Importance of Phonological and Orthographic Processing Skills for English Literacy Abilities in English Monolingual, Chinese-English Bilingual, and English Monolingual Learners with Dyslexia

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Abstract

Phonological and orthographic processing skills are important underlying skills for English word reading and spelling in English monolingual individuals. Yet, there is still much to learn about these skills in other specific populations, such as individuals learning English with another language and individuals who have difficulty acquiring English literacy skills. This thesis addresses this issue by examining phonological and orthographic processing skills in Chinese-English bilingual children and adults, English monolingual children and adults, and English monolingual children with dyslexia. More specifically, we investigate the importance of these skills for English word reading and spelling across these different language groups.

Phonological and orthographic processing skills were assessed and their importance for English word reading and spelling was examined in younger (8-9 years) children, older (11-12 years) children and adults (19-20 years) from different language backgrounds: English monolingual, English first language (L1)-Chinese second language (L2) and Chinese L1-English L2. Results showed that proficiency in English phonological and orthographic processing skills was dependent on age and language background status. Both English monolingual and English-L1 children had better phonological processing skills compared to the Chinese-L1 children, and the English monolingual adults had better phonological processing skills than the bilingual adults. In contrast, the younger bilingual children had better orthographic processing skills compared to the English monolingual children, but there were no group differences in the older children and adults. Furthermore, different skills contributed to English word reading and spelling for each language background group and within each age group. Orthographic processing was the only significant predictor of word reading and spelling for the English monolingual children and adults. However, phonological processing skills were important for word reading for the bilingual children and adults. For spelling,
phonological skills were a significant predictor for the younger bilingual children and orthographic skills were important for the older bilingual children, but neither skill contributed significantly for the bilingual adults. The finding that different skills are important for the different language groups suggests an influence of learning a second language on English literacy acquisition.

The proposal that children with dyslexia have a differential pattern of phonological and orthographic skills, with poorer phonological skills relative to their orthographic skills (e.g., Stanovich & Siegel, 1994), similar to that of Chinese-English bilingual children was then explored. The phonological and orthographic skills of English monolingual children with dyslexia were compared to those of chronological age matched and reading-age-matched English monolingual, Chinese L1-English L2, and English L1-Chinese L2 children, and the relationships between phonological and orthographic skills and English word reading and spelling in the dyslexic children were investigated. Results showed that the children with dyslexia were as proficient as the reading-age-matched English monolinguals in terms of their phonological and orthographic skills and hence, were not similar in profile to the Chinese-English bilingual children. In addition, similar to the English monolinguals, only orthographic skills contributed significantly to word reading and spelling for the children with dyslexia.

Phonological and orthographic skills are important for Chinese-English bilingual, dyslexic and typically developing English monolingual individuals for English word reading and spelling. However, group differences in skill proficiencies, as well as differences in the extent to which phonological and orthographic skills are relied upon, imply that different populations approach English literacy tasks in different ways. An important implication of these findings is that these differences need to be taken into account before applying models of literacy development to populations other than
English monolinguals. Further theoretical and practical implications of these findings are discussed.
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An earlier version of this paper has been published. This article may not exactly replicate the final version published in the APA journal. It is not the copy of record.


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Statement of Contribution

Each of the studies in this thesis was designed by the candidate in collaboration with one of her supervisors, Professor Janet Fletcher. All participant recruitment and testing, data entry, analysis and interpretation were conducted by the candidate. The manuscripts were written by the candidate, with revisions made in accordance with her supervisors, Professor Janet Fletcher and Dr Donna Bayliss, and anonymous reviewers.

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Preface

Literacy research has focused mainly on individuals with English as their only language. However, with the increasing number of bilingual individuals learning English as a first or second language, and the need to formulate effective interventions for individuals with literacy difficulties, it is crucial to understand how these other groups of individuals learn English. Though there has been a recent growth in the research focusing on these specific populations, there is still much to be learned about how bilingual individuals or individuals with dyslexia approach English word reading and spelling tasks, and whether this differs at different stages of literacy development.

This thesis explores phonological and orthographic processing skills, which are important for English literacy acquisition, in Chinese-English bilinguals, English monolingual individuals with dyslexia, and English monolingual individuals. By examining these skills in bilinguals and monolinguals across age groups, this thesis has shown that learning a second language can influence both skills in different ways, depending on the nature of both the first language (L1) and second language (L2). Furthermore, early L2 exposure can have long-lasting effects on the skills underlying English literacy acquisition as well as how bilinguals approach English literacy tasks, despite bilinguals being able to attain similar levels of English literacy achievement as their monolingual peers. Comparing English monolingual children with dyslexia to the other groups also suggests that children with dyslexia may not have a differential pattern of poorer phonological skills relative to their orthographic skills, and may be more similar to younger typically developing English monolingual children.

