This study investigated the effects of English and Chinese phonological awareness (PA) and naming speed (NS) on English reading achievement and the evidence for cross-linguistic transfer in Chinese English-immersion students. English PA was a significant predictor of English reading achievement for immersion students in Grades 2 and 4. There was little evidence of cross-linguistic transfer from Chinese PA and NS to English reading achievement. English immersion students performed equal to non-immersion students on NS and mathematics in both grades, and in Chinese PA in Grade 4. Results are discussed in terms of theories of reading development in second language.

A decade ago, early English immersion programs, modeled after French immersion programs in Canada, were established 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 (Cheng, Li, Kirby, Qiang, & Wade-Woolley, 2010). These programs were based on the belief that early immersion leads to early acquisition of the second language and high 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 et al., 2010). However, little research has been conducted to explore the cognitive processes in academic achievement, especially reading achievement, in the English immersion programs. Therefore, this study investigated the different contributions of English and...
Chinese cognitive predictors to English reading achievement and whether cross-linguistic transfer from Chinese cognitive predictors to English reading achievement existed in Chinese English-immersion students. The differences between English-immersion students and nonimmersion students in terms of Chinese cognitive skills and mathematics achievement were also examined.

**English Immersion Programs in China**

The English immersion programs in China were set up in light of the successful French immersion programs in Canada but differ from them in some ways. The basic curriculum design of French immersion programs is that students study content materials for at least 50 percent of the school day in French, studying the remainder of the time in English (Swain, 2000). Thus not only the second language, but also some content subjects, are taught through the second language. The extant research on 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; Genesee, 1987; Lapkin, Hart, & Turnbull, 2003; Swain, 1996; Turnbull, Lapkin, & Hart, 2001). For example, Turnbull et al. (2001) found that French immersion students performed equal to their monolingual peers on English language arts and mathematics after formal instruction in English language arts started in Grade 3. Moreover, Lapkin et al. (2003) indicated that at Grade 6, immersion students’ English literacy and mathematics test scores were better than their peers’ in English-only programs.

The English immersion programs in China primarily start in Grade 1. However, they do not have as much English (L2) as immersion programs in other countries do. For example, a minimum of 50% instruction is given through French (L2) in French immersion programs in Canada (Genesee & Jared, 2008). Chinese English-immersion programs did not just borrow the entire model of French immersion programs but adopted the concept underlying immersion programs, which ensures some non-language subjects are taught in the second language. The curriculum design is that 30% to 40% of the curriculum is taught in English, including English language arts, social studies, and
science. The other 60% to 70% of the curriculum is taught in Chinese, including key subjects such as Chinese and mathematics. Chinese is included from Grade 1 to establish a high level of L1 (the first language) proficiency. Other subjects, such as physical education, art, and music are taught in Chinese or English, varying from immersion program to immersion program. English immersion and nonimmersion students spend the same amount of school time learning English in the English language arts class. The only difference is that nonimmersion students do not receive other subjects taught in English (Knell et al., 2007). With regard to the teacher resources in the English immersion programs, all the English teachers are native Chinese speakers and most of them have obtained bachelor’s degrees. However, their English proficiency levels are not considered equal to those of native English speakers (Knell et al., 2007). Although there is an abundance of research on French immersion programs, few studies of immersion programs in the Chinese context have been conducted. Recently, Knell et al. (2007) indicated that it was an additive bilingual system without any detrimental effects on students’ L1.

The majority of published studies have reported high achievement of L2 (the second language) competence for early immersion programs (Cummins & Carson, 1997; Lapkin et al., 2003; Swain, 1996); however, 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 of 12,784 middle school students. They argued that late immersion in English as the language of instruction had large negative effects on nonlanguage subjects (mathematics, science, geography, and history) taught in English. This result challenged the generality of previous findings of positive effects of early immersion programs.

Cognitive Predictors of L1 Reading Ability

There is considerable evidence that many cognitive variables, such as phonological awareness, naming speed, phonological memory, morphological awareness, and syntactic awareness, predict
reading achievement in English and other L1s. Among them, phonological awareness and naming speed prove to be two critical predictors of reading ability, according to the double-deficit hypothesis proposed by Wolf and Bowers (1999).

