English-Chinese bilingual children's reading:
An exploration of influences of learning a distinct writing system through visual processing

by

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Abstract

Experienced adult readers demonstrate significant priming effects for semantically related prime-target pairs (golden-GOLD) and pseudo prime-target pairs (mother-MOTH), while children benefit from only semantically related primes. Findings like this support a dual-route processing model in which the whole word and the root word are processed in parallel by experienced readers, with no regard to the meanings of these two components. Despite these age-related differences, it is not clear if the non-semantic morphological advantage is limited to adult readers. This study sought to explore if an early-emerging non-semantic morphological advantage can occur in children by examining potential influences of children's exposure to Chinese character reading. The majority of Chinese characters are compounds that involve similar parallel processing as adult processing of multi-morphemic alphabetic words. Young Chinese children are able to recognize a whole character despite the interference of a non-meaningful composing unit, which is often a stand-alone character. The current study examined whether cross-language facilitation of non-semantic morphological processing in children is possible. Using a primed lexical decision task involving semantic and pseudo-primes in English reading, results showed that early experience of Chinese character learning, compared to no such experience in children, was associated with stronger priming in the semantic-suffixed condition. This stronger priming persisted when letters within primes were transposed near the suffix boundary, indicating that those children had a preference for processing the given words as wholes, rather than focussing on the suffix boundary. However, the non-semantic morphological advantage was not found. The implications of this finding in relation to the dual route model is discussed.

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This study focuses on how Chinese character learning influences English reading through visual word processing measured by the lexical decision task. The study was motivated by research showing that conflicting root-word and whole-word meanings within English compound words inhibit children’s word processing performance, but that this effect is not found in experienced readers. The conflicting semantic relation between parts and the whole character widely occurs in the Chinese writing system, and Chinese learners are required to process the conflict more frequently than learners do with English reading acquisition, or reading acquisition in other languages involving alphabetic writing systems. This requirement could differentiallyimpact children learning Chinese character readering in their abilities to initially parse words. In lexical decision task performance in conditions where prime-target words (the whole word and the root word) are semantically related or semantically conflicting, children who concurrently learn Chinese characters while learning to read English might parse prime words (both semantically related and conflicting primes) differently compared to children who do not concurrently learn Chinese characters.

This review of the literature begins by establishing the importance of phonological processes in reading acquisition, followed by an examination of the evidence for visual processing involvement, and finally I present research that indicates potential influences of learning to read Chinese characters on acquisition of alphabetic reading skills in children. I argue that potential beneficial influences of learning to read Chinese characters would involve enhanced development of visual processing skills that are relevant to learning to read in both

Chinese (logographic) and English (alphabetic) scripts, particularly in processing multi-morphemic words. These influences are expected to be demonstrated in enhanced priming effects in lexical decisions in children learning Chinese characters.

Phonological Processing in Reading

Reading is a complex combination of various cognitive processes; each individual process or cluster of processes, if anomalous, can potentially contribute to reading failure. Among these processes, those involving phonology, such as phonological awareness, have long been the main focus of reading research on alphabetic-script reading. In the 1980s, the inability to process the sounds of language was established to be the most common explanation of dyslexia, the unexpected difficulty in learning to read (Bradley and Bryant, 1983). Ever since then, a large research base has emerged on the phonological components in reading difficulty in English and other languages involving alphabetic writing systems (Hoeft, Meyler, Hernandez, Juel et al, 2007; Horwitz, Rumsey, & Donohue, 1998; Schlaggar and McCandiss, 2007).

The phonological deficit perspective on dyslexia has become the dominant position in accounting for the causes of dyslexia, as deficits in phonological processes are consistently shown to be influential to almost every aspect of reading in English (Liberman and Shankweiler, 1991: Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2002; Vellutino and Scanlon, 1987). It is a well-established phenomenon that good phonological awareness facilitates English reading by establishing good letter-sound connections (Gabrieli, 2009). However, a visual perspective involving investigating the importance of the form of printed words in reading and reading acquisition has received less research attention compared to phonological-based research, despite the possibility that visual anomalies might also have important influences in reading acquisition in children (Franceschini, Gori, Ruffino, Pedrolli, & Facoetti, 2012).

Visual Processing Involvement in Reading

Conceptually, learning to read can be treated as a learning process to match sound units, namely phonemes, to their written (visual-form) units (Gabrieli & Norton, 2012). The process of visual analysis of print-word information could be important to reading and reading acquisition, in addition to the importance of well-established phonological processes. Following this line of reasoning, individuals with a reading disability may show deficits not only in sound processing, but also in visual processing. Evidence supporting the hypothesis of a visual processing involvement in reading comes from a variety of behavioural studies focusing primarily on visual attention anomalies in individuals with reading disability. For example, adults with dyslexia have a poorer ability than adults without dyslexia to locate nonverbal target items that potentially appear in one of five screen locations (Kevan and Pammer, 2008). This group difference indicates an independent contribution of visual-spatial attention processing in accounting for variability in reading performance (Kevan and Pammer, 2008). Also, longitudinal research demonstrates that visual-spatial attention, a core visual processing skill, is a unique predictor of later alphabetic reading acquisition (Franceschini et al., 2012). A similar relation is observed when using visual stimuli containing language-related information. For example, children's letter knowledge, such as ability to distinguish "b" from "d" thatinvolves visual-orthographic knowledge, predicts future reading development in English (Lonigan et al., 2000). Findings like these are interesting and promising as they demonstrate that visual processes can have independent influences on emerging abilities in word recognition. However, much is still unknown about the involvement of perceptual and cognitive process in reading acquisition (and reading disability).

The importance of visual processing is more-established when learning to read in a logographic language system, such as Chinese. As phonological cues are less informative than those in English and in other alphabetically based writing systems, character parts in Chinese logographs contain combinations of strokes that are collected and employed for word recognition. Similarly, complex English words often contain parts with certain combinations of letters that modulate word meaning (e.g. the "er" and the "teach"of the word "teach-er"). The successful segmentation of these meaningful word parts requires visual processing in relation to morphological skills. There could be ways in which learning to read in a logographic language facilitates the visual segmentation of English words by applying such skills learned in the logographic language to reading in the alphabetic language. Linking visual segmentation to morphological processing, exposure to written Chinese, which involves a significant amount of visual segmentation, may provide children with transferable visual-segmentation skills that could be used to their advantage in morphological processing of English words, particularly those that involve similar root word (root character)-morpheme (radical) structure between English and Chinese. The possible mechanism of and supporting evidence for this claim are explained in the following section.

English and Chinese: The relation between morphological awareness and print word recognition

Morphological awareness is an important predictive factor in reading acquisition (Deacon & Kirby, 2004). Morphemes are the smallest units of meaning in language. In alphabetical languages like English, it is straightforward to identify the root morpheme (e.g. "dog" from "dogs") and the grammatical morpheme – e.g., the affix (e.g. "s" from "dogs", meaning the noun is a plural). **Morphological awareness,** which refers to the detection of morphemes and the ability to reproduce similar structure (Carlisle, 1995), has been shown to have a close relation to English reading acquisition in addition to the established influence of phonological processing.

Three main kinds of morphological relations are found in English: Infection, derivation, and compounding (Kuo & Anderson, 2006). The example of "dog-dogs" is an illustration of inflection involving no change to the grammatical category of the word (a noun in both forms), while derivation changes the word meaning (like-dislike) or category (teach-teacher), or both. Compounding nvolves joining two or more words to form a new word (class-classroom).

Although morphological awareness was initially studied using spoken-language tasks, recent research on the nature of morphology using reading tasks allows for the consideration of the potential roles of visual processes. The morphology concept discussed in the present study refers primarily to its print context. Following this concept, the examination of morphological abilities during reading calls for a visual scanning and detecting process to recognize the root word as well as the affix, which is assumed to ease the difficulty of reading morphologically complex words. This research uses a specific methodology, the primed lexical decision task. A prime (a word, for example) is briefly displayed, typically for about 50 ms, and is visually masked (a series of shapes or abstract forms are displayed briefly in the same location as the prime, before the prime is displayed), and finally a target (a word or a non-word) is displayed until the participant makes a lexical decision on whether or not the target is a word. Because performance on this task is usually quite accurate, the response time (time to make a decision after the target is displayed) for correctly identified words is used as the outcome measure. So-called "priming effects" involve a difference in response times, with longer latencies for "control" conditions (for example, a prime that has no relationship to a word target), compared to experimental conditions (in which morphological relations between the prime and the word target are manipulated to facilitate access to lexical memories of the target).

Experiments with experienced adult readers demonstrate significant priming effects for semantically related prime-target pairs (golden-GOLD) and pseudo prime-target pairs (mother-MOTH) (Beyersmann, Castles, & Coltheart, 2012; Rastle, Davis, & New, 2004). In the latter (pseudo) condition, the prime stem ("moth") has no semantic relation with the prime suffix (-"er"). In addition, the target (-"MOTH") has no semantic relation with the prime (-"mother"). This condition carries a special implication, as priming in this type of condition signifies the presence of morpho-orthographic segmentation skill, with the assumption that this kind of segmentation of root and grammatical morpheme occurs automatically in reading, prior to considering semantic content. There are three competing theories that explain morphological segmentation: the localist (Giraudo & Grainger, 2000; Marslen-Wilson et al., 1994), the connectionist ((Plaut & Gonnerman, 2000; Rueckl & Raveh, 1999) and the dual-route models (Baayen,Dijkstra, & Schreuder, 1997; Diependaele et al.,2009). These differ in the way they deal with word meaning and word form. The localist model proposes that word units are activated separately and interact with the whole word meaning. The connectionist model and the dual-route model both recognize the importance of the form of words in addition to their meanings; however, only the latter, dual-route model, weighs the influence of the word form as much as that of the word meaning in word recognition. Within the context of preliminary visual word recognition in experienced readers, research results show equally strong priming with semantic and pseudo primes skilled adult readers. This is contrary to what would be expected by the localist theory of morphological processing (Giraudo & Grainger, 2000; Marslen-Wilson et al., 1994), which proposes that morphological decomposition is semantically based, and also inconsistent with the distributed-connectionist theory (Plaut & Gonnerman, 2000; Rueckl & Raveh, 1999), which predicts that purely structural-based decomposition would never reach the effect size (for example in primed lexical decision) of semantically based decomposition (see the example in the table). Instead, results from empirical studies indicate morphological processing in reading is facilitated by the visual word recognition system. This facilitation is reached by processing morpheme information (semantic or pseudo) in parallel to the whole word. For the pseudo-suffixed condition, the automatic decomposition of suffix and root are activated in parallel to the processing of whole word, as the dual-route model suggests (Baayen,Dijkstra, & Schreuder, 1997; Diependaele et al.,2009).

→ *Sample input stimuli: teacher, corner*

The localist model	**The connectionist model**	**The dual-route model**
A decomposition of "corn-er" cannot take place because the meaning of "corn" has no relation to the meaning of "corner".	A decomposition of "corn-er" can take place, but is more difficult than a decompostion of "teach-er".	A decomposition of "corn-er" can take place, and it happens as easily as a decompostion of "teach-er".

The relation between morphological awareness and printed word recognition is especially salient when reading with a logographic language like Chinese. The picture-like characters (Hanzi) involve a significant amount of visual processing, which is reflected in brain activation patterns. For English native speakers, mere exposure to Chinese script leads to right lingual gyrus brain activation, instead of the left that is typical with English reading (Deng, Booth, Chou, Ding, & Peng, 2008; Deng, Chou, Ding, Peng, & Booth, 2011; Liu, Dunlap, Fiez, & Perfetti, 2007). Chinese (logographic) reading generally relies less on sound units than English (alphabetic) reading; for developing morphological awareness, visual information is more important to analyzing word structure than is typical in alphabetic reading. Experienced Chinese adult readers take longer to associate characters with their lexical tone (Mingjin, Hasko, Schulte-

Körne, & Bruder, 2012). Notably, in terms of reading development, phonological awareness is not a significant predictor for early Chinese reading development, while morphological awareness is a significant predictor (McBride-Chang et al, 2005). Findings like these indicate that grapheme-morpheme correspondence is likely to be directly established through learning to read Chinese characters (more so than in learning to read in English).Similarly, grapheme-phoneme correspondence is considered the basis of print word deciphering in English (Metsala & Ehri, 1998), and likely is directly established through learning to read in English. The importance of gapheme-phoneme correspondence in English word processing is likely as English, although less transparent than other alphabetic languages, still requires a considerable amount of phonological processing while learning to read letter strings.