Understanding how different populations approach English literacy tasks allows us to fill the gaps in theoretical models of English reading development, suggesting that group differences may need to be considered before applying these models to populations other than English monolinguals.
This thesis is presented as a collection of papers in a format suitable for publication. **Chapter 1** consists of a review of the literature on the acquisition of English literacy for English monolingual individuals, bilingual individuals and English monolingual individuals with dyslexia. This review focuses on the role of phonological and orthographic processing skills for English word reading and spelling, as well as the importance of such skills at various stages of literacy development. **Chapter 2** presents a study investigating the importance of phonological and orthographic skills for English word reading and spelling in adults. These adults were from three different language background groups: English monolingual, English first language (L1)-Chinese second language (L2) bilingual, and Chinese L1-English L2 bilingual. **Chapter 3** further explores the relationships between such skills and English word reading and spelling with a cross-sectional study of phonological and orthographic skills in younger (8-9 years) and older (11-12 years) children from the same three language background groups as the adult study reported in Chapter 2. **Chapter 4** compares phonological and orthographic skills in English monolingual children with dyslexia with reading age matched and chronological age matched bilingual and English monolingual children. An examination of the relationships among phonological and orthographic skills and English word reading and spelling in English monolingual children with dyslexia is also conducted. Finally, **Chapter 5** provides a summary of the findings from the presented studies as well as the theoretical and practical implications of these findings.
Chapter 1

Introduction: An overview of English literacy acquisition in English monolingual individuals, bilingual individuals and English monolingual individuals with dyslexia
As more and more children around the world learn another language, which is often different from the language spoken at home, there is a growing practical necessity for more research on how individuals learn a second language and become competent in reading and writing it. Indeed, learning English as a Second Language (ESL) is more common than we might expect. In the United States, there was a 64% growth in the number of ESL learners from 1994 to 2009 (National Clearinghouse for English Language Acquisition, 2011). Also, the number of ESL learners in the world is estimated to outnumber the number of English monolingual learners (Crystal, 2012). Hence, it is increasingly important to understand how ESL bilinguals approach English literacy tasks and how they develop English word reading and spelling skills.

Moreover, the issues encountered by ESL bilinguals in learning to read and write in English may be similar to those who are struggling to read and write in English despite having English as their only language. About 10% of the population is considered to have literacy difficulties, also known as dyslexia (Shaywitz, Shaywitz, Fletcher & Escobar, 1990; Siegel, 2006). Although there has been much research on the conceptualisation of dyslexia, many aspects remain unexplored, particularly with regards to the skills individuals with dyslexia use to approach English reading and spelling. Furthering our knowledge of how specific populations, such as ESL bilinguals and individuals with dyslexia, acquire English literacy skills will not only have pedagogical implications for these groups but may add to what we already know about the development of English literacy skills in general.

To address these issues, this thesis examines the underlying component skills thought to be crucial for the learning of English word reading and spelling in Chinese-English bilinguals and English monolinguals with dyslexia. Specifically, this thesis examines phonological processing and orthographic processing skills in the above two groups: their proficiency in such skills as well as the relationships between these skills.
and English word reading and spelling. As Chinese and English differ markedly in their linguistic structures, making comparisons between bilingual individuals with Chinese as their first language (L1) and English as their second language (L2), bilingual individuals with English as L1 and Chinese as L2, and English monolinguals, offers insight into the impact of the L1 on underlying component skills and how the L2 is processed by individuals from differing language backgrounds. In addition, this thesis provides a cross-sectional perspective by examining these skills across different ages within each language group. This will contribute new knowledge with regards to the competency in such skills at different stages of literacy development and if the importance of phonological and orthographic skills for English word reading and spelling changes with increasing proficiency and exposure to the English language. This will help to answer the question of whether bilingual individuals follow a similar developmental sequence to acquiring English as their English monolingual peers. Furthermore, an examination of the bilingual learner’s profile also allows an investigation of how bilingual ESL learners compare with English monolinguals with dyslexia. Any differences between the English monolinguals with dyslexia and bilinguals with respect to their proficiency in underlying component skills and their approach to the learning of English may facilitate the formulation of alternative approaches in assisting English monolinguals with dyslexia with English literacy.