Substantial evidence indicates that phonological awareness (PA), the sensitivity to and the ability to manipulate the sound structure of words, is a powerful concurrent and longitudinal predictor of reading development in both alphabetic (see e.g., English: Adams, 1990; Goswami & Bryant, 1990; Kirby, Parrila, & Pfeiffer, 2003; Scarborough, 1998; Share & Stanovich, 1995; Wagner, Torgesen, Laughon, Simmons, & Rashotte, 1993; Wagner et al., 1997; Dutch: de Jong & van der Leij, 1999; Turkish: Durgunoglu & Oney, 1999; German: Wimmer, Mayringer, & Landerl, 2000) and nonalphabetic languages (see e.g., Chinese: Ho & Bryant, 1997a, 1997b; Hu & Catts, 1998; Liao, Georgiou, & Parrila, 2008; McBride-Chang & Ho, 2000; McBride-Chang & Kail, 2002; Shu, Anderson, & Wu, 2000).

Naming Speed (NS), also known as rapid automatized naming (RAN) or speed of lexical access, is the speed at which children can name a set of stimuli, such as digits, letters, colors, or pictured objects (Kirby, Georgiou, Martinussen, & Parrila, 2010; Wolf & Bowers, 1999). It is a unique and strong predictor of reading development in alphabetic languages (e.g., English: 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; Dutch: de Jong & van der Leij, 1999; German: Wimmer et al., 2000), and in nonalphabetic languages (see e.g., Chinese: Liao, Georgiou, & Parrila, 2008; McBride-Chang & Ho, 2000).

Most of the reading literature exploring the roles of phonological awareness and naming speed has focused on word-level reading as the outcome measure. However, phonological awareness and naming speed are also associated with reading comprehension. For example, Torgesen, Wagner, Rashotte, Burgess, and Hecht (1997) demonstrated that individual differences in phonological awareness in both Grades 2 and 3 uniquely explained word-reading development and reading comprehension beyond vocabulary 2 years later. In another longitudinal study, Kirby et al. (2003) followed 79 children from kindergarten to Grade 5. After
controlling for general mental ability and letter recognition, PA and NS were strong predictors of both word reading and reading comprehension from kindergarten to Grade 5, but the effect of PA was greater in kindergarten and Grade 1 and NS had stronger effects on word reading and reading comprehension in the later grades (Kirby et al., 2003). In addition, Ehri et al. (2001) summarized the effects of PA instruction on learning to read from 52 studies, 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.

**Cross-Linguistic Transfer of Phonological Awareness and Naming Speed**

Phonological awareness and naming speed are not only important in learning to read in L1, but also in L2. Research studies focusing on bilingual learners have shown 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 (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). Cross-linguistic transfer happens especially among different alphabetic languages, as they share fundamental alphabetic principles and depend on common phonological processes.

With respect to phonological awareness, Cisero and Royer (1995) found a similar developmental order in acquiring phonological awareness skills in English and Spanish for Spanish-speaking children. Comeau et al.’s (1999) study of English-speaking children in a French immersion program indicated that phonological awareness in English (L1) strongly predicted word decoding in both English and French (L2), and phonological awareness in French (L2) significantly predicted word decoding in French and English (L1). MacCoubrey, Wade-Woolley, Klinger, and Kirby (2004) found that phonological awareness and naming
speed in English (L1) predicted reading performance in French (L2) for French immersion students in the primary grades.

There is little research available on the cross-linguistic role of rapid naming in different alphabetic languages. However, 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 after accounting for naming speed in English. This finding may be due to the association of naming speed with orthographic processing, because both require the formation of automatic visual-verbal codes (Kirby et al., 2010; Wolf & Bowers, 1999). Also, both English and Farsi are alphabetic languages, which may make cross-linguistic transfer more possible.