An important concept that connects phonology, morphology and orthography is that English orthography is morphophonemic: the print form of a word preserves semantic information and pronunciation indication (Chomsky & Halle, 1968). As semantic information and pronounciation indication are related, phonological information may help to promotechildren's emerging understanding of English morphological structure, given that children can learn to write morphologically complex words from their pronunciations. Visual processing is another way to develop understanding of English morphological structure; however, less is known about the contribution of visual processes to acquisition of knowledge of English morphological structure. The current study examines the visual processing contribution by making use of a visual-based measure of children's awareness of English word structure, the primed lexical decision task. Another novel contribution of the current study involves the target population: bilingual English/Chinese children with English as the stronger language, as opposed to expert adult readers, or monolingual Chinese children. Reading Chinese over a relatively short span of time could result in a change in the way adult monolingual English readers' brains process languages (e.g.: Deng et al. , 2011, described above). In the case of children learning to read concurrently in English and Chinese, it is not clear to what extent influences of exposure to Chinese character reading on their visual-processing skills in reading can extend to changes in how visual processes are applied to reading in English. The current study focuses on the question of whether the differences and similarities between these two languages influence the formation of early-emerging reading skills compared with matched non-Chinese peers.

Participant selection and potential cross-language transfer

English-Chinese bilingual children, whose Chinese is a less-dominant language were selected as the target group of subjects in this study. The differences in how morphological development is influenced by acquisition of reading skills in English compared to Chinese may be related to the degree of involvement of morphological compared to phonological information processing required in decoding in the two writing systems. A more-complete understanding of these differences might be revealed by considering alternative methodologies in measuring abilities related to reading in the two writing systems. In previous studies focusing on English-Chinese bilingual children's reading development (e.g., Pasquarella et al. 2011; Wang, Cheng & Chen 2006; Wang et al. 2009), morphological awareness was measured using spoken-language tasks. This may be effective for alphabetic languages, but the spoken-language method fails to capture all the potential effects of exposure to printed words, including in logographic languages like Chinese. Spoken-language methodology could mask influences of visual processes in morpho-orthographic segmentation skills in children. The methodology issues will be further explained in the next section.

With regard to participant selection, studying cross-language transfer involves challenges in relation to the participants' knowledge of spoken and written Chinese. For English-Chinese bilingual children, recruiting participants with consistent Chinese-language skills in a Chinese-language-dominant environment is straightforward in comparison to recruiting in a non-Chinese-language-dominant environment. Chinese-background children living in Chinese-language-dominant environments typically receive additional-language (e.g., English) education in a structured way, typically as part of the school curriculum. Chinese-background children living in English-language-dominant environments are more likely to receive Chinese education more informally, such as in heritage-language schools with significantly less exposure to Chinese language and text. English-Chinese bilingual children living in English-language-dominant contexts typically have relatively limited Chinese language skills, especially with written Chinese. Nevertheless, focusing on children with Chinese as a less-dominant language (L2) is an interesting and important issue at least for two reasons:

1. Comparable compounding structures exist across English and Chinese at the lexical level (a well-studied area). From the English lexical level to the Chinese sub-lexical level, a competing relationship between a part of the word/character and the whole word/character exists. This is a relatively under-studied area that merits consideration in relation to questions related to cross-language transfer of skills in disambiguating semantic conflicts in word recognition, for example.
2. Previous research focusing on English L2/Chinese L1 children living in English-languge contexts has found cross-language transfer between vocabulary and compound awareness (a potential product of comparable morphological structure between the two languages) (Pasquarella et al., 2011).

Despite the challenges, past research has yielded interesting results on concurrent Chinese-English reading acquisition. Researchers in this area typically focus on the similarities between languages, for which the hypothesized transfer is most likely to take place. Despite the differences between alphabetic and the logographic writing systems, comparable written structures do exist at the English lexical level and the Chinese lexical level. Compounding is one of the shared morphological structures in both languages. For example, the print form of "class-room" corresponds to two Chinese characters that mean "class" and "room" separately. Accordingly, a cross-language transfer effect between vocabulary and compound awareness has been found from Chinese vocabulary to English compound awareness and vice versa (Pasquarella et al., 2011). However, no direct transfer involving compound awareness between these two languages has been observed (Pasquarella et al, 2011), suggesting the pattern of cross-language transfer is complex in nature due to the existing differences between the language systems.

Apart from compounding at the lexical-to-lexical level, another common structure in English and Chinese that is generally neglected in cross-language reading research involves the English lexical level to Chinese sub-lexical level comparisons. For example:

The character "砖" is the equivalent to the English word "brick". It can be divided into two parts: The left half ("石", which means "stone") and the right half ("专", which means "focus"). In this example, the left half gives the indication to the character's true meaning, and is known as the "semantic radical". The semantic radical can involve stand-alone characters or legal combinations of strokes; both are high-frequency graphemes observed in Chinese. The right half offers phonological cues (both of which spoken as "zhuan", in the first tone), and is known as the "phonetic radical." It is also a stand-alone character containing its own meaning in addition to the whole character. For this reason, the phonetic radical itself acts as a non-meaningful unit because the right half ("focus") has no relation to its true meaning ("brick"). The successful recognition of a Chinese compound thus involving resolving conflicting semantic meaning between the phonetic radical and the whole character.

The conflicting semantic meaning between parts of the word and the whole word can also be identified in English words containing pseudo-morphemes. The word "mother", for instance, can be divided into two parts ("moth" and "er"). The root word, "moth", is a non-meaningful unit to understanding the whole word (though it has an independent meaning on its own).

Within the Chinese writing system, compound characters containing semantic and phonological indications are defined as "Phono-semantic compounds", which comprise more than 80% of the Chinese vocabulary (Kang, 1993; Zhu, 1987). As a consequence, children learning to read in Chinese are frequently required to process the semantic and phonological parts (radicals) of a print character.

Similar to the visual recognition of morphologically complex English words, decomposition of Chinese compound characters occurs by the sight. If the parallel dual-route model can be applied to sub-lexical character decomposition in Chinese, then there is a reason to believe a possible cross-language transfer (indicated by facilitation in performance on relevant tasks) could occur in reading acquisition.

Interestingly, experiments using the primed lexical decision task found that Chinese sub-lexical level processing is comparable to English word level processing by the mechanism of grapheme-phoneme correspondence. The decomposition of the phonetic radical within a compound character, specifically, involves the automatic activation of its pronunciation information (Hue, 1992; Zhou & Marslen-Wilson, 1999b). The semantic part of the logograph in

Chinese is also decomposed and activated to aid retrieval of the whole word meaning (Feldman & Siok, 1999; Zhou & Marslen-Wilson, 1999). Recognition of compound Chinese characters is thus similar to the visual processing of morphologically complex English words, where the pseudo root morpheme (that semantically conflicts with the whole word meaning) and the suffix (legal string of letters) are activated in parallel as proposed by the dual-route morphological segmentation model. Despite the distinctions between logographic and alphabetic language systems, the findings listed above indicate that the mechanism underlying sub-lexical recognition across languages is similar.

In Beyersmann et al.'s study (2012), that included an examination of pseudo-suffixed morphological decomposition (e.g. mother-MOTH), priming the target word with a morphologically related while semantically conflicting prime interfered with children's lexical decision performance. The pseudo-morpheme (moth) was likely decomposed in parallel with the whole word (mother); hence interference can be explained as involving the stand-alone meaning of the pseudo morpheme competing with that of the whole word. In Chinese character reading, similar decomposition was replicated. The semantic information contained within the phonological part was found to be automatically activated in addition to the phonological cue, whose conflicting meaning to the whole word interfered with compound character recognition (Zhou & Marslen-Wilson, 1999). Nevertheless, the false semantic activation drawn from the phonetic radical did not interfere with its phonological activation; if it did, then the recognition of whole character would have been unsuccessful. Event-related potential (ERP) studies concentrating on phonetic radical processing show that sub-lexical semantic ERP activation starts to decay about 50ms after the character is presented and disappears completely by about 300ms after presentation (Lee, Tsai, Huang, Hung, & Tzeng, 2006), while phonological activation, indicated by its comparable ERP wave component, continues to be strong at 140ms after presentation (Zhou, Fong, Minett, Peng, & Wang, 2014)**.** If the cognitive mechanisms between Chinese compound processing and English morphologically complex word processing are comparable, then the automatic, efficient processing of conflicting sub-lexical and lexical information in Chinese could transfer onto English word recognition processes involved in minimizing semantic conflicts between the pseudo root morpheme primes and the whole word targets.

The measurement issue of morphological awareness

In the research focusing on the morphological transfer between English and Chinese (e.g., Pasquarella et al. 2011; Wang, Cheng & Chen 2006; Wang et al. 2009), the measurement of morphological awareness in both languages involved orally-presented items. The finding was limited to unidirectional transfer from English morphological awareness to Chinese reading, but not the other way around (Wang, Cheng & Chen 2006; Wang et al. 2009). Although such a spoken measure of morphology is easier to work with in young children, the possible influence of visual processes that may lead to a transfer from Chinese to English cannot be determined.

In relation to the measurement issue described above, the **masked priming lexical-decision paradigm,** also known as priming, is a method widely used to identify nonstrategic (automatic) processes in recognizing complex words (Longtin, Segui, & Hallé, 2003; see description above). The time frame of prime display employed in the paradigm (50 ms) is too short for conscious detection; hence, no strategic reaction can be taken towards the presented prime stimulus. Initially applied to adults (Longtin,Segui, & Hallé, 2003; Rastle, Davis, Marslen Wilson, & Tyler, 2000), this method has proved workable with school-aged children (Beyersmann et al, 2012). A masked priming trial typically takes the following form:

1. A mask is presented for about 500 ms and then immediately replaced by the prime.
2. A prime (typically a string of non-word or word symbols) is presented briefly for about 40-70 ms.
3. The target (either non-word or word) is presented until receiving the participant's lexical-decision response (Beyersmann et al , 2012).

Within the context of alphabetic language systems, experiments using masked priming lexical decision tasks found that adults perform such tasks more efficiently when presented with either a morphological (semantically related) prime (e.g., singer-SING, where singer is the prime and SING is the target for a lexical decision judgment, as the two words are related in meaning) or a pseudo-derivation prime (e.g.: corner-CORN, where the two words are unrelated in meaning, but related in form), but not with a strict-orthographic prime (e.g.: spinach-SPIN, where "ach" is not a legal suffix) (Quemart et al., 2011). The observed effect is called **morpho-orthographic segmenting**, where automatic decomposition occurs when processing print words, with no regard to the true morphological rule that connects the prime with the target (Beyersmann et al., 2012). For children in Grades 3 and 5, the priming effect occurs only in a true morphological priming condition (Quemart et al., 2011; Beyersmann et al , 2012), when the prime is semantically related to the target. A straightforward explanation of the different patterns of performance between children and adults is in their difference in reading experience. Children, who have generally limited exposure to written English, have not yet established morphological decomposition abilities on a purely structural basis.

Following this line of reasoning, morpho-orthographic segmenting is crucial in that it is the sign that such an automatic grapheme-morpheme correspondence is fully established. In the pseudo-suffixed situation, the morphological structure (i.e.: the presence of the grammatical morpheme, such as -er) is so well established in experienced readers' perceptions that they are still able to benefit from the recognition of the suffix despite being paired with a semantically conflicting root morpheme. As discussed above, Beyersmann et al. (2012) demonstrated that this decomposition, independent of semantic relatedness, is established relatively later in learning to read in an alphabetic language system. In contrast, comparable research using Chinese characters found Chinese Grade 3 and Grade 6 children were able to decompose phono-semantic compound characters and retrieve the phonological and semantic information in parallel to whole character processing (Zhou & Shu, 1999). It seemed as though children learning Chinese character reading were more adapted to decomposition independent of semantic relatedness at a younger age, compared to their peers learning to read in an alphabetic language system alone, as a consequence of different emphasis in learning to read. For the priming paradigm employed, the decomposition occurred in an automatic manner. The nature of the physical division (visible space between phonemic and semantic radicals in Chinese characters), the practical functions of these two radicals, and the teaching method focusing on radical awareness have been identified as the three explanations for the early-emerging visual decomposition ability (and its automaticity) in Chinese readers (Zhou & Marslen-Wilson, 1999a). In summary, exposure to both spoken and written Chinese might contribute to the relatively early development of abilities involved in sub-lexical structural segmenting of Chinese characters. The former (exposure to spoken Chinese) is related to the activation of the phonological information embedded in the phonemic radical, and the latter (exposure to written Chinese) is directly linked to the visual decomposition process.

In light of the developmental differences identified between English and Chinese children in morphological decomposition abilities in written text, it would be interesting to determine whether learning to read in Chinese could benefit English reading in terms of the morpho-orthographic segmenting ability of English-Chinese bilingual children, who are learning to read in English and Chinese concurrently. I expect that a cross-language transfer on common word (character) structure will be observed. Increasing exposure to spoken and written Chinese is expected to facilitate morpho-orthographic segmentation in an English-language primed lexical decision task.

The Current Study

Traditionally, English-French bilingual studies have been the main focus of cross-language reading research within the Canadian context. However, due to similar phonological (language sound), morphological (language structure), and orthographic (writing system) characteristics, the cross-language research based on these two similar alphabetical languages leaves important gaps in our understanding of cross-language reading acquisition in bilingual children. Examining distinct languages with differing (logographic vs alphabetic) writing systems allows a broader range of questions about reading acquisition in bilingual children to be addressed, one of them involving morphological issues. Based on the similarities and differences in language structure it would be fruitful to examine the following research issue:

The possible morphology transfer from Chinese to English.