As literacy research has focused mainly on English monolingual learners, this body of work will be reviewed, focusing on the roles of phonological and orthographic processing skills over the course of the individual’s literacy development. Following this will be a review of the current research examining the influence of the L1 on the L2 in bilinguals. More specifically, the linguistic properties of Chinese and how this may affect Chinese ESL bilinguals learning English will be addressed. Finally, research pertaining to phonological and orthographic processing skills and their contributions to
English reading and spelling in English monolinguals with dyslexia will be covered. At the end of the review, gaps in the current body of research will be identified, which this project aims to address.

**Phonological and Orthographic Processing Skills in English Monolinguals**

Spoken English has 24 consonants and approximately 20 vowels (Crystal, 2006). It has a complex syllable structure, with a high frequency and variety of consonant clusters in word-initial and word-final positions. As English is written alphabetically, to read requires one to know how symbols, or graphemes, relate to sounds, or phonemes (e.g., \( B \) is pronounced as /b/); and to write and spell in English requires the reverse, knowledge of how the units of sounds relate to visual symbols (e.g., /b/ is written as \( B \)). The difficulty with learning to read and write in English is that these letter-sound relationships are highly inconsistent in English: a letter can be pronounced in different ways, and a phoneme can be spelled in various ways (Bosman & Van Orden, 1997; Ziegler & Goswami, 2005).

Exposure to spoken language facilitates awareness of the sound structure of the language and it is apparent that sensitivity to the sounds of a language is important for the successful acquisition of any language. Indeed, there is a consensus that the ability to process the sounds of the language, also known as phonological processing skill, is crucial to learning English (Wagner & Torgesen, 1987). The phonological processing skills that have been linked to reading include phonological awareness, which is the ability to recognise, discriminate, and manipulate sounds in the language (Gillion, 2004), phonological coding in working memory, which is the coding of information in a sound-based representational system for temporary storage (Wagner & Torgesen, 1987), and phonological access to lexical storage, which is the ability to retrieve phonological codes for letters and word segments from long-term memory (Wagner, Torgesen & Rashotte, 1994; see also Anthony & Francis, 2005). Of these, phonological awareness
has been found to be most strongly related to English literacy skills (Bradley & Bryant, 1983; Bryant, MacLean, Bradley & Crossland, 1990). Researchers have measured phonological awareness in various ways. For example, measures of phonological awareness typically include blending sounds together, replacing a sound in a word with another sound, or judging the similarities of sounds in two words (see Yopp, 1988). Though most tasks focus on the phoneme as the sound unit of interest, other tasks have also focused on the syllable, onset and rime. The general pattern of development is that children progress from an understanding of the word-level, to syllable-level, then onset-rime and phoneme-level skills, and can judge whether sounds are the same or different before blending sounds and then segmenting sounds as they grow older (Anthony & Francis, 2005). Despite the different levels of phonological awareness, confirmatory factor analyses by Anthony and Lonigan (2004; see also Anthony et al., 2002) have shown that phonological awareness is a single unified construct involving discrimination and manipulation of both small and large phonological units.

Numerous studies have found phonological processing skills, particularly phonological awareness, to be strongly predictive of learning to read and spell in English (Bryant et al., 1990; Lundberg, Olofsson & Wall, 1980; Wagner et al., 1997; Wagner & Torgesen, 1987). A seminal longitudinal study conducted by Bradley and Bryant (1983) found that children’s ability to categorise sounds before they learned to read was strongly related to their reading and spelling skills four years later. This relationship between phonological awareness and literacy is further supported by studies that have shown that implementing phonological awareness training programs can bring about gains in reading and spelling (Blachman, Tangel, Ball, Black & McGraw, 1999; Foorman, Francis, Shaywitz, Shaywitz & Fletcher, 1997; Hatcher, Hulme & Snowling, 2004). Bradley and Bryant (1983) reported a second study where they trained a group of children on sound categorisation (e.g., *hen* and *hat* share the
same beginning sound) and found that these children surpassed the other children who did not go through the same training program in terms of performance on reading and spelling tests.