Therefore, a growing body of research on reading performance in children learning English as a second language points to concurrent transfer of phonological awareness and naming speed across alphabetic languages (Cisero & Royer, 1995; Comeau et al., 1999; Gholamain & Geva, 1999). 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). The large gap between alphabetic and logographic orthographies may influence cross-linguistic transfer. For example, in learning to read Chinese and English, because of the sharp contrast in the two writing systems as well as their spoken forms, children have to confront the unique demands of the different writing systems and languages (Wang, Perfetti, & Liu, 2005). Several studies have explored cross-linguistic transfer between L1 (Chinese) and L2 (English) in reading development, but the evidence is somewhat inconsistent.

There are two methods to assess cross-linguistic transfer. One is a liberal method of predicting reading ability in L2 from phonological awareness in L1 without controlling for phonological awareness in L2. For example, Chow, McBride-Chang, and Burgess (2005) found that Chinese phonological awareness predicted English word reading abilities concurrently and longitudinally after accounting for variance due to age, Chinese vocabulary, and visual skills among 227 kindergarteners in Hong Kong. Knell et al. (2007) showed Chinese phonological awareness predicted English word recognition moderately for Grades 1 to 3 Chinese English-immersion students after controlling for age and
Chinese vocabulary. These two studies explored cross-linguistic transfer, taking into account factors such as age and Chinese vocabulary, but without controlling for English (L1) phonological processing skills.

The other way to explore cross-linguistic transfer is more conservative, controlling for the process of interest in L2. For example, Gottardo, Yan, Siegel, and Wade-Wodley (2001) administered parallel measures of phonological, syntactic, and orthographic processing skill and word reading in English and Chinese to 65 Chinese children. They found that L1 phonological awareness contributed unique variance to L2 word reading performance even after controlling for children’s L2 phonological awareness.

Gholamain and Geva (1999) have shown that there is cross-linguistic transfer of naming speed between English and Farsi. If NS assesses a general characteristic such as cognitive speed, it would make sense if children who were quick to recognize and name stimuli in one language were also quick to do so in a second language, relative to other children with the same amount of exposure. On the other hand, if NS is more specific to the automaticity of the visual-verbal codes, there is less reason to expect cross-linguistic relationships, especially when the orthographies are very different. To our knowledge, there is no existing research on the cross-linguistic transfer of NS between Chinese and English. We do know, however, that naming speed is more related to orthographic skills, and that there is limited generalization across these two scripts: for example, Wang et al. (2005) found that orthographic processing skill in Chinese and English did not predict each other’s word reading for Chinese children. There is thus less reason to expect cross-linguistic transfer of NS compared to PA.

The Present Study

Drawing on previous research concerning the prediction of English reading development from phonological awareness and naming speed and cross-linguistic transfer (e.g., Gottardo, Yan, Siegel, & Wade-Woolley, 2001; Chow et al., 2005; McBride-Chang & Ho, 2005), the purpose of this study was to examine the different contributions of both English and Chinese cognitive predictors to English reading achievement and cross-linguistic transfer
in Chinese English-immersion students. The secondary purpose of the study was to investigate the differences, if any, between English immersion students and nonimmersion students in terms of Chinese cognitive skills (phonological awareness and naming speed) and mathematics achievement in Chinese. Mathematics achievement in Chinese was included to control for students’ general level of achievement when assessing the effects of the cognitive predictors on reading, and as a measure of academic achievement with respect to the second purpose.

The present study aimed to address three questions related to English reading achievement in Chinese English-immersion students: (a) How well do English PA and NS predict English reading achievement for English immersion students at the Grade 2 and 4 levels? (b) Is there cross-linguistic transfer from Chinese PA and NS to English reading achievement? (c) Do English-immersion and nonimmersion students differ in Chinese PA, Chinese NS, and mathematics achievement at these two grade levels?