As there is a comparable morphological structure between Chinese phono-semantic compounds and English pseudosuffixed words, and empirical studies in English (Beyersmann et al, 2012) and in Chinese (Zhou & Marslen-Wilson, 1993) indicated that the automatic print word recognition in these two languages followed a process consistent with that posited by the dual-route processing model, it is possible that cross-language transfer takes place between the two languages. Specifically, it would be important to discover whether Chinese character learning will influence English reading acquisition by facilitating the visual processing of morpheme-derived written words, where the morpheme has no true meaning with the whole word. If this is the case, then children learning Chinese character reading (or who are more advanced in such learning) in addition to English reading are expected to perform better on an English-language primed lexical decision task pseudo-morphological priming condition (that is, show a stronger priming effect) than children who are not learning Chinese character reading in addition to learning English reading.

Another possible benefit of learning Chinese characters is that children's whole word processes might be strengthed by learning to read whole-word units. This would be demonstrated in the transposed-letter prime condition in a lexical decision task, in which children learning to read Chinese characters were expected to outperform matched (alphabet-only) peers because of their preference for or familiarity with processing whole word units. Their matched non-Chinese peers might be more likely to experience interference by the presence of transposed letters in part of the word, effectively treating the primes as nonwords and unrelated to the target, resulting in no beneficial priming effect.

Several cognitive/language characteristics related to reading (both in English and Chinese) may be influential to the hypothesized outcomes. English language abilities (in vocabulary and word reading) were used as part of the matching criteria for pairing bilingual Chinese-English children with non-Chinese peers, and were included in the data analysis to rule out these abilities as potential alternative explanations of the results. Chinese ability measurements were used as indicators of Chinese vocabulary and reading level for Chinese-English bilingual children.

1 Vocabulary

Morphological awareness is related to vocabulary (Carlisle, 1995). Understanding of language structure facilitates vocabulary growth (for example, a root word "teach" can facilitate learning of derived words like "teacher" and "teaching") and reciprocally, a larger vocabulary helps the learning of similar language structures. A cross-language study showed this set of relations is consistent in English-speaking children and in Chinese-speaking children (Ku & Anderson, 2003). In both Chinese and English contexts, a larger vocabulary is associated with superior morphological awareness. Hence, vocabulary knowledge in English was controlled by matching individuals between groups on English vocabulary.

2 Print word (character) reading

The decomposition of English print words becomes more automatic with increasing exposure to English written words, perhaps for the purpose of efficient reading. Hence, English reading ability was controlled by matching each group on reading ability.

In conclusion, stronger morpho-orthographic segmentation ability is expected in English-Chinese bilingual children who are learning to read in two languages than in matched children learning to read in English only (with age, vocabulary, and reading ability controlled by matching groups on these factors). Of particular interest is possible cross-language transfer of morphological skills.

Method

Participants

Eleven English-Chinese bilingual children (Sample A, age mean=9.8 years, SD= 2.1), with variability in terms of background and experience to Chinese character learning, were recruited from a weekend Chinese language heritage school in Winnipeg. Those children were tested in the Early Years Reading lab at the University of Manitoba. The school principal, teachers' and parents' consent forms were distributed and collected prior to data collection. Eighty parental consent forms were distributed to the eight classes. Another eight teacher's consent forms were distributed to class teachers. Eleven English-Chinese children were successfully recruited. Children all had normal or corrected-to-normal vision, based on responses by parents/guardians on a parent/guardian questionnaire. Language spoken at home and home postal code (for estimating family income) were collected from the questionnaire. The method used to teach reading was asked in the teacher consent form.

Another sample of eleven children (Sample B, age mean=10.3 years, SD= 1.6), all English speakers (7 monolingual English speakers and 5 English speakers who also spoke another alphabetic language at home), were selected from a larger sample of 136 children recruited from public schools. Those children were tested in their schools. The non-Chinese children were matched with English-Chinese bilinguals on age, gender, family income and English vocabulary. Unless otherwise specified, participants in each group were tested using the same measures. Both the parent consent (in Chinese and in English) and child assent (in English; see Appendix D) were collected for recruiting Chinese-bilingual children. English parent consent and child assent were collected for recruiting non-Chinese children.

Outcome Measurement

Masked primed lexical decision task. The testing material and procedure used in Beyersmann et al. (2012) were modified and employed in this study (see Appendix A). Each participant experienced 240 trials in the complete experiment. Within the six word-target related trial conditions, three of the sets involved primes with no letter transposition: the semantic suffixed set (golden-GOLD), the pseudo suffixed set (mother-MOTH) and the purely orthographic set (spinach-SPIN). The other three sets involved primes with letter transpositions across suffix boundaries: the transposed semantic suffixed set (goledn-GOLD), the transposed pseudo suffixed set (motehr-MOTH) and the transposed purely orthographic set (spianch-SPIN). For each set, there were 10 pairs of words containing a related prime-target pair. A set of comparisons of various item attributes across prime and item conditions is given in Table 1, showing comparability on prime and item characteristics in frequency, neighbourhood size, length, orthographic overlap and relatedness. A 50 ms prime duration, as tested by Beyersmann et al (2012), was used as this was assumed to give children sufficient time to process the stimulus. As no priming was expected in the purely orthographic condition, the purely orthographic condition was treated as the control condition. The priming effects for each condition were calculated by subtracting each participant's mean response time in the unrelated prime-target pair from his/her response time in the related prime-target pair respectively. Response times from only word-target trials that were responded to correctly were used in the calculation. Response times that were larger than 3000 ms were considered errors and were not included in the final analysis. Response times shorter than 200 ms were considered guesses and these trials were treated as incorrect and were not included in the results.

The screening measures were used to ensure participants had basic reasoning ability, English morphological awareness and/or Chinese print character knowledge (specific to English-Chinese participants). Cut-off scores were indicated in each test subsection. The matching measures were used to yield English vocabulary and reading scores to match participants from two language groups.

Screening Measures

1. Non-verbal intelligence. The Matrix Reasoning subtest from the WASI-II (Wechsler, 2011) was employed to measure non-verbal intelligence. There are 30 items of matrix reasoning questions arranged with increasing difficulty. For each item, children were asked to choose the piece out of 5 options that best match the missing part of a pattern. The standardized T scores were used.

2. **English compound awareness.** Morphological segmentation is assumed to take place on the basis of some existing spoken morphological knowledge. The Morphological Awareness Task is a brief 16-item measure of children's spoken abilities involving construction of two- and three-syllable compound words following the presentation of the word root and a set of clues for the construction of each compound word (see Appendix C). Full sample reliability was 0.89 (Cronbach's alpha). The raw score was used. Participants were required to reach a minimum score of three on this test; the stop rule was three consecutive errors.

3. **Chinese character reading.** To ensure that the English-Chinese bilingual children participating in the study had exposure to Chinese print character, a non-standardized Chinese character-naming test was constructed and administered to the Chinese-English bilingual group, which consisted of 40 unrelated Chinese characters selected from reading textbooks employed by local Chinese schools from Grade 1 to Grade 7. The characters were arranged in order of decreasing frequency and increasing difficulty in recognition. The test was terminated when five wrong answers were given in a row. The raw score was used. Participants were required to reach a minimum score of one on this test.

Matching Measures

1. **Vocabulary.** Every third item of the complete Peabody Vocabulary Test-Fourth Edition (PPVT-4; Dunn & Dunn, 2007) was used to generate an English Vocabulary measurement and a Chinese one (verified by back translation) as performed by previous studies (Pasquarella et al, 2011; Lam, Chen, & Cummins, 2016). The items used in the English version

were not used in the Chinese version. In this way, the progressive difficulty was maintained while the testing time was shortened. For each item, four pictures were presented with a word orally presented twice. Children were asked to choose from one of the pictures that best matched the word. The test discontinued when children made eight mistakes in a row. The total number of correctly recognized English words was recorded as one of the matching criteria for -non-Chinese peers.

2. English word reading. English word reading was measured by the Sight Word Efficiency Subtest from the Test of Word Reading Efficiency-Second Edition (TOWRE-2; Torgesen, Wagner, & Rashotte, 1999). In a given 45-second period of time, children are asked to read the words as quickly as possible. The total number of correctly read words was used as one of the matching criteria for English-non-Chinese peers.

Procedure

For English-Chinese-bilingual children, the study took place at the Early Years Reading Lab located in Department of Psychology, University of Manitoba. The background questions were collected earlier in the recruitment process, completed by parents who provided consent for children to participate in the study. Parents accompanied their children to the experiment location; they were led to a separate waiting room next to the experimental room. All research assistants were trained undergraduate or graduate students in psychology. English-non-Chinese children participated at their schools in a quiet room, and the administered tasks included all non-Chinese tests. The PPVT-4 (Peabody Picture Vocabulary Test, 4th edition) was administered in a standardized way for English-bilingual children, but the same items administered to English-Chinese bilingual children were used in scoring English-non-Chinese children's vocabulary. Chinese-language measures were administered by a Chinese speaker.

Before the formal testing with the lexical decision task, children were introduced to the computer program and allowed to become familiar with the simple manipulation of clicking mouse buttons (left for YES, and right for NO, in response to the question "Is this a word?") to respond at the end of each lexical decision trial. After two practice trials to confirm that participating children understood the test procedure, the formal testing began. Children were asked to complete the masked primed lexical-decision task in English and the rest of the tasks as listed previously. The order of tasks was counterbalanced across participants. For example, participant 1 received tasks in the order of 1,2,3, …, 6; Participant 2 received tasks in the order of 2, 3, … 6, 1, and so forth.

Data Analysis Plan

1. **Matching**

Sample A (11 English-Chinese bilingual children) and sample B (11 English-non-Chinese children) were matched following the priority order of: 1. Family income 2. Sex 3. Age of testing 4. Performance of English picture vocabulary (PPVT-4). PPVT-4 scores were selected as matching criteria instead of TOWRE-2 scores as the process of semantic processing in the PPVT-4 was thought more likely to influence the lexical decision task performance. TOWRE-2, Morphological processing task and Matrix Reasoning tasks were not matched on one-to-one basis. Group differences were tested using paired t-tests for TOWRE-2, Morphological processing task and Matrix Reasoning tasks to ensure there were no significant group differences in the performance on these tasks. None of the comparisons was significant.

2. **Masked primed lexical decision task**

Incorrect responses for the lexical decision task were removed. Response times (RTs) shorter than 200ms or longer than 3000 ms were treated as incorrect and removed. Linear mixed-effect modeling (Baayen, 2008; Baayen, Davidson, & Bates, 2008; also known as multilevel linear modeling) was the main method of analysis. The data structure of the present study had two levels: The individual level (level 2) and the trial level (level 1). Measures for each trial were nested under each individual. The collected data contained both the trial level's variance (how a given individual's key presses differed) and individual participant level's variance, namely how each individual tended to respond to the task. To make the best use of multiple observations under each participant, linear mixed effect modeling was applied to the data analysis. This method captures random variance from both levels, which is adjusted for random differences yielded by individual participants and individual items. Compared to simply testing mean differences, this method is considered more appropriate in detecting the true differences than the conventional t test, when multiple observations are clustered and come from the same participants. In the data analysis procedure, RTs were collected and reciprocally transformed to -1/RT. This transformation was necessary to ensure that the normality assumption at the item level was not violated, following typical practice with response time data.

For the model adjustment, preliminary models were constructed to include all possible variables. The fixed and random effects of the preliminary models were tested by a backward stepwise procedure as described in Beyersman et al. (2016). Starting from the most complicated interactions in the model, each variable underwent F test. Variables were included in the final model only if they significantly improved the model fit. The variables' levels of significance were yielded by the R package lmerTest (Kuznetsova, Brockhoff, & Christensen, 2014). The package provided p-values for both the fixed effects (calculated from F tests based on Sattethwaite's approximation) and random effects (calculated from the likelihood ratio test; Kuznetsova, Brockhoff, & Christensen, 2014).

In summary, the three models (a model with both language groups included, a model with the English-Chinese group only, and a model matched non-Chinese group only) underwent the following data processing procedure:

1 Initial models with full variable sets were constructed.

2 Nonsignificant variables were excluded after fitting data.

3 Final models were generated after excluding nonsignificant variables.

4 Final models were retested.

3. **Analysis of Power**

In multilevel analysis, questions about power and adequate sample size under each level have been the focus of many studies (Bell et al., 2010; Schunck, 2016). Schunck's (2016) simulation study revealed decreasing statistical error in estimating regression coefficients when the number of observations under each Level 2 unit increased from 5 to 80. In the present study, the number of observations under each individual is more than 95. As for Schunck's simulation (2016), the bias in estimating Level 2 regression coefficients from aggregated data (Level 2 variables are functions of Level 1 variables) showed a different pattern from that found in estimating Level 1 regression coefficients (Schunk, 2016). Importantly, the number of Level 2 units is not significantly related to the size of bias in estimating Level 2 regression coefficients from aggregated data. Increasing the number of Level 1 observations decreased the size of bias at Level 2 (Schunck, 2016).