However the relationship between phonological skills and reading ability is thought to be bidirectional (Perfetti, Beck, Bell, & Hughes, 1987; Wagner, Torgesen, & Rashotte, 1994; Ziegler & Goswami, 2005). Rayner, Foorman, Perfetti, Pesetsky and Seidenberg (2001) suggest that children only have partial knowledge of phonological structures at the beginning of learning to read and it is only through learning the mappings between the written language and sound that children experience further growth in phonological skills. Hence, children’s proficiency in phonological skills improves over time with reading and writing instruction as they begin to learn about the correspondences between graphemes and phonemes. Scarborough, Ehri, Olson and Fowler (1998) investigated children’s performance on a phonological sensitivity task and phoneme deletion task from Year 2 to Year 12, and showed positive growth increments in performance on each task for both good readers and poor readers. Results from Hulslander, Olson, Willcutt and Wadsworth (2010), showing that 10-year-old children improved significantly on tasks assessing phoneme awareness and phonological decoding across a five year period, also support the notion that children become more proficient in phonological skills with exposure to reading and writing (see also Perfetti et al., 1987).

Exposure to the written language not only enhances phonological processing skills but also allows for the acquisition of orthographic processing skills. Despite a lack of clarity on how orthographic processing skills are defined, there is a growing consensus that orthographic processing skills form a multi-dimensional construct (Hagiliassis, Pratt, & Johnston, 2006). Two components of orthographic processing skills have been proposed: general orthographic knowledge, which is an understanding
of general patterns or properties of the writing system (e.g., letter position frequencies; Vellutino, Scanlon & Tanzman, 1994), and word-specific knowledge, which consists of knowledge of individual word-specific forms (Barker, Torgesen & Wagner, 1992; see also Castles & Nation, 2006; Conrad, Harris, & Williams, 2013).

General orthographic knowledge is often assessed using a word-likeness task, similar to that developed by Siegel, Share and Geva (1995). In this task, participants are presented with two nonword alternatives and are asked to choose the nonword that most looks like a real word (e.g., *filv* vs. *filk*). Since general orthographic knowledge includes awareness of the legality of letter combinations and the statistical frequencies with which these occur, an individual with good general orthographic knowledge would be able to choose the correct alternative (e.g., *filk*). On the other hand, tests of word-specific orthographic knowledge tend to tap an individual’s knowledge of the spellings of specific words. Examples of these tests are the orthographic choice task, which requires an individual to select the correct spelling of a word from pseudohomophones (e.g., *rane* vs. *rain*), the homophone choice task, which requires one to choose the correct word from two homophones (e.g., *eight* vs. *ate*), and the exception word reading task, which involves reading words that cannot be decoded phonetically (e.g., *yacht*, *pint*). There is debate over the use of the above tasks as measures of orthographic processing skills on the grounds that tasks such as the orthographic choice task actually measure skilled word recognition (Castles & Nation, 2006), and that phonological skills may confound performance on the word-likeness tasks (Vellutino et al., 1994). However, Compton, Gilbert and Olson (2011) found that children who were unable to read the word options on the orthographic choice task were still able to select the correct word choice, suggesting that this task taps a skill beyond word reading ability. Furthermore, factor analyses carried out in various studies have shown that orthographic tasks do indeed reflect orthographic processing skills independent of phonological skills.
For example, Hagiliassis et al. (2006) assessed children from Grades 3, 4 and 5 on a range of phonological and orthographic processing tasks, including a word-likeness task and tests of word-specific orthographic knowledge. A factor analysis conducted on the scores from these tasks revealed that all the phonological processing tasks loaded on one factor, while the orthographic processing tasks loaded on another separate factor (see also Cunningham, Perry & Stanovich, 2001; Leong, Tan, Cheng & Hau, 2005).

In addition, the separability of orthographic and phonological skills is further supported by studies that have found orthographic processing skills to make unique contributions to both reading and spelling, over and above phonological processing skills (Barker et al., 1992; Conrad et al., 2013; Cunningham et al., 2001; Cunningham & Stanovich, 1993). For example, Barker et al. (1992) tested Grade 3 children on measures of orthographic processing, phonological processing and five different reading tasks: nonword reading, untimed single word reading, timed single word reading, oral text reading and silent text reading. Scores on the orthographic tasks were entered in hierarchical regression analyses after general intelligence and phonological skills, and were found to contribute significantly to each type of reading. A more recent study by Conrad et al. (2013) assessed Grade 1 to 3 children on tasks of both general orthographic knowledge and word-specific knowledge. They found unique contributions of each orthographic skill to reading and spelling, beyond the contributions of phonological skills.