**Method**

**Participants**

A total of 159 students with parental permission participated in this study, 96 students from English immersion programs (49 and 47 in Grades 2 and 4 respectively), and 63 students from non-immersion programs (30 and 33 from Grades 2 and 4 respectively). In Grade 2, the sample contained 26 boys and 23 girls in immersion programs, and 16 boys and 14 girls in nonimmersion programs. In Grade 4, the numbers were 25 boys and 22 girls in immersion programs, and 17 boys and 16 girls in nonimmersion programs. Students were randomly selected from three schools in three Chinese cities, Dongguan, Guangzhou, and Xi’an, primarily from the middle class.

**English Measures**

ENGLISH READING MEASURES (CAMBRIDGE YOUNG LEARNERS ENGLISH (YLE) READING & WRITING)

The Cambridge Young Learners English (YLE) test for Reading and Writing was employed to assess English reading
comprehension. The YLE is a paper and pencil group-administered test that takes 20 minutes in Grade 2 (Starters) and 30 minutes in Grade 4 (Movers). 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 writing answers to open-ended questions (Cambridge ESOL, 2007). The recommended ages to administer these two levels of tests are 9 years and 10.6 years (Cambridge ESOL, 2007). The measures were appropriate for the samples in the present study. The score for each test is the number of correct answers. The maximum score for the Grade 2 (Starters) is 25 points and for Grade 4 (Movers) is 40 points. The alpha reliability coefficients of these measures in the present study in Grades 2 and 4 were .79 and .83, respectively.

ENGLISH SOUND DETECTION

Two individually administered tests of initial sound detection and final sound detection in English, developed by James (1996), and adapted from Bryant and Bradley (1985), were administered to assess the phonological awareness of all English immersion students. There were 2 practice items and 10 test items in each of initial and final sound detection. All the items were recorded on a CD in English by a native English speaker, and the time interval between items was fixed at 5 seconds. During the testing, the tester and the student each used headphones so as not to be influenced by environmental noises. The tester asked each student to listen to the CD with headphones. In each practice item, four words were presented aurally and the student was asked to indicate which one of the words began with a different sound from the other three words. 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*. This response method was employed to ensure that children’s difficulty in pronouncing the words would not compromise the children’s scores. Once they finished the two practice items and were familiar with the test, they were given the 10 test items. Similarly, in English final sound detection, the
TABLE 1 Descriptive Statistics for English Immersion and Nonimmersion Students

<table>
<thead>
<tr>
<th>Variable</th>
<th>Grade 2</th>
<th></th>
<th>Grade 4</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$ (EI) $N = 48$</td>
<td>$M$ (NI) $N = 30$</td>
<td>$M$ (EI) $N = 47$</td>
<td>$M$ (NI) $N = 33$</td>
</tr>
<tr>
<td>English phonological awareness</td>
<td>13.67 (4.65)</td>
<td>—</td>
<td>17.60 (2.31)</td>
<td>—</td>
</tr>
<tr>
<td>English naming speed$^a$</td>
<td>0.96 (0.41)</td>
<td>—</td>
<td>1.37 (0.25)</td>
<td>—</td>
</tr>
<tr>
<td>English Reading</td>
<td>7.76 (3.67)</td>
<td>7.50 (1.84)</td>
<td>12.11 (6.24)</td>
<td>11.59 (4.71)</td>
</tr>
<tr>
<td>Chinese phonological awareness</td>
<td>17.63 (6.75)</td>
<td>21.60 (5.22)</td>
<td>22.50 (4.62)</td>
<td>22.94 (4.69)</td>
</tr>
<tr>
<td>Chinese naming speed$^a$</td>
<td>1.84 (0.39)</td>
<td>1.96 (0.55)</td>
<td>2.38 (0.58)</td>
<td>2.58 (0.70)</td>
</tr>
<tr>
<td>Mathematics</td>
<td>96.06 (4.03)</td>
<td>95.78 (5.73)</td>
<td>93.63 (4.71)</td>
<td>94.79 (6.63)</td>
</tr>
</tbody>
</table>

Note. EI = English Immersion program, NI = Nonimmersion program

$^a$ Naming speed score is the number of items named correctly divided by the time taken. SDs are in the parentheses below the means.