Another simulation study from Bell et al. (2010) used models with 2 and 3 Level-1 predictors crossed with 2 and 3 Level-2 predictors for both main effect and three different interaction models (Level-1 interaction, Level-2 interaction, and cross-level interaction). Within the scope of examined conditions, the number of predictors at each level, the type of model, and correlations among predictor variables did not pose substantial risk of bias in the statistical analysis (Bell et al., 2010). Increasing the sample size in both Level 1 and Level 2 helps to increase the power, but the simulated sample sizes never reached the extent to have a power stably over 0.80 (Bell et al., 2010). The highest combination of sample sizes tested in Bell's study were 20 to 40 participants in Level 1 and 30 in Level 2 (Bell et al., 2010).

The present study contains more than 95 Level 1 observations for each participant based on the smallest number of trials per participant after deleting incorrect word-target items. There are 22 (overall analysis – corresponding to the total sample size) or 11 (group analysis – corresponding to the number of participants in each group) Level 2 units. The size of individual units is deemed adequate for 80% power based on Schunck's study (2016). While the Level 2 sample size was smaller than the highest condition examined in Bell et al.'s (2010) study, the size of the Level 1 sample (number of trials per participant) was large enough to increase the power of the overall analysis. As shown in previous studies (Bell et al., 2010; Schunck, 2016), power increased when the Level 1 sample size increased and the Level 2 sample size remained constant. Another notable point is that the simulation formula used in Bell et al.'s (2010) study was more complex than that in Schuck (2016) and that used in the present study. Bell et al.'s simulation (2010) included an additional two to three predictors in Level 2 and two to three predictors in Level 1. The added complexity of their model may have lowered the statistical power reported. When there is only one predictor in Level 2, the number of Level 2 units is not significantly related to the size of bias in estimating the Level 2 regression coefficient (Schunck, 2016). The present study contained one predictor in Level 2 for the overall model and zero predictors in the Level 2 group-specific models. Hence, based on the analyses of Bell et al., and

Schunk, the sample size of Level 1 in the present study has more direct influence on the study's power than the Level 2 sample size.

Further, the main interest of this study focuses on Level 1 interactions, Level 2 interactions and cross-level interactions. As Bell et al. (2010) found, the examination of multiple interaction effects does not pose a problem in power in obtaining statistical outcomes.Taken together, the previous research indicates that the current study's sample size combination, although not examined specifically in previous simulation studies, is adequate in producing valid results.

Results

The results section starts with a description of the outcome of the matching process followed by the descriptive analysis and inferential analysis. The descriptive analysis provides means and standard deviations of Response Times (RTs) for the overall sample and that of each language group, presented in tables. The inferential analysis contains detailed explanations of the mixed linear models used in the study.

Matching

A summary of performance by matched Sample A and Sample B participants on relevant tasks is given in Table 2. The participant matching process was conducted on an individual basis. Matching began with characteristics of members of the Chinese bilingual group who were paired with the closest-matching members of the non-Chinese sample based on the following order of characteristics: 1. Family income 2. Sex 3. Age at testing 4. Performance on the English picture vocabulary test (PPVT-4). Family income was assumed to have a major influence on children's reading development. Higher family income is connected to enriched reading resource availability, better reading environment and more exposure to reading. As all eleven English-

Chinese children lived in higher income census areas (yearly income > $50000), the eleven matched non-Chinese participants were chosen from families with similar income based on median income of the school neighbourhood. Sex and age were matched after the family income. The age difference did not exceed 2 years across each pair of matched samples. PPVT-4 raw score, as an indicator of English spoken proficiency level, was matched after sex and age. The maximum raw score difference in PPVT-4 across each matched pair was 4 points. Group differences on all other measures were tested using paired *t*-tests (the two groups were not independent as they were linked by matched participant characteristics.) No significant differences between Sample A and Sample B were found on the TOWRE-2, t = -0.069, p>0.05, Morphological Processing, t = -0.33, p>0.05, or Matrix Reasoning, t =-1.25 , p>0.05. Hence, the matching was successful in that indicators of socio-economical status, English vocabulary level, and cognitive ability did not yield significant difference between the two groups, which were matched on sex and age.

Descriptive Analysis

A summary of Chinese task performance, available only for the English -Chinese group (Sample A), is presented in Table 3. Participants’ Chinese character recognition levels were measured by the non-standardized Chinese Character naming task, and Chinese receptive vocabulary was measured by the PPVT-4 (modified Chinese version). A Beginner level was classified as Character Naming <=10 or PPVT(Chinese)<=20. A Medium level was classified as- Character Naming >10 and PPVT (Chinese)>20. There were 6 Beginner level participants and 5 Medium level participants in total.

The Mean respone times and error rates on the Lexical Decision Task for participants across both language groups and in separate language group are presented in Table 4 (all participants) and Table 5 (language-specific). Response times in the semantic suffixed condition for the English-Chinese group were shorter than those of the matched non-Chinese group. Error rates of the English-non-Chinese group were higher than those of the English-Chinese group across all suffixed conditions. The two language groups showed differences in demonstrating positive or negative priming effects across conditions.

Inferential Analysis: Masked primed lexical decision task

The data analysis was implemented by using the lme4 package in RStudio (Version 1.0.153, RStudio Team, 2015). An initial generalized linear mixed-effect model was created with five fixed-effects variables (prime type; suffix type; transpose type; language group; and each of the interaction combinations among them) and two random-effect variables (random intercepts for participants and items) for model testing purposes. Language group was the only Level 2 fixed-effect variable and the random intercept for participants was the only Level 2 random-effect variable. A final model including both language groups was simplified as follows:

*transformed RT ~ prime type + suffix type + transpose type + language group + prime type * suffix type + prime type * transpose type + prime type * language group+ transpose type * language group +* ***prime type*transpose type* language group****+ random intercepts for subject + random intercepts for item*

For random effects, the random intercept for item was 0.0024, with a standard deviation of 0.049; The random intercept for subject was 0.099, with a standard deviation of 0.31. The residual variance was 0.096 with a standard deviation of 0.31.

For fixed effects, the *t*-values and *p*-values of the model variables are summarized in Table 6. As stated in the data analysis plan, the critical test of the hypotheses lies in the interaction effects. The three-way interaction among language group, prime type and transposed letter type was significant ($t = 2.19$, $p < 0.05$), indicating the interaction between prime type and transposed letter type differed between language groups. Two separate data sets were then generated for each of the two language groups.

The initial generalized linear mixed-effect model was created with the four fixed-effects variables (prime type; suffix type; transpose type and the interactions among them) and two random-effect variables (random intercepts for participants and items). Variables that significantly improved the model fit were retained in the final model for each language group. A final model for English-Chinese bilingual children was simplified as follows:

transformed RT ~ prime type + suffix type + ***prime type * suffix type*** *+ random intercepts for subject + random intercepts for item*.

For random effects, the random intercept for item was 0.0076, with a standard deviation of 0.087; The random intercept for subject was 0.096, with a standard deviation of 0.31. The residual variance was 0.093 with a standard deviation of 0.31.

For the English-Chinese bilingual group, the RT analyses showed priming was significant in the semantic suffixed condition ($t = 2.39$, $p < 0.05$; see Table 7). No significant priming was observed in the pseudo suffixed condition ($t = -1.78$, $p = 0.076$) or in the orthographic suffixed condition ($t = 0.28$, $p = 0.78$). A significant facilitation effect was found with semantic primes. A trend indicating an interference effect, but that failed to reach significance, was found with pseudo primes. The orthographic primes showed neither facilitation nor interference effects.

For the matched English-non-Chinese group, the same steps were used to form the final model. The final model for matched English-non-Chinese children was simplified as follows:

*transformed RT ~ transpose type + suffix type +****transpose type * suffix type*** *+ random intercepts for subject*.

For random effects, the random intercept for subject was 0.10, with a standard deviation of 0.32. The residual variance was 0.096 with a standard deviation of 0.31.

As for fixed effects, within the English-non-Chinese dataset, the interaction between prime type and suffix type was not a significant predictor ($F = 1.54$, $p = 0\ .22$) and was thus excluded from the final model (see Table 8). The non-significant interaction between these two variables indicates that no significant priming effect was found in each of the three suffix conditions for the English-non-Chinese group. Instead, the interaction between suffix type and transposed letter type was significant ($F = 3.48$, $p < 0.05$). For the transposed letter condition, children in this group responded with no significant differences across the three suffix types. For the non-transposed (intact) letter condition, however, English-non-Chinese children made lexical decisions fastest in the semantic condition, then orthographic, followed by the pseudo condition across prime type (related and unrelated combined). The RT difference between the orthographic condition and the semantic condition was non-significant, so it seemed that English-non-Chinese children processed target words with semantic primes only slightly faster than target words with orthographic primes, but both semantic and orthographic primes were processed more effectively (even for unrelated targets) in comparison to pseudo primes.

Discussion

The main purpose of this study was to examine whether cross-language transfer of common word (character) structure from Chinese to English can occur in children learning L2 Chinese character reading concurrently with L1 English reading acquisition. With increasing exposure to spoken and written Chinese, it was expected that evidence for an earlier development of morpho-orthographic segmentation would be revealed in the English lexical decision task. Translating this hypothesis into the data level, I expected to see differences shown in priming effects across the two language groups, especially within semantic and pseudo suffix conditions, with the English-Chinese bilingual group showing stronger priming than the English-non-Chinese group.

Results provided some evidence in favour of the proposed difference between language groups. Significant priming was observed in the English-Chinese bilingual group but not in the matched English-non-Chinese group. However, the expectation of automatic morpho-orthographic decomposition as reflected by a consistent significant priming effect in the lexical decision task for related-intact primes is not strongly supported by the results. A significant priming benefit was shown only in the English-Chinese bilingual group, and was limited to the semantic suffixed condition. No significant priming effect was found in any of the three suffix condition for the matched English-non-Chinese group. It appeared that English-Chinese bilinguals were developmentally advanced in using the semantic suffix to facilitate complex word reading, while their age-matched peers who who had no experience learning Chinese characters did not benefit from the semantic suffix. Group differences will be discussed in detail in the following section, and a possible explanation for the differences will be provided. The theoretical and practical implications of present results follow. Finally, limitations and future research directions are discussed.

English-Chinese bilinguals: Preference for coarse-grained analysis

Results from the pseudo suffix condition do not match the hypothesis. It was hypothesized that exposure to Chinese character reading would facilitate word processing in the pseudo suffixed condition, but the results showed the opposite. A slight inhibition effect, while not statistically significant, was observed. Conflicting root-word meaning and whole-word meaning in the pseudo suffixed primes may explain the observed inhibition (for example,: "corn" versus "corner"). To overcome this conflict, some form of automatic"neglect" brought by exposure to written Chinese might have been occurring. The neglect of semantic content of the prime item, however, was not occurring in the case of pseudo-primes and no facilitation in resolving the semantic conflict was witnessed.

Compared to the unified pattern (nonsignificant priming across the three suffix conditions) observed with the English-non-Chinese matched group, the performance of the English-Chinese bilingual group showing facilitation in the semantic suffix condition, and slight inhibition in the pseudo suffix condition, is interesting. To examine whether the difference reached statistical significance, the relevel function in R was used to readjust level comparisons. (The default condition for comparing levels was the orthographic-suffixed condition. To permit the comparison between semantic and pseudo conditions, the relevel function was used to reset the comparison level to the pseudo-suffixed condition). Results showed that the scope of priming in these two conditions within the English-Chinese sample differed significantly ($p < 0.01$), with positive priming by semantic primes being stronger than the negative priming by pseudo primes. What might account for this facilitation in the semantic suffix condition, and inhibition in the pseudo suffix condition? One explanation is that morpho-orthographic decomposition did take place consistently in both suffix conditions, causing the difference in priming effects by either easing the subsequent lexical decision or complicating it. With the semantic suffix condition, the decomposed suffix had a semantic relation with the target word, thus potentially easing the task of making a lexical decision. With the pseudo suffix condition, the decomposed suffix had no semantic connection with the target word, thus inbibiting lexical decision task performance. Alternatively, the difference can be explained by differential preferences for fine-grained analysis versus coarse-grained analysis in processing the prime. If English-Chinese children prefer to use coarse-grained analysis in the lexical decision task, they will tend to process the prime word as a whole. With the semantic suffix condition, the whole prime word has a semantic relation to the target word, thus facilitating the task. With the pseudo suffix condition, the whole prime word has a conflicting semantic meaning to the target word, thus inhibiting the task.

In order to clarify which explanation is more likely to be true, a consideration of the transposed condition is necessary. If the coarse-grained approach was used by children in the English-Chinese bilingual group, then when letters were transposed across the suffix boundary, there would be little to no transposed letter effect, as the transposition would be less likely to be perceived (as a fine-grained characteristic of the whole word). If the transposition were perceived (with the possible consequence of reducing or eliminating the priming effect, especially in the semantic-prime condition), then a fine-grained decomposition process would be indicated. The results of the present study showed significant group differences in the transposed-letter effect. For English-Chinese children, transposing letters in the middle of a complex word caused little interference, suggesting a coarse-grained process was taking precedence. By contrast, the matched English-non-Chinese peers were likely preferring a fine-grained strategy, consistent with being influenced by the subtle letter change across the suffix boundary.

