

	Grade 2 (N=30)		Grade 4 (N=33)		Grade 6 (N=40)	
Measure	S/SE	K/SE	S/SE	K/SE	S/SE	K/SE
Chinese PAIF	-.44	-1.47	-1.00	-0.76	-1.03	-1.66
Chinese PA	-.72	-1.43	-1.07	-0.93	-1.11	-1.22
Chinese NS	1.30	-1.00	2.34	0.95	0.78	-0.97
Chinese PAIF	.35	-0.24	1.49	0.64	2.38	1.58
Chinese Achievement	-5.70	9.81	-4.27	6.10	-2.60	0.59
Math Achievement	-3.86	3.32	-5.12	4.50	-2.03	0.25

Note. S = Skewness; K = Kurtosis; SE = Standard Error; PA = Phonological Awareness; NS = Naming Speed; PAIF = Phonological Awareness Initial and Final Sound Detection.

Appendix E: Skewness and Kurtosis Values of Transformed Scores

Table 1

Measures with Skewness and Kurtosis Values of Transformed Scores for English immersion Students

	Grade 2 (N=48)		Grade 4 (N=47)		Grade 6 (N=40)	
Measure	S/SE	K/SE	S/SE	K/SE	S/SE	K/SE
English PA [a b]			-1.54	-0.59	-1.46	-2.48
English Reading [a]	2.18	1.51	-1.51	2.21		
Chinese Achievement [a]	-1.41	0.21	-2.09	0.46		
Math Achievement [a]	-1.82	-0.75			-1.60	-0.67

Note. S = Skewness; K = Kurtosis; SE = Standard Error; PA = Phonological Awareness.
[a] This measure underwent a square root transformation; [b] This measure underwent a dichotomized transformation.
For English PA measure, Grade 4 English PA underwent a square root transformation but Grade 6 English PA underwent a dichotomized transformation.

Table 2

Measures with Skewness and Kurtosis Values of Transformed Scores for Non-immersion Students

	Grade 2 (N=30)		Grade 4 (N=33)	
Measure	S/SE	K/SE	S/SE	K/SE
Chinese Achievement [a]	-2.74	1.82	-1.27	0.70
Math Achievement [a b]	-2.12	-0.17	-1.10	-0.06

Note. S = Skewness; K = Kurtosis; SE = Standard Error.
[a] This measure underwent a square root transformation; [b] This measure underwent a logarithmic transformation.
For Math Achievement measure, Grade 2 Math underwent a square root transformation; Grade 4 Math underwent a logarithmic transformation.

Appendix F: Two-way ANOVAs for Chinese PA and NS

Table 1
Two-way ANOVA – Chinese Phonological Awareness

Effect	Mean Square	df	F	Sig.	Partial η^2
Grade	787.75	2	33.30	.000	.22
Program	5.20	1	.22	.640	.001
Grade * Program	270.91	2	11.45	.000	.09
Error	23.66	232			

Note. R^2 = .30 (Adjusted R^2= .29)

Table 2
Two-way ANOVA – Chinese Naming Speed

Effect	Mean Square	Df	F	Sig.	Partial η^2
Grade	39.10	2	93.77	.000	.45
Program	.05	1	.11	.741	.00
Grade * Program	1.00	2	2.40	.093	.02
Error	.42	232			

Note. R^2 = .46 (Adjusted R^2 = .45)

Appendix G: Repeated Measures ANOVAs for PA and NS

Table 1

Repeated Measures ANOVA – Phonological Awareness

Effect	Mean Square	df	F	Sig.
Language	221.85	1	56.85	.000
Language * Grade	20.64	2	5.29	.006
Error(within)	3.90	132		
Grade	861.22	2	48.20	.000
Error (between)	17.87	132		

Table 2

Repeated Measures ANOVA – Naming Speed

Effect	Mean Square	df	F	Sig.
Language	95.09	1	526.88	.000
Language * Grade	3.90	2	21.58	.000
Error(within)	.18	132		
Grade	31.06	2	90.50	.000
Error (between)	.34	132		