...student was asked to choose which one of four words 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 scores was termed English PA. The maximum score of English PA is 20 points. The alpha reliability coefficients of English PA for the present study in Grades 2 and 4 were .85 and .64. The lower reliability coefficient of English PA in Grade 4 may be caused by the fact that the English PA task was too easy for Grade 4 students (the mean was 17.6 out of 20; see Table 1).

ENGLISH RAPID AUTOMATIZED NAMING

We designed this individually administered measure for the present study, based on that in the Comprehensive Test of Phonological Processing (CTOPP; Wagner, Torgesen, & Rashotte, 1999). Naming performance in English of all English-immersion students was measured using a continuous number-naming task. There was one practice task and one test task. The practice task consisted of five randomly arranged digits (i.e., 1, 2, 4, 5, and 8) in one row, and the test task consisted of 40 items, with five rows and eight columns of the same five randomly arranged digits.
Students were required to read all five digits in the practice task from left to right before starting the test. Once they were familiar with this procedure and had demonstrated that they knew the names of the digits, they were asked to read all the digits in English as fast as possible without making mistakes, from left to right and top to bottom. 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 score was termed English NS.

**Chinese Measures**

**MATHEMATICS ACHIEVEMENT IN CHINESE**

School-issued achievement tests in mathematics in the three different schools were employed to assess and control the group differences. The content of the mathematics tests was similar across schools in each grade. All of the grades had sections on addition, subtraction, and logic, but the percentage for each section varied across grades. All students’ scores were marks of correct answers out of 100.

**CHINESE SOUND DETECTION**

The Chinese initial and final sound detection tests developed by Liao et al. (2008) were adapted and administered to each student to assess Chinese phonological awareness. 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. There were 10 initial sound detection items and 10 final sound detection items, each preceded by 2 practice items. All the items were recorded on a CD in Mandarin by a native Chinese speaker, and the interval between items was fixed again at 5 seconds. The same procedure used in the English sound detection tests was used in the Chinese sound detection tests.
CHINESE TONE DETECTION

As Chinese is a tonal language in which a change in tone always changes the meaning of a syllable (Ho & Bryant, 1997a), tone awareness is an additional facet of Chinese phonological awareness (Li, Anderson, Nagy, & Zhang, 2002). An individually administered tone detection test adapted from that developed by Liao et al. (2008) was administered to all participants. 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. The same procedure used in the English and Chinese sound detection tests was used here. A further score, termed Chinese PA, was created by summing the scores of Chinese sound detection and Chinese tone detection. The maximum score for Chinese PA is 30 points. The alpha reliability coefficients of Chinese PA for the present study in Grades 2 and 4 were .87 and .78.

CHINESE RAPID AUTOMATIZED NAMING

This test was essentially identical to English Rapid Automated Naming, with the exceptions that the instructions were given in Mandarin and the participants were required to respond in Mandarin. The same practice digits used in the English version were used in the Chinese version but in a different order. The same procedure and score evaluation as in the English NS test were used here. This score was termed Chinese NS.

Procedure

The school-issued achievement tests in mathematics were administered at the end of the last term of the previous academic year, at the beginning of July. The other tests were administered in October. The Cambridge YLE for Reading and Writing was administered to all students (English immersion and nonimmersion) before the individual PA and NS tests. PA and NS tests in both English and Chinese were given to English immersion students, but nonimmersion students were given PA and NS tests only in Chinese, because our primary purpose was to explore the cognitive predictors of reading in English immersion students, and also because of time constraints in the three schools. The
English PA and NS testing sessions lasted approximately 15 minutes, and the Chinese sessions 20 minutes. Tests were administered by four graduate students who were fluent in both English and Chinese. The four graduate students received a full day of training from the second author to ensure that they understood the test administration and the nature of the tests, and to practice administering the tests under supervision. 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.