English-Non-Chinese-matched group: Preference for fine-grained analysis

For the matched English-non-Chinese group, the interaction between transposed type and suffix type was significant ($F = 3.48$, $p < 0.05$), rather than the interaction between prime type and suffix type as found in the English-Chinese group. As for why the interaction between prime type and suffix type failed to show significance within matched English-non-Chinese group, the descriptive data in Table 5 reveals that the matched English-non-Chinese children had similar patterns of facilitation and inhibition in terms of priming, but the effect was weaker than that found in the English-Chinese group. The statistical method used in the present study adjusted for random errors generated from the individual level and item level, thus requiring a larger priming effect to be significant in the final model.

With regard to the significant interaction between transposed type and suffix type within the matched English-non-Chinese sample, the reasons why participants' response times differed between the letter-intact condition and letter-transposed condition will be discussed. For the letter-intact condition, English-non-Chinese children processed quickly the semantic-suffixed primes and the orthographic-suffixed primes (t = -0.52, p > 0.05), and they processed slowest with pseudo-suffixed primes (compared to the RT with semantic-suffixed primes: t = -3.19, p < 0.01; and compared to the RT with orthographic primes: t = -2.70, p < 0.01). The facilitation brought about by semantically related primes compared to unrelated primes showed a trend towards a beneficial priming effect of 51ms, in the descriptive analysis. A similar trend towards facilitation was observed in the comparison of the RT of orthographically related primes to the RT of orthographically unrelated primes (priming benefit of 37ms). A small trend indicating an inhibitory effect (-60ms) was found in the comparison of the RT of pseudosuffixed related primes and the RT of pseudosuffixed unrelated primes. It is important to note that all three effects were equal to zero after accounting for contributions from other fixed and random variables in the inferential analysis. For the transposed-letter condition, English-non-Chinese children showed no significant processing speed differences across the three suffix conditions. Transposed letters, however, seem to act as powerful distractors for the English-non-Chinese participants in that this manipulation effectively converted otherwise meaningfully related primes to nonsense strings of letters. Further, English-non-Chinese children had a trend to take longer to process transformed unrelated primes than transformed related primes across the three suffix conditions. For example, they had longer processing times for "darekr-CREAM; faulyt-CORN; oledst-FAR" than for "winenr-WIN; lisetn-LIST; stavre-STAR". The orthographic pattern of letter repetition in prime and in target seemed to facilitate their processing when the semantic information in the primes was eliminated by transposed letter, thought the trend was not statistically significant. An explanation would be that these children differentially allocated attention to the suffix boundary, likely reflecting the application of a fine-grained strategy. To conclude, the transposed letter effect observed only in the matched English-non-Chinese group indicates a preference for fine-grained analysis. Hence, primes in prime-target pairs like "darekr-CREAM; faulyt-CORN; oledst-FAR; winenr-WIN; lisetn-LIST; stavre-STAR" were all treated similarly by matched English-non-Chinese children.

Implications of the present study

As discussed in the previous section, language-group differences in lexical decision task performance were mainly related to the effect of the transposed letter manipulation, as found in the differential absence of a transposition effect in English-Chinese bilingual children's results and presence of the effect in matched English-non-Chinese children's results. Transposing letters seems to have acted as a powerful distractor for English-non-Chinese participants. Upon transposing, a prime word such as "goledn" turns into nonsense strings of letters for these children. The RT differences that were observed when the letter-orders were intact were then diminished across the three suffix conditions when the letter-orders were transposed. For English-Chinese children, results were quite distinct from those of English-non -Chinese bilingual children. Transposing prime letters did not seem to interfere with the priming effect found with semantic primes for English-Chinese children.

In previous research (Beyersman et al, 2012), the facilitation effect observed from both semantic primes and pseudo primes was found only in adult readers and was interpreted as a consequence of experienced reading. Within developing readers, a narrowing gap between the semantic prime's effect and the pseudo prime's effect was found as children matured and reading exposure increased (Beyersman et al, 2012). In the present study, a facilitation effect was found in English-Chinese children with semantic primes, but not in matched English-non-Chinese children. It seems that English-Chinese children were developmentally superior than their matched peers in using semantic suffixes to facilitate word processing. However, with pseudo-primes, a trend towards inhibition instead of facilitation was discovered in English-Chinese children. The interference by pseudoprimes is likely a result of a conflict caused by the whole-word meaning (e.g., stocking) and the root word/target word (the "stock" in "stocking"), as suggested by the application of a coarse-grained analysis strategy.

In this study, the eleven English-Chinese bilingual children were matched on factors that can influence reading development with eleven English-non-Chinese- children: age, sex, family socio- economic status, and English picture vocabulary level on a one-to-one basis. No group difference in English reading level was found, as measured by the TOWRE-2. The careful matching process excluded many possible explanations for the effects that were observed, and helped to support the explanation put forward for the unique pattern of priming results found in the English-Chinese bilingual group. The participating English-Chinese bilingual children were recruited from a population living and studying in an English-language-dominant environment. They attended Chinese heritage school weekly for only one to two hours a week. Their completion rates of assigned exercises and curricula from the heritage school varied among their families. In order to have a clear understanding of their Chinese-language and literacy capabilities, all participating English-Chinese children were asked to name a list of basic Chinese characters presented to them according to their frequency of written usage. These children's reading and vocabulary abilities for Chinese were generally at the beginner to medium levels (refer to Table 3 for frequencies) as measured by the non-standardized Chinese character naming and vocabulary tasks used in the study. Nevertheless, despite the children's limited exposure to written Chinese, they showed differential effects in the English-language lexical decision task compared to English-non-Chinese- children who had no experience with written Chinese. Overall, the results showed positive benefits of learning Chinese characters during English reading development.

Limitation and future research direction

The present study found promising yet limited results by using a lexical decision task as the outcome measure reflecting morphological abilities. The language group difference was specific to the semantic-suffixed condition. The inhibition effect in the pseudo-suffixed condition, although nonsignificant in both language groups, was difficult to interpret. The proposed explanation based on automatic decomposition that is blind to the semantic relation between prime and target words, needs further validation with more participants, ideally representing a wider range of proficiency in Chinese language and literacy.

Recruiting English-Chinese children with more exposure to written Chinese would have a broader benefit of validating the general patterns identified in this study. For example, recruiting children attending English-Chinese bilingual public schools could be considered; such schools are well-established in several Canadian jurisdictions, but not yet available in the province of Manitoba.

Understanding the demands of Chinese character learning is helpful in answering the question about why exposure to Chinese character reading might be beneficial to the Chinese-English bilingual group's English reading development. To start with, most Chinese characters (about 80-90%) are compound characters (Kang, 1993; Zhu, 1987), in which half of the radical is a symbol that can only be used to compose compound characters, and the other half can be separated to be a stand-alone character. For clarity, the term "morphological awareness" within the Chinese writing system typically refers to the lexical (multi-character) level. The sub-lexical level, which is more likely to be parallel to its English counterpart as in the example of "sing-er," is referred as "radical awareness." Interestingly, Chinese children living in Chinese-language-dominant contexts in Grades Three and Five are able to choose the correct radical when examining unfamiliar characters, showing an early trend towards an emerging development of radical awareness (Shu & Anderson, 1997). For children living in an English-language-dominant environment, more exposure to Chinese character reading is likely to help develop similar awareness that may be transferred to facilitating processing of compound English words, as the sub-lexical structure for compound Chinese characters appears to correspond to the morphological structure of English compound words. Moreover, automatic decomposition is necessary for developing fluent Chinese character reading. The better children are able to deal with conflicting stand-alone character and whole-character meaning, the more successful is their Chinese character reading. Transferred to English complex word reading, it is likely to be reflected by a skillful "blindness" to the conflicting root-word and whole-word meaning. The present study has demonstrated that English-Chinese bilinguals, with limited but meaningful exposure to written Chinese, had an advantageous "blindness" to the transposed letter within complex English word primes (Example: Treating "goledn" as "golden"). This finding demonstrates that English-Chinese bilinguals have a preliminary skill in selectively neglecting (ignoring) conflicting (task-irrelevant) sub-lexical letter traits to facilitate whole-word processing, likely indicating a preference for course-grained processing. It would be important to examine whether more exposure to written Chinese leads the automatic neglect of conflicting information to a level that is adequate to overcome conflicts caused by distinct root-word and whole-word meanings (Example: "Corn" versus "Corner"). Once overcome, the non-semantic morphological advantage (with pseudo-primes) will likely emerge, which was not demonstrated within the present study.

References

Baayen, R. H. (2008). Analyzing linguistic data: A practical introduction to statistics using R. *Analyzing Linguistic Data: A Practical Introduction to Statistics Using R.* https://doi.org/10.1017/CBO9780511801686

Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language, 59*(4), 390–412. https://doi.org/10.1016/j.jml.2007.12.005

Baayen, R. H., Dijkstra, T., & Schreuder, R. (1997). Singulars and plurals in Dutch: Evidence for a parallel dual-route model. *Journal of Memory and Language, 37*(1), 94–117. https://doi.org/10.1006/jmla.1997.2509

Bell, B., Morgan, G. B., Schoeneberger, J. a, Loudermilk, B. L., Kromrey, J. D., & Ferron, J. M. (2010). Dancing the Sample-Size Limbo with Mixed Models: How Low Can You Go? *SAS Global Forum 2010*, 1–11.

Beyersmann, E., Castles, A., & Coltheart, M. (2012). Morphological processing during visual word recognition in developing readers: Evidence from masked priming. *The Quarterly Journal of Experimental Psychology*, *65*(7), 1306–1326. https://doi.org/10.1080/17470218.2012.656661

Beyersmann, E., Cavalli, E., Casalis, S., & Colé, P. (2016). Embedded stem priming effects in prefixed and suffixed pseudowords. *Scientific Studies of Reading, 20*(3), 220-230.

Bradley, L., & Bryant, P. E. (1983). *Categorizing sounds and learning to read - A causal connection. Nature, 301*(5899), 419–421. https://doi.org/10.1038/301419a0

Carlisle, J. F. (1995). Morphological awareness and early reading achievement. In L. B. Feldman (Ed.), Morphological aspects of language processing (pp. 189–209). Hillsdale, NJ: Erlbaum. https://doi.org/10.2307/495689

Chomsky N., & Halle M. (1968). *The sound pattern of English.* New York: Harper & Row.

Deacon, S. H., & Kirby, J. R. (2004). Morphological awareness: Just "more phonological"? The roles of morphological and phonological awareness in reading development. *Applied Psycholinguistics*. https://doi.org/10.1017/S0142716404001110

Deng, Y., Booth, J. R., Chou, T.-L., Ding, G.-S., & Peng, D.-L. (2008). Item-specific and generalization effects on brain activation when learning Chinese characters. *Neuropsychologia, 46*(7), 1864–1876. https://doi.org/10.1016/j.neuropsychologia.2007.09.010

Deng, Y., Chou, T., Ding, G., Peng, D., & Booth, J. R. (2011). The involvement of occipital and inferior frontal cortex in the phonological learning of Chinese characters. *Journal of Cognitive Neuroscience, 23*(8), 1998–2012. https://doi.org/10.1162/jocn.2010.21571

Diependaele, K., Sandra, D., & Grainger, J. (2009). Semantic transparency and masked morphological priming: The case of prefixed words. *Memory and Cognition, 37*(6), 895–908. https://doi.org/10.3758/MC.37.6.895

Dunn, L. M., & Dunn, D. M. (2007). Peabody Picture Vocabulary Test--Fourth Edition. PsycTESTS. https://doi.org/10.1037/t15144-000

Feldman, L. B., & Siok, W. W. T. (1999). Semantic Radicals Contribute to the Visual Identification of Chinese Characters. *Journal of Memory and Language, 40*(4), 559–576. https://doi.org/10.1006/jmla.1998.2629

Franceschini, S., Gori, S., Ruffino, M., Pedrolli, K., & Facoetti, A. (2012). A causal link between visual spatial attention and reading acquisition. *Current Biology, 22*(9), 814–819. https://doi.org/10.1016/j.cub.2012.03.013

Gabrieli, J. D. (2009). Dyslexia: a new synergy between education and cognitive neuroscience. *Science, 325*(5938), 280-283. https://doi.org/10.1126/science.1171999

Gabrieli, J. D. E., & Norton, E. S. (2012). Reading abilities: Importance of visual-spatial attention. *Current Biology, 22*(9). https://doi.org/10.1016/j.cub.2012.03.041

Giraudo, H., & Grainger, J. (2000). Effects of prime word frequency and cumulative root frequency in masked morphological priming. *Language and Cognitive Processes, 15*(4–5), 421–444. https://doi.org/10.1080/01690960050119652

Hoeft, F., Meyler, A., Hernandez, A., Juel, C., Taylor-Hill, H., Martindale, J. L., … Gabrieli, J. D. E. (2007). Functional and morphometric brain dissociation between dyslexia and reading ability. *Proceedings of the National Academy of Sciences, 104*(10), 4234–4239. https://doi.org/10.1073/pnas.0609399104

Horwitz, B., Rumsey, J. M., & Donohue, B. C. (1998). Functional connectivity of the angular gyrus in normal reading and dyslexia. *Proceedings of the National Academy of Sciences, 95*(15), 8939–8944. https://doi.org/10.1073/pnas.95.15.8939

Hue, C. W. (1992). Recognition Processes in Character Naming. *Advances in Psychology, 90,* 93-107. https://doi.org/10.1016/S0166-4115(08)61888-9

Kang, J. S. (1993). Analysis of semantics of semantic-phonetic compound characters in modern Chinese. In Y. Chen (Ed.), *Information analysis of usage of characters in modern Chinese* (pp. 68-83). Shanghai: Shanghai Education Publisher (in Chinese).