Due to the inconsistency of grapheme-phoneme correspondences in English (e.g., a letter can be pronounced in multiple ways), children need to acquire strategies that use both small (i.e., phoneme in grapheme-phoneme recoding) and large (i.e., rimes, syllables, and even whole words in a more lexical approach) units to read and spell English words (Treiman, Mullennix, Bijeljac-Badic & Richmond-Welty, 1995; Ziegler & Goswami, 2005). In other words, successful English acquisition requires both
phonological processing skills and orthographic processing skills that deal with small (i.e., phoneme) and large (e.g., whole words) units respectively. Indeed, the dual route cascaded (DRC) model by Coltheart, Rastle, Perry, Langdon and Ziegler (2001) incorporates both a lexical route, which involves mapping a word based on its visual characteristics onto a stored whole word representation, and a phonological route, which requires the conversion of graphemes to phonemes using grapheme-phoneme rules, for word recognition. Thus, according to this model, skilled word reading requires the competent and flexible use of both the lexical route (i.e., the use of orthographic skills) and the phonological route (i.e., the use of phonological skills).

Most researchers agree on how phonological skills develop and are acquired, but the same cannot be said about orthographic skills (e.g., Castles & Nation, 2006). Though the mechanisms by which orthographic processing skills are acquired are unclear, it is generally accepted that repeated exposure to print aids growth in orthographic skills (Barker et al., 1992; Stanovich & West, 1989). With exposure to print, children begin to group letter patterns in words into larger orthographic “chunks” (Adams, 1990). These “chunks” may include spellings of common rimes, morphemes or syllables (e.g., -ight, -ing, -er, etc. are treated as units, Ehri, 2005). Over time, as children retain more sight words and pick out familiar letter patterns in different words, their orthographic processing skills improve. If this is true, it implies that phonological skills may be necessary before the development of orthographic skills. Indeed, traditional models of reading and spelling acquisition have included both phonological and orthographic skills as core skills required in children’s literacy development but have typically proposed orthographic skills to be a later development than phonological skills (Ehri, 1995, 2005; Frith, 1985; Share, 1995).

According to Ehri’s phase model (1995, 2005), there are four developmental phases in learning to read: pre-alphabetic, partial alphabetic, full alphabetic and
consolidated alphabetic (see also Ehri & McCormick, 1998). In the pre-alphabetic phase, children rely on non-alphabetic visual features to recognise words (e.g., *look* has two eyes in the middle and *dog* has a tail at the end, Gough, Juel, & Griffith, 1992) because they have not learnt to form letter-sound connections. Children in this phase lack letter knowledge and the ability to manipulate sounds in the language. This is followed by the partial alphabetic phase, where children have learnt some letter names and sounds and use these to read. Children at this phase still have much difficulty with reading as they do not have full letter-sound knowledge and are not yet able to parse words correctly into their constituent phonemes. The full-alphabetic phase is when children have extensive knowledge about phoneme-grapheme correspondences and are able to make connections between the letters and sounds when they read. Children in this phase tend to be slow readers due to their emphasis on the decoding process. Their sight vocabulary builds slowly with each successful decoding and they become able to use analogies to read unfamiliar words. Finally, the consolidated alphabetic phase refers to when children recognise recurring letter patterns in different words (e.g., rimes, syllables and morphemes such as -ing, -est, etc.) and are able to read using these larger units. Children can decode much faster and more accurately with these larger consolidated units. In this phase, reading unfamiliar words by analogy is also more common as children have retained a large number of sight words. Hence, this model proposes a shift from the use of phonological skills to orthographic skills as children get older and more proficient. Initially, children learn words through a connection-forming process between letters and sounds using their phonological skills, before gradually building up orthographic skills as whole words or parts of words secure connections in memory and become automatised after repeated print exposure.

Similar to Ehri’s (1995) model, Share’s (1995) self-teaching hypothesis also argues for the importance of phonological skills for the acquisition of orthographic
knowledge. According to this theory, repeated phonological recoding of unfamiliar words provides the opportunity for children to extract word-specific orthographic information. Hence, children acquire phonological skills, which are needed for the decoding process (i.e., translation of letters to sounds), before learning orthographic knowledge. It is only with orthographic learning that children can shift to the use of orthographic skills instead of relying solely on phonological skills. Computer simulations by Harm and Seidenberg (2004) also concur with the proposal that there is a shift from a reliance on phonological skills for decoding words to the recognition of whole words