Results

Descriptive Statistics

The means and standard deviations of all predictors and the outcome measures of English immersion and nonimmersion groups in Grades 2 and 4 are shown in Table 1. One outlier in English naming speed in Grade 2 was deleted because that participant’s naming speed was too slow. Measures whose skewness or kurtosis values fell outside of the acceptable range (i.e., the absolute value of Skewness/SE or Kurtosis/SE > 3.09) were transformed according to the guidelines in Tabachnick and Fidell (2007). Square root transformation was applied to Grades 2 and 4 English reading achievement scores, which were positively skewed. Square root transformation (reflection, transformation, and reflection) was applied to Grade 2 mathematics and Grade 4 English PA, which were negatively skewed. All transformed measures had skewness and kurtosis values within the acceptable range. The hierarchical regression analyses were based upon the transformed data.

Prediction of English Reading in Immersion Students

To answer the first and second research questions, 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 assess cross-linguistic transfer.


| Step Predictor | Grade 2 | | | | | | Grade 4 | | | | |
|----------------|---------|---|---|---|---|---|---|---|---|---|---|---|
|                | $\beta^a$ | $\beta^b$ | $\Delta R^2$ | $\beta^a$ | $\beta^b$ | $\Delta R^2$ |
| 1. Mathematics  | .42**   | .22 | .18** | .36*   | .15 | .13* |
| 2. English phonological awareness | .29†   | .36† | .16** | .44**   | .39* | .17** |
| English naming speed | .25†   | .24 | .11 | .07 |
| 3. Chinese phonological awareness | .10 | .10 | .00 | .13 | .13 | .01 |
| Chinese naming speed | .05 | .05 | .02 | .02 |
| 2A. Chinese phonological awareness | .30†   | .10 | .08† | .28†   | .13 | .08 |
| Chinese naming speed | .09 | .05 | .11 | .02 |
| 3A. English phonological awareness | .36†   | .36† | .08† | .39*   | .39* | .10† |
| English naming speed | .24 | .24 | .07 | .07 |

Note. $^a$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.  
**$p < .01$, *$p < .05$, †$p < .10$  

Data were analyzed separately at the two grade levels because the dependent measure was different in each grade.

The regression analyses examining the prediction of English reading achievement from English and Chinese PA and NS for English immersion students are summarized in Table 2. To control for the general level of achievement, mathematics achievement was entered into the regression equation at step 1. In step 2, English PA and NS were entered. Chinese PA and NS were entered into the regression equation at step 3; this step provides the conservative test of cross-linguistic transfer. In a second analysis, the order of steps 2 and 3 was reversed; the third step here tests whether English cognitive processes have a language-specific effect, even when controlling L1 cognitive processes.

The results indicate that English PA and NS together significantly predicted English reading achievement after mathematics
achievement was controlled in Grades 2 and 4. The unique effect was from English PA at both grade levels. After controlling for both mathematics and the Chinese predictors in the second analysis, the English predictors together only had a marginal effect \((p < .10)\) in both grades, but the unique effect was still only from English PA \((p < .05)\).

With respect to the second research question, regarding transfer, Table 2 shows that Chinese PA and NS did not explain additional variance in English reading achievement after the English predictors were included in the equation at each grade level. Thus, by the conservative test, there is no evidence here for cross-linguistic transfer. When Chinese PA and NS were entered into the equation before the English predictors (shown in the lower part of Table 2), they made a marginal \((p < .10)\) contribution to the variance in Grade 2 but no other significant contribution. Furthermore, English predictors still added extra variance to English reading achievement beyond that contributed by the Chinese predictors at each grade level, though the effects were only marginally significant in each grade.

**Differences on Chinese Measures between Programs**

To answer the third research question about the differences among children in the English immersion and nonimmersion programs, 2 (Grade) \(\times\) 2 (Program) ANOVAs and \(t\)-tests were conducted. For Chinese PA, the Grade and Program effects were not significant, but the Grade \(\times\) Program effect was significant, \(F(1, 154) = 3.92, p = .05,\) partial \(\eta^2 = .03\). The interaction is illustrated in Figure 1. To explore this interaction further, \(t\)-tests were carried out between programs at each grade. The nonimmersion students performed higher in Grade 2, \(t(76) = -2.75, p < .01,\) but the groups did not differ in Grade 4, \(t(78) = -0.43.\)

For Chinese NS, there was a Grade effect, \(F(1, 154) = 249.34, \ p < .05,\) partial \(\eta^2 = 1.00,\) but there was no difference between programs and no interaction. Grade 4 children had faster NS than Grade 2 children.