Kevan, A., & Pammer, K. (2008). Making the link between dorsal stream sensitivity and reading. *NeuroReport*, *19*(4), 467-470. https://doi.org/10.1097/WNR.0b013e3282f5f7ad

Ku, Y. M., & Anderson, R. C. (2003). Development of morphological awareness in Chinese and English. *Reading and Writing*, *16*(5), 399–422. https://doi.org/10.1023/A:1024227231216

Kuo, L. J., & Anderson, R. C. (2006). Morphological awareness and learning to read: A cross-language perspective. *Educational Psychologist, 41*(3), 161–180. https://doi.org/10.1207/s15326985ep4103_3

Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2014). LmerTest: Tests for random and fixed effects for linear mixed effect models. *R package, version 2.0-3*. URL http://CRAN. R-project. org/package= lmerTest.

Lam, K., Chen, X., & Cummins, J. (2015). To Gain or To Lose: Students' English and Chinese Literacy Achievement in a Mandarin Language Bilingual Program. *Canadian Journal of Applied Linguistics/Revue canadienne de linguistique appliquée, 18*(2), 96-124.

Lee, C. Y., Tsai, J. L., Huang, H. W., Hung, D. L., & Tzeng, O. J. L. (2006). The temporal signatures of semantic and phonological activations for Chinese sublexical processing: An event-related potential study. *Brain Research, 1121*(1), 150–159. https://doi.org/10.1016/j.brainres.2006.08.117

Liberman, I. Y., & Shankweiler, D. (1991). Phonology and beginning reading: A tutorial. In L. Rieben & C. A. Perfetti (Eds.), *Learning to read: Basic research and its implications* (pp. 3–17). Hillsdale, NJ: Lawrence Erlbaum Associates. Retrieved from http://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=psyc3&AN=1991-97720-001

Liu, Y., Dunlap, S., Fiez, J., & Perfetti, C. (2007). Evidence for neural accommodation to a writing system following learning. *Human Brain Mapping*, *28*(11), 1223–1234. https://doi.org/10.1002/hbm.20356

Longtin, C. M., Segui, J., & Hallé, P. A. (2003). Morphological priming without morphological relationship. *Language and Cognitive Processes, 18*(3), 313–334. https://doi.org/10.1080/01690960244000036

Lonigan, C. J., Burgess, S. R., & Anthony, J. L. (2000). Development of emergent literacy and early reading skills in preschool children: Evidence from a latent-variable longitudinal study. *Developmental Psychology, 36*(5), 596–613. https://doi.org/10.1037//0012-1649.36.5.596

Marslen-Wilson, W., Tyler, L. K., Waksler, R., & Older, L. (1994). Morphology and meaning in the English mental lexicon. *Psychological Review, 101*(1), 3–33. https://doi.org/10.1037/0033-295X.101.1.3

McBride-Chang, C., Cho, J. R., Liu, H., Wagner, R. K., Shu, H., Zhou, A., … Muse, A. (2005). Changing models across cultures: Associations of phonological awareness and morphological structure awareness with vocabulary and word recognition in second graders from Beijing, Hong Kong, Korea, and the United States. *Journal of Experimental Child Psychology, 92*(2), 140–160. https://doi.org/10.1016/j.jecp.2005.03.009

Metsala, J. L., & Ehri, L. C. (Eds.). (1998). *Word recognition in beginning literacy. Word recognition in beginning literacy*. Mahwah, Nj: Lawrence Erlbaum Associates.

Mingjin, H., Hasko, S., Schulte-Körne, G., & Bruder, J. (2012). Automatic integration of auditory and visual information is not simultaneous in Chinese. *Neuroscience Letters, 527*(1), 22–27. https://doi.org/10.1016/j.neulet.2012.08.031

Pasquarella, A., Chen, X., Lam, K., Luo, Y. C., & Ramirez, G. (2011). Cross-language transfer of morphological awareness in Chinese-English bilinguals. *Journal of Research in Reading, 34*(1), 23–42. https://doi.org/10.1111/j.1467-9817.2010.01484.x

Plaut, D. C., & Gonnerman, L. M. (2000). Are non-semantic morphological effects incompatible with a distributed connectionist approach to lexical processing? *Language and Cognitive Processes, 15*(4–5), 445–485. https://doi.org/10.1080/01690960050119661

Quémart, P., Casalis, S., & Colé, P. (2011). The role of form and meaning in the processing of written morphology: A priming study in French developing readers. *Journal of Experimental Child Psychology, 109*(4), 478–496. https://doi.org/10.1016/j.jecp.2011.02.008

Rastle, K., Davis, M. H., Marslen-Wilson, W. D., & Tyler, L. K. (2000). Morphological and semantic effects in visual word recognition: A time-course study. *Language and Cognitive Processes, 15*(4–5), 507–537. https://doi.org/10.1080/01690960050119689

Rastle, K., Davis, M. H., & New, B. (2004). The broth in my brother's brothel: Morpho-orthographic segmentation in visual word recognition. *Psychonomic Bulletin & Review, 11*(6), 1090–1098. https://doi.org/10.3758/BF03196742

Rayner, K., Foorman, B. R., Perfetti, C. A., Pesetsky, D., & Seidenberg, M. S. (2002). How reading should be taught? *Scientific American, 286*(3), 84–91. https://doi.org/10.1038/scientificamerican0302-84

Rueckl, J. G., & Raveh, M. (1999). The influence of morphological regularities on the dynamics of a connectionist network. *Brain and Language, 68*(1-2), 110–117. https://doi.org/10.1006/brln.1999.2106

Schlaggar, B. L., & McCandliss, B. D. (2007). Development of Neural Systems for Reading. *Annual Review of Neuroscience*, *30*(1), 475–503. https://doi.org/10.1146/annurev.neuro.28.061604.135645

Schunck, R. (2016). Cluster Size and Aggregated Level 2 Variables in Multilevel Models. A Cautionary Note. *Methods, 10*(101), 97–108. https://doi.org/10.12758/mda.2016.005

Shu, H., & Anderson, R. C. (1997). Role of Radical Awareness in the Character and Word Acquisition of Chinese Children. *Reading Research Quarterly*, *32*(1), 78–89. https://doi.org/10.1598/RRQ.32.1.5

Torgeson, J., Wagner, R., & Rashotte, C. (2009). TOWRE-2 - Test of Word Reading Efficiency 2. Test of word reading efficiency. Retrieved from https://www.mhs.com/product.aspx?gr=edu&prod=towre2&id=overview

Vellutino, F. R., & Scanlon, D. M. (1987). Phonological coding, phonological awareness, and reading ability: Evidence from a longitudinal and experimental study. *Merrill-Palmer Quarterly, 33*, 321-363.

Wang, M., Cheng, C., & Chen, S. W. (2006). Contribution of morphological awareness to Chinese-English biliteracy acquisition. *Journal of Educational Psychology*, *98*(3), 542–553. https://doi.org/10.1037/0022-0663.98.3.542

Wang, M., Yang, C., & Cheng, C. (2009). The contributions of phonology, orthography, and morphology in Chinese English biliteracy acquisition. *Applied Psycholinguistics*, *30*(2), 291–314. https://doi.org/10.1017/S0142716409090122

Wu, N., Zhou, X., & Shu, H. (1999). Sublexical processing in reading Chinese: A development study. *Language and Cognitive Processes, 14*(5–6), 503–524. https://doi.org/10.1080/016909699386176

Zhou, L., Fong, M. C. M., Minett, J. W., Peng, G., & Wang, W. S. Y. (2014). Pre-lexical phonological processing in reading Chinese characters: An ERP study. *Journal of Neurolinguistics*, *30*(1), 14–26. https://doi.org/10.1016/j.jneuroling.2014.03.002

Zhou, X., & Marslen-Wilson, W. (1999). The nature of sublexical processing in reading Chinese characters. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *25*(4), 819–837. https://doi.org/10.1037/0278-7393.25.4.819

Zhu, Y.P. (1987). Analysis of cuing functions of the phonetic in modern China. Unpublished manuscript, East China Normal University. (In Chinese).

Table 1. *Mean word frequency, neighbourhood size, length, orthographic overlap and relatedness for the stimuli in the Experiment.*

Targets	**Semantic suffixed**		**Pseudo-suffixed**		**Orthographic-suffixed**	
log word frequency	1.93	(0.40)	1.75	(0.94)	1.81	(0.88)
orthographic neighbourhood size	7.73	(4.25)	8.00	(5.22)	9.68	(5.32)
phonological neighbourhood size	18.00	(7.58)	17.00	(8.33)	18.45	(7.49)
length, in letters	3.88	(0.79)	4.00	(0.73)	3.63	(0.59)
length, in phonemes	3.25	(0.74)	3.00	(0.73)	3.03	(0.70)
Primes						
log word frequency	1.37	(0.57)	1.27	(0.78)	1.28	(0.69)
length, in letters	6.15	(0.86)	5.80	(0.99)	5.58	(0.87)
length, in phonemes	5.08	(0.89)	4.86	(0.98)	4.40	(0.93)
orthographic prime-target overlap	1.59	(1.09)	1.45	(1.35)	1.54	(1.49)
semantic prime-target relatedness	0.57	(0.18)	0.15	(0.12)	0.13	(0.11)

Table 2. *Performance summary for Sample A (English & Chinese) and Sample B (non-Chinese) matched pairs.*

Age of testing		**PPVT-raw score**		**TOWRE-standard score**		**Morphological processing**		**Matrix reasoning**	
A	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**
10	11.06	63	60	126	110	11	13	19	19
9.04	7.09	44	48	78	97	3	6	9	8
6.07	7.02	35	36	142	114	10	5	14	9
9.04	11.03	58	57	124	119	15	13	14	8
11.07	11.06	67	70	132	130	15	15	21	12
10.07	11	64	61	126	118	12	13	16	16
8.08	11.01	58	54	102	92	4	8	9	19
10.05	11.02	64	65	91	122	13	13	23	20
14.06	11.11	69	65	108	128	15	16	25	23
8.05	10.02	61	60	93	80	8	13	20	7
12.11	12	62	62	86	104	12	9	22	18
M9.79	**10.31**	**58.6**	**58**	**109.8**	**110.4**	**10.73**	**11.27**	**17.5**	**14.5**
SD(2.15)	**(1.67)**	**(10.2)**	**(9.36)**	**(21.3)**	**(15.7)**	**(4.20)**	**(3.66)**	**(5.47)**	**(5.79)**

Notes:
Uinit for Age of testing: years
Maximum scores for PPVT (76), Morphological processing (16) and Matrix reasoning(30)

Table 3. *Chinese task Performance summary for Sample A (English & Chinese)*

	Character Naming	PPVT(Chinese)	*Level
1	31	40	Medium
2	1	1	Beginner
3	10	3	Beginner
4	11	25	Medium
5	32	56	Medium
6	19	5	Beginner
7	6	11	Beginner
8	8	39	Beginner
9	32	36	Medium
10	10	6	Beginner
11	13	24	Medium

**Beginner-Character Naming <=10 or PPVT(Chinese)<=20; Medium- Character Naming >10 and PPVT (Chinese)>20*

Maximum score for Character naming (40) and PPVT(Chinese)(76)

Table 4. *Mean Reaction Times and Error Rates for all participants.*

Condition	***Reaction times***	***Error rates***	***Example***
Semantic suffixed			
Related	805(364)	12.7%	farmer-FARM
Unrelated	881(428)	16.4%	louder-BUY
Priming Effect	76		
Transformed-Related	859(432)	11.4%	winenr-WIN
Transformed-Unrelated	938(493)	12.7%	darekr-CREAM
Priming Effect	79		
Pseudosuffixed			
Related	959(520)	16.8%	stocking-STOCK
Unrelated	900(393)	19.1%	force-OFF
Priming Effect	-59		
Transformed-Related	938(501)	17.7%	lisetn-LIST
Transformed-Unrelated	918(496)	17.7%	faulyt-CORN
Priming Effect	-20		
Orthographic suffixed			
Related	867(435)	15.9%	freeze-FREE
Unrelated	888(484)	15.5%	arts-BEE
Priming Effect	21		
Transformed-Related	917(483)	14.5%	stavre-STAR
Transformed-Unrelated	907(450)	17.3%	oledst-FAR
Priming Effect	-10		