Because the Chinese mathematics achievement tests were different at the two grade levels, \(t\)-tests were used to examine the differences. The results showed no significant difference between immersion and nonimmersion students in Grades 2 and 4.
Discussion

This study investigated the effects of PA and NS on English reading achievement and explored the evidence for cross-linguistic transfer for Chinese English-immersion students. The differences in Chinese cognitive skills and Chinese mathematics achievement between immersion students and nonimmersion students were also investigated. We address each of our research questions in turn.

*Prediction of English Reading Achievement for English Immersion Students*

We found that Chinese English-immersion students’ English PA and NS explained variance in their English reading achievement. This result is consistent with 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). More
importantly, the present result holds even after statistically controlling general academic background (as represented by mathematics achievement), Chinese PA, and Chinese NS.

English PA had unique effects in Grades 2 and 4 and its effect increased in Grade 4. The change in strength of the relationship of English PA to English reading achievement between Grades 2 and 4 may be due to the students’ relative levels of word recognition skills. Ehri (1997) classified word learning into various phases. Grade 2 students in the present study may be in the first, prealphabetic or logographic phase in English, using a holistic approach to recognize words without directing their attention to the internal details (e.g., spelling) of written words; as such their reading is not strongly related to phonological awareness. By Grade 4, most students may be in the partial or full alphabetic phases; they have learned spelling and phonological decoding and are paying more attention to sounds and letters in an analytic way, which should be more dependent upon, and more strongly related to, their PA skill.

English NS did not make a unique contribution to English reading achievement at either grade level. This may be due to the low English language proficiency levels of the Chinese students in their early grades. Their orthographic processing, which has been argued to depend upon the same skills as naming speed (Kirby et al., 2010; Wolf & Bowers, 1999) because both require the formation of automatic visual-verbal codes, may not have developed well enough in English by Grade 4.

It is worth noting that the developmental phases shown here are delayed relative to those of native English-speaking children. English-speaking children in Grades 1 and 2 are typically in the partial-alphabetic and full-alphabetic phases (Ehri & McCormick, 1998), whereas our results suggest that Chinese English-immersion children may be moving into these phases in Grade 4. Difference in exposure to oral and written English is the most plausible explanation for this delay.

**Is There Cross-Linguistic Transfer?**

The second research question concerns cross-linguistic transfer, asking whether Chinese phonological awareness and naming speed predict English reading achievement. Several research
studies have argued that phonological awareness can transfer across languages, no matter whether the two languages are classified in the same orthographic category or not (Chow et al., 2005; Gottardo et al., 2001; Knell et al., 2007; McBride-Chang & Ho, 2005). We know of no similar argument for naming speed, but it would make sense if children who were quick to recognize and name stimuli in one language were also quick to do so in a second language, relative to other children with the same amount of exposure.

We indicated in the literature review that two different methods have been used to address this issue. One is the liberal way, in which only background factors, such as general mental ability, are controlled. The other is a more conservative way, in which phonological awareness and naming speed in the language of the outcome achievement variable are also controlled. When we used the liberal method, after controlling for achievement (represented by mathematics achievement), Chinese PA and NS explained a marginally significant ($p < .10$) amount of the variance in English reading achievement in Grade 2 but not in Grade 4. When we used the conservative method, Chinese PA and NS did not contribute to the prediction of English reading achievement at either grade. This result might not be surprising, because English and Chinese are so different orthographically and linguistically and because the number of participants is limited. Neither method is ideal. The liberal method allows many other variables to be potentially responsible for the relationship between L1 processes and L2 outcomes. However, the conservative method may be controlling too much: for example, if L1 PA contributes to L2 PA, then controlling for L2 PA may eliminate the effect of L1 PA. The best way to resolve this is through an experiment in which L1 PA was taught, to see if it improved L2 PA. There was no evidence of cross-linguistic transfer in this study following the conservative method, and only little following the liberal method. Two possible reasons for the lack of observed transfer are: (a) the large distance between Chinese and English phonology and orthography may be an obstacle, and (b) most of the previous studies found cross-linguistic transfer using oral word reading measures as outcome measures (e.g., Chow et al., 2005; Gottardo et al., 2001; McBride-Chang & Ho, 2005), but our study used silent reading comprehension as the outcome measure.
Is There an English Immersion Advantage or Disadvantage?