Table 5. *Mean Reaction Times and Error Rates for participants in English-Chinese group (Sample A) and non-Chinese group (Sample B).*

Condition	***Reaction times***		***Error rates***		***Example***
	A	***B***	***A***	***B***	
Semantic suffixed					
Related	781(355)	825(369)	7.30%	15.50%	farmer-FARM
Unrelated	878(417)	876(435)	6.40%	23.60%	louder-BUY
Priming Effect	97	51			
Transformed-Related	852(425)	867(441)	3.60%	18.10%	winenr-WIN
Transformed-Unrelated	872(432)	1008(542)	0.90%	20.00%	darekr-CREAM
Priming Effect	20	141			
Pseudosuffixed					
Related	999(569)	904(441)	10.00%	20.00%	stocking-STOCK
Unrelated	914(400)	886(381)	11.80%	25.40%	force-OFF
Priming Effect	-85	-60			
Transformed-Related	974(474)	933(552)	13.60%	20.90%	lisetn-LIST
Transformed-Unrelated	857(397)	984(399)	14.50%	19.10%	faulyt-CORN
Priming Effect	-117	51			
Orthographic suffixed					
Related	891(486)	826(365)	10.90%	18.10%	freeze-FREE
Unrelated	902(489)	865(472)	10.90%	17.30%	arts-BEE
Priming Effect	11	37			
Transformed-Related	927(499)	897(458)	9.10%	16.40%	stavre-STAR
Transformed-Unrelated	864(392)	951(504)	6.40%	25.50%	oledst-FAR
Priming Effect	-63	54			

Table 6. *t-values, p-values and effect sizes for the overall model-participants in English-Chinese group (Sample A) and non-Chinese group (Sample B).*

	Estimate	**SE**	**df**	t-**value**	**p-value**	***Eta²***
(Intercept)	-1.322e+00	9.788e-02	2.210e+01	-13.512	3.69e-12 ***	2.87E+00
Primetype[u]	3.950e-02	3.216e-02	2.145e+03	1.228	0.21957	
Suffixtype[p]	8.140e-02	2.585e-02	2.523e+02	3.149	0.00184 **	3.78E-02
Suffixtype[s]	-5.363e-02	2.551e-02	2.439e+02	-2.102	0.03654 *	1.78E-02
Transtype[t]	3.412e-02	2.537e-02	2.099e+03	1.345	0.17884	
Language[e]	-9.005e-03	1.370e-01	2.120e+01	-0.066	0.94821	
Primetype[u]:suffixtype[p]	-6.251e-02	3.405e-02	1.390e+03	-1.836	0.06661	
Primetype[u]:suffixtype[s]	3.214e-02	3.352e-02	1.496e+03	0.959	0.33777	
Primetype[u]:transtype[t]	-5.476e-02	3.583e-02	2.099e+03	1.529	0.12653	
Primetype[u]:language[e]	-3.966e-02	3.890e-02	1.576e+03	-1.019	0.30820	
Transtype[t]:language[e]	-2.477e-02	3.876e-02	1.426e+03	-0.639	0.52280	
Primetype[u]:transtype-e[t]:language[e]	1.206e-01	5.515e-02	1.438e+03	2.186	0.02898 *	3.31E-03

Linear mixed model fit by REML (Package used:lme4)
t-tests use Satterthwaite approximations to degrees of freedom (Package used: lmerTest). Basis for comparisions: related prime, orthographic prime, non-transposed letter conditions; u = unrelated prime, p = pseudo prime, s = semantic prime, t = transposed letter, and e= non-Chinese group
$Eta^2 = t^2/(t^2 + df)$

Table 7. *t-values, p-values and effect sizes for the English-Chinese model-participants in English-Chinese group (Sample A)*

	Estimate	**SE**	**df**	**t-value**	**p-value**	***Eta²***
(Intercept)	-1.295e+00	9.669e-02	1.140e+01	-13.389	2.62e-08 ***	9.40E-01
Primetype[u]	-8.741e-03	3.072e-02	1.089e+03	-0.285	0.7761	
Suffixtype[p]	9.068e-02	3.663e-02	2.635e+02	2.475	0.0139 *	2.27E-02
Suffixtype[s]	-8.978e-02	3.614e-02	2.529e+02	-2.484	0.0136 *	2.38E-01
Primetype[u]:suffixtype[p]	-4.697e-02	4.391e-02	1.097e+03	-1.070	0.2849	
Primetype[u]:suffixtype[s]	8.024e-02	4.288e-02	1.087e+03	1.871	0.0616	

Linear mixed model fit by REML (Package used:lme4)
t-tests use Satterthwaite approximations to degrees of freedom (Package used: lmerTest). Basis for comparisions: related prime, orthographic prime, non-transposed letter conditions; u = unrelated prime, p = pseudo prime, s = semantic prime, t = transposed letter, and e= non-Chinese group
$Eta^2 = t^2/(t^2 + df)$

Table 8. *t-values, p-values and effect sizes for the non-Chinese model-participants in non-Chinese group (Sample B).*

	Estimate	**SE**	**df**	**t-value**	**p-value**	***Eta***^{2}
(Intercept)	-1.35200	0.10035	10.90000	-13.473	3.69e-12 ***	9.43E-01
Suffixtype[p]	-0.01715	0.03328	1007.00000	-0.515	0.00706 **	2.63E-04
Suffixtype[s]	0.09067	0.03359	1007.00000	2.699	0.60646	
Transtype[t]	0.08531	0.03345	1007.00000	2.550	0.01092*	6.42E-03
Suffixtype[s]:transtype[t]	-0.01628	0.04730	1007.00000	-0.344	0.73073	
Suffixtype[p]:transtype[t]	-0.11584	0.04748	1007.00000	-2.440	0.01488*	5.88E-03

Linear mixed model fit by REML (Package used:lme4)
t-tests use Satterthwaite approximations to degrees of freedom (Package used: lmerTest). Basis for comparisions: related prime, orthographic prime, non-transposed letter conditions; u = unrelated prime, p = pseudo prime, s = semantic prime, t = transposed letter, and e= non-Chinese group
Eta2 = t2/(t2 + df)

Appendix A

English lexical decision task

Prime-unrelated	Prime-related	Prime-unrelated, transposed	Prime-related, transposed	Target
smelly	walked	smelyl	walekd	WALK
lovely	filled	lovley	fileld	FILL
frosty	golden	frosyt	goledn	GOLD
posted	crying	posetd	criyng	CRY
liked	badly	likde	baldy	BAD
weaker	drying	weaekr	driyng	DRY
boards	opened	boarsd	opeend	OPEN
mower	shyly	moewr	shlyy	SHY
softer	flying	sofetr	fliyng	FLY
tighter	playing	tighetr	plaiyng	PLAY
doing	mixer	diong	miexr	MIX
louder	buying	louedr	buiyng	BUY
boiler	fixing	boielr	boielr	FIX
robbery	teacher	robbeyr	teacehr	TEACH
nearer	acting	neaerr	acitng	ACT
waved	moody	wavde	mooyd	MOOD
fuller	mainly	fulelr	mailny	MAIN
stormy	farmer	storym	faremr	FARM
named	lucky	namde	lucyk	LUCK
messy	boxer	mesys	boexr	BOX
filthy	harder	filtyh	haredr	HARD
soften	trying	sofetn	triyng	TRY
locker	eating	locekr	eaitng	EAT
milky	layer	milyk	laeyr	LAY
darker	creamy	darekr	creaym	CREAM
leader	slowly	leaedr	slolwy	SLOW

banker	deeply	banekr	deelpy	DEEP
rainy	aimed	raiyn	aiemd	AIM
loved	sadly	lovde	saldy	SAD
stars	dirty	stasr	diryt	DIRT
grassy	weaken	grasys	weaekn	WEAK
bumpy	owner	bumyp	boexr	OWN
postal	banker	posatl	owenr	BANK
greedy	singer	greeyd	faremr	SING
sleepy	killer	sleeyp	banekr	KILL
nearly	hunter	nealry	sinegr	HUNT
widely	reader	widley	deaelr	READ
fruity	teller	fruiyt	hunetr	TELL
lately	winner	latley	winenr	WIN
oddity	tester	odidty	tesetr	TEST
fluffy	pollen	flufyf	poleln	POLL
petal	siren	peatl	siern	SIR
acidic	bother	adiidc	botehr	BOTH
zealous	brother	zeaolus	brotehr	BROTH
bushy	cater	busyh	caetr	CAT
faulty	corner	faulyt	corenr	CORN
gawky	cower	gawyk	coewr	COW
earthy	flower	eartyh	floewr	FLOW
sticky	mister	sticyk	misetr	MIST
pricey	mother	pricye	motehr	MOTH
syrupy	ponder	syruyp	ponedr	POND
bossy	proper	bosys	proepr	PROP
smelly	shower	smelyl	shoewr	SHOW
messy	taper	mesys	taepr	TAP
milky	tower	milyk	toewr	TOW
stormy	wander	storym	wanedr	WAND
eater	slimy	eaetr	sliym	SLIM

likely	easter	likley	easetr	EAST
eggs	lady	egsg	layd	LAD
fighting	shoulder	fighitng	shouledr	SHOULD
older	scary	oledr	scayr	SCAR
prayer	forest	praeyr	foerst	FOR
bricks	poster	bricsk	posetr	POST
tower	party	toewr	paryt	PART
sleepy	listen	sleeyp	lisetn	LIST
used	many	usde	mayn	MAN
sandy	metal	sanyd	meatl	MET
cats	army	cast	arym	ARM
eaten	belly	eaetn	belyl	BELL
nearly	fasten	nealry	fasetn	FAST
beans	fairy	beasn	faiyr	FAIR
others	united	othesr	unietd	UNIT
clearly	million	clealry	mililon	MILL
lower	every	loewr	eveyr	EVER
editor	planet	ediotr	plaent	PLAN
cheaper	factory	cheaepr	facotry	FACT
wooden	sandal	wooedn	sanadl	SAND
filling	country	fililng	counrty	COUNT
warmer	hungry	waremr	hunrgy	HUNG
caller	finish	calelr	fiinsh	FIN
prayer	button	praeyr	butotn	BUTT
speaker	address	speaekr	adrdess	ADD
tender	freeze	tenedr	frezee	FREE
curled	single	cureld	sinlge	SING
tidying	against	tidiyng	agaisnt	AGAIN
early	think	earyl	thikn	THIN
salty	tease	salyt	teaes	TEA
fruity	window	fruiyt	winodw	WIND

ants	howl	anst	holw	HOW
sooner	carrot	sooenr	carrot	CAR
maps	beer	masp	bere	BEE
lighter	twinkle	lighetr	twiknle	TWIN
curly	sight	curyl	sigth	SIGH
risky	hotel	risyk	hoetl	HOT
oldest	farmer	oledst	faremr	FAR
player	carton	plaeyr	carotn	CART
cars	area	casr	arae	ARE
jelly	china	jelyl	chian	CHIN
bumpy	tooth	bumyp	totoh	TOO
snowy	begin	snoyw	beign	BEG
dusty	skirt	dusyt	skrit	SKI
magical	spinach	magiacl	spianch	SPIN
bags	menu	basg	meun	MEN
going	crown	giong	cronw	CROW
slower	turnip	sloewr	turinp	TURN
hunter	yellow	hunetr	yelolw	YELL
camped	starve	camepd	stavre	STAR
pipes	disco	pipse	disoc	DISC
gloomy	wonder	glooym	wodner	WON
rocky	pasta	rocyk	pasat	PAST
poetry	dragon	poerty	draogn	DRAG
lesser	pillow	lesesr	pilolw	PILL
bossy	camel	bosys	camle	CAME
richer	lesson	ricehr	lesosn	LESS
seeing	cashew	seieng	casehw	CASH
within	market	witihn	marekt	MARK
ninety	scrape	nintey	scraep	SCRAP
arming	fleece	arimng	flecee	FLEE
misty	stunt	misyt	stutn	STUN

asking	galaxy	asikng	galxay	GALA
smelly	walked	smelyl	walekd	CRA
lovely	filled	lovley	fileld	DAL
frosty	golden	frosyt	goledn	LOV
posted	crying	posetd	criyng	VAR
liked	badly	likde	baldy	OGG
weaker	drying	weaekr	driyng	COV
boards	opened	boarsd	opeend	RID
mower	shyly	moewr	shlyy	VAB
softer	flying	sofetr	fliyng	DAR
tighter	playing	tighetr	plaiyng	EEF
doing	mixer	diong	miexr	ELD
louder	buying	louedr	buiyng	WEF
boiler	fixing	boielr	boielr	ORM
robbery	teacher	robbeyr	teacehr	ZEZ
nearer	acting	neaerr	acitng	FOM
waved	moody	wavde	mooyd	ZIL
fuller	mainly	fulelr	mailny	GED
stormy	farmer	storym	faremr	ZOP
named	lucky	namde	lucyk	RER
messy	boxer	mesys	boexr	GUK
filthy	harder	filtyh	haredr	NAV
soften	trying	sofetn	triyng	VOS
locker	eating	locekr	eaitng	ZOK
milky	layer	milyk	laeyr	YOL
darker	creamy	darekr	creaym	YIT
leader	slowly	leaedr	slolwy	YOW
banker	deeply	banekr	deelpy	JUN
rainy	aimed	raiyn	aiemd	KUN
loved	sadly	lovde	saldy	ALT
stars	dirty	stasr	diryt	ABE

grassy	weaken	grasys	weaekn	MON
bumpy	owner	bumyp	boexr	OWD
postal	banker	posatl	owenr	ZAL
greedy	singer	greeyd	faremr	SOV
sleepy	killer	sleeyp	banekr	HOZ
nearly	hunter	nealry	sinegr	YAD
widely	reader	widley	deaelr	UXT
fruity	teller	fruiyt	hunetr	WOL
lately	winner	latley	winenr	GAV
oddity	tester	odidty	tesetr	ELV
fluffy	pollen	flufyf	poleln	PYB
petal	siren	peatl	siern	NORT
acidic	bother	adiidc	botehr	NUMP
zealous	brother	zeaolus	brotehr	PIRD
bushy	cater	busyh	caetr	GLON
faulty	corner	faulyt	corenr	PULE
gawky	cower	gawyk	coewr	LEUL
earthy	flower	eartyh	floewr	RESK
sticky	mister	sticyk	misetr	RIBE
pricey	mother	pricye	motehr	RINT
syrupy	ponder	syruyp	ponedr	DAID
bossy	proper	bosys	proepr	SANT
smelly	shower	smelyl	shoewr	SELK
messy	taper	mesys	taepr	QUEK
milky	tower	milyk	toewr	TASE
stormy	wander	storym	wanedr	TASH
eater	slimy	eaetr	sliym	TIND
likely	easter	likley	easetr	TUFE
eggs	lady	egsg	layd	QUEK
fighting	shoulder	fighitng	shouledr	BLOM
older	scary	oledr	scayr	WARR

prayer	forest	praeyr	foerst	PEIM
bricks	poster	bricsk	posetr	CIBE
tower	party	toewr	paryt	SARC
sleepy	listen	sleeyp	lisetn	NOLC
used	many	usde	mayn	FLUN
sandy	metal	sanyd	meatl	MOME
cats	army	cast	arym	ZEAN
eaten	belly	eaetn	belyl	ZEET
nearly	fasten	nealry	fasetn	SHYC
beans	fairy	beasn	faiyr	SUSK
others	united	othesr	unietd	ZODD
clearly	million	clealry	mililon	CALN
lower	every	loewr	eveyr	GIGN
editor	planet	ediotr	plaent	YASC
cheaper	factory	cheaepr	facotry	TEWK
wooden	sandal	wooedn	sanadl	MEMK
filling	country	fililng	counrty	PEWN
warmer	hungry	waremr	hunrgy	VISC
caller	finish	calelr	fiinsh	LOLK
prayer	button	praeyr	butotn	SHEA
speaker	address	speaekr	adrdess	ROMF
tender	freeze	tenedr	frezee	WEIM
curled	single	cureld	sinlge	HESC
tidying	against	tidiyng	agaisnt	LERG
early	think	earyl	thikn	TADE
salty	tease	salyt	teaes	YODE
fruity	window	fruiyt	winodw	ONTS
ants	howl	anst	holw	ARLD
sooner	carrot	sooenr	carrot	FAVE
maps	beer	masp	bere	METH
lighter	twinkle	lighetr	twiknle	CUZZ

curly	sight	curyl	sigth	GIPH
risky	hotel	risyk	hoetl	JOLM
oldest	farmer	oledst	faremr	OGED
player	carton	plaeyr	carotn	GWAT
cars	area	casr	arae	KNOV
jelly	china	jelyl	chian	METS
bumpy	tooth	bumyp	totoh	WADD
snowy	begin	snoyw	beign	PEAB
dusty	skirt	dusyt	skrit	ISPS
magical	spinach	magiacl	spianch	SUNE
bags	menu	basg	meun	MAGE
going	crown	giong	cronw	WOIN
slower	turnip	sloewr	turinp	LOOD
hunter	yellow	hunetr	yelolw	VUID
camped	starve	camepd	stavre	HETH
pipes	DISCO	pipse	disoc	SEWF
gloomy	wonder	glooym	wodner	WROS
rocky	pasta	rocyk	pasat	HYFT
poetry	dragon	poerty	draogn	CUNK
lesser	pillow	lesesr	pilolw	TULM
bossy	camel	bosys	camle	NOID
richer	lesson	ricehr	lesosn	GLUFE
seeing	cashew	seieng	casehw	SLEEF
within	market	witihn	marekt	JOWNS
ninety	scrape	nintey	scraep	SEEND
arming	fleece	arimng	flecee	PLORN
misty	stunt	misyt	stutn	QUARD
asking	galaxy	asikng	galxay	SPLINX

Appendix B

Chinese character naming test items

Simplified version with English translation:

一 one

不 no

了 has/have done

在 at

人 person

有 own

我 I

他 he

这 this

个 count word/not exist in English

们 they

中 middle

来 come

上 up

大 big

为 for

国 country

地 land

以 to

说 say

时 time

要 want

可 can

也 too

你 you

生 live

自 from

里 in

学 learn

好 good

小 small

想 miss

第 rank order indication

机 machine

将 will

很 very

战 war

等 wait

相 looks

特 special

Traditional version (The meanings of traditional Chinese characters are identical to simplified ones listed above):

一

不

了

在

人

有

我

他

這

個

們

中

來

上

大

為

國

地

以

說

時

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Appendix C

Morphological Processing:

Description: a measure of knowledge of word forms and meanings in spoken language

Materials: Answer sheet, 16 picture cards on Powerpoint slides

"In this game I'm going to describe a made-up word, and I want you to tell me what that word might be. I'll give you some choices, and you choose the one that sounds right. Let's try some for practice."

Present the practice words (and the picture cards) to the child while saying:

"If I say:
Early in the morning, we see the sun rising. This is called a sunrise. At night, we might also see the moon rising. What could we call this: Moonrise or Rise-moon?

You choose moonrise because moonrise sounds right. Now you try. At night, we might also see the moon rising. What could we call this: Rise-moon, or Moonrise?

If correct say, ***"That's right, moonrise sounds more like a real word."***

If incorrect say, ***"That's not quite right. Moonrise sounds more like a real word."*** Repeat the item, and give feedback again if required.

Continue with the next practice item:

"If I say:
When volcanic ash drops from the sky, it is called ash fall. If cats dropped from the sky, what could we call it? Fall-cat, or Cat-fall?

Continue to give correct/incorrect feedback with this practice item.

After completing the practice items, move on to the 16 test items. **Do not give feedback for any of the test items.** Show the picture card, and CIRCLE the response on the Morphological Test score sheet and move on to the next item. Correct answers are underlined on the answer sheet. Continue until all 16 test items have been presented or until the child makes **3 consecutive errors**.

Participant Number ________________

(circle the child's response; discontinue after 3 consecutive errors)

	Question	Score
1	What would be the best name for a tray used to store mail? traymail or mailtray?	
2	If we were very lucky, we might need bags to carry money. What would be the best name for these bags? money bags or bags money.	
3	Which is a better name for a bee that lives in the grass? grass bee or bee grass?	
4	Some people wear laces on their shirt, what should we call that? shirtlace or laceshirt.	
5	There is a kind of train that runs over the ground. What would be the best name for that? train over ground, over train ground, over ground train, or ground train over.	
6	There is a drawer in my dresser where we keep books and I have a key that locks it. What would be the best name for the key? book drawer key, or drawer book key, book key drawer, key book drawer.	
7	We have a box that contains pencils and there is a lid for the box. What would be the best name for the lid? box pencil lid, pencil lid box, pencil box lid, or lid pencil box.	
8	There is a shop selling hats for a birthday. What would be the best name for the shop? shop hat birthday, hat birthday shop, birthday hat shop, or shop birthday hat.	
9	Cows produce milk. What would be the best name for a farm that keeps these cows? cow farm milk, farm milk cow, milk farm cow, or milk cow farm.	
10	Every morning, Tom makes coffee with a small bag of coffee powder. What would be the best name for this bag? morning coffee bag, coffee morning bag, bag morning coffee, or bag coffee morning.	

11	Mary has a shelf full of glasses and she uses these glasses to hold juice. What would be the best name for this shelf? shelf glass juice, juice glass shelf, glass juice shelf, or shelf juice glass.	
12	There are some ties that are used to fasten hair. If we use these ties to make a knot, what would be the best name for it? knot tie hair, tie hair knot, tie knot hair, or hair tie knot.	
13	Sam takes many photos of his dog. Sam uses these photos to make a poster. What would be the best name for the poster? dog poster photo, poster photo dog, photo dog poster, or dog photo poster.	
14	Tim made up a new game where he throws a ball into a bucket. What would be the best name for the court he played this new game? ball court bucket, court bucket ball, bucket ball court, or court ball bucket.	
15	If you found a cover for a dish to keep candy in, what would it be called? dish cover candy, candy dish cover, dish candy cover, or cover candy dish?	
16	There is a bird that lives in a tree. The bird eats bugs What would be the best name for the tree? bird bug tree, bug bird tree, tree bird bug, or bug tree bird?	

Appendix D

Child Assent Script

The same script for children's assent used in the behavioural phase at the school will be used in the ERP lab phase, as follows:

"We will be playing some reading games together. Some of these games will be on the computer, and some will be on paper. Are you ok with us doing these together?"

<PAUSE – WAIT FOR A YES OR NO ANSWER>

"If you don't feel you'd like to do a game, or at any time would like to stop, please say 'I want to stop.' We can go on to another game, or stop altogether. Are you ready to start?"

<PAUSE – WAIT FOR A YES OR NO ANSWER >

If the child says 'I want to stop,' or provides other indication of not wishing to continue with a task, the researcher will end the task in a positive way, saying: "That's fine. Would you like to go on to another game, or stop altogether for today?"

<PAUSE – WAIT FOR ANSWER >

If the child indicates interest in beginning the next task, the researcher will begin the next task. If the child indicates wishing to stop the session altogether, the child will be asked "Would you like to continue another day?"

<PAUSE – WAIT FOR A YES OR NO ANSWER >

If the child indicates "yes," then the child will be asked again to participate for the remaining tasks, the next available day. If "no," then no further participation will be sought, and the child will be provided with a short debriefing explanation of the purpose of the study. In the school phase, the child will be given debriefing and compensation, and will be escorted back to the classroom by the researcher. In the lab phase the exit protocol will be followed, with debriefing and compensation for participation provided.

Appendix E: Teacher Consent Form and Parental Consent Form

UNIVERSITY OF MANITOBA | Department of Psychology

190 Dysart Road
Winnipeg, Manitoba
Canada R3T 2N2
Telephone: 204. 474. 9338

English-Chinese bilingual Reading Study

Teacher Consent Form

Jie Zhou, Dept. of Psychology

University of Manitoba

Name: ___________________________________

Grade: ___________________________________

School: __________________________________

CHECK HERE

____ I give permission for children in my class to participate in the University of Manitoba, Psychology Department study conducted by Jie Zhou.

____ I do NOT give permission for children in my class to participate in the University of Manitoba, Psychology Department study conducted by Jie Zhou.

With the wide range of approaches teachers use to teach reading skills, it is important to us to have information about the general approach that you use in your classroom. In the lines below, please describe the general approach to teach reading that you are using this year with the class from which the participating children are being selected:

____

Signature of teacher: _______________________ Date: ________________

Researcher's Signature: _____________________ Date: ________________

If interested in receiving a copy of a report of the final results by mail, please write your mail or email address below:

____

____

____

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190 Dysart Road
Winnipeg, Manitoba
Canada R3T 2N2
Telephone: 204. 474. 9338

English-Chinese bilingual Reading Study
Parent/Guardian Consent Form
Jie Zhou, Dept. of Psychology
University of Manitoba

Name of Child: ______________________________________

Child's Date of Birth (day/month/year): _________________

CHECK HERE

____ I give permission for my child to participate in the study conducted by Jie Zhou.
____ I do NOT give permission for my child to participate in the study conducted by Jie Zhou.
If you are giving permission, please provide us with additional information:

Language(s) spoken at home: _______________________________

Home postal Code: _______________________________

Does your child require corrective lenses (eye glasses) for reading? Yes__ No __

Highest level of education: ____ some high school
____ high school diploma
____ some post-secondary
____ post-secondary diploma/degree

Signature of Parent/Guardian: _______________________ Date: _________________

Researcher's Signature ____________________________ Date _________________

If interested in receiving a copy of a report of the final results by mail, please write your mailing (or email) address below:

____