The literature reviewed on bilingualism and immersion programs has claimed that immersion students achieve a 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). Some have even argued for a cognitive advantage from immersion programs (Bruck & Genesee, 1995; Yelland, Pollard, & Mercuri, 1993). But the vast majority of the evidence relates to languages and orthographies that are similar to each other. Therefore, knowing whether there are English immersion advantages or disadvantages in cognitive skills and mathematics achievement 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 mathematics achievement in students’ first language between English immersion and nonimmersion students, we discovered that there was no overall difference between the two groups in their Chinese NS and mathematics at any grade level. Nonimmersion students performed better than immersion students on Chinese PA in Grade 2, but no significant difference was found between the two groups in Grade 4. Research into how immersion programs influence students’ cognitive development and language proficiency has produced inconsistent results. Although the majority of previous studies have reported an advantage for immersion students (Bruck & Genesee, 1995; Yelland et al., 1993), Bialystok, Majumder, & Martin (2003) found that bilingual children do not have an advantage over monolingual children in PA. It is also possible that the English immersion programs have a long-term effect that will not be obvious until later grade levels. Our study examined the characteristics of immersion and nonimmersion students at the beginning of Grades 2 and 4. Future research needs to be done to investigate whether immersion students will have an advantage over nonimmersion students in academic achievement and cognitive tasks in later grades.

The finding with Chinese PA in Grade 2 may reflect a conflict between English and Chinese at the beginning level for
English immersion students, and thus an initial disadvantage of immersion. But in Grade 4, English immersion students performed as well as nonimmersion students on Chinese PA. No significant differences were found between the two groups on Chinese NS and mathematics achievement in both grades. This suggests that English immersion programs did no harm to these L1 skills. Although some researchers and parents in Canada suspect that immersion programs may be detrimental to reading in L1 and to academic achievement (Cummins & Carson, 1997; Swain, 1996), we found the English immersion students in our study performed equal to nonimmersion students on L1 naming speed and mathematics achievement at the two grade levels, though the immersion students did not perform as well as the nonimmersion students on Chinese PA in Grade 2, perhaps due to an early conflict between the two languages.

**Limitations and Implications for Future Research**

Several limitations should be noted. First, although the number of participants per group was adequate for the analyses, greater numbers would have provided more power and stability, especially in the tests of cross-language transfer. Second, previous research has most frequently been based on the relationship between the PA and NS predictors and oral word reading, but a silent reading comprehension measure was used for the present study. Use of this broader reading comprehension score may help to explain why the present results differ from those of the previous studies regarding NS. Future research should aim to clarify the relations between these predictors and various reading outcomes, in both first and second languages. Third, the present study measured PA using only sound detection tasks. In future research, a broader range of PA tasks should be included to obtain a more complete understanding of how PA relates to reading development for Chinese students.

**Conclusion**

This study extends previous research in showing that English PA is a significant predictor of English reading in Chinese English-immersion students in Grades 2 and 4. However, this study does
not provide clear evidence for cross-linguistic transfer, perhaps because of the great differences between Chinese and English, and the nature of the outcome measures. Finally, the disadvantage that English immersion students demonstrated compared to nonimmersion students on Chinese PA in Grade 2, but not in Grade 4, or on other Chinese cognitive tasks in either grade, suggests that there are no enduring detrimental effects to the English immersion students’ L1 achievement, although they have been exposed to more L2 than the nonimmersion students.

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Notes

2. English (Arabic) numerals are commonly used in Chinese schools.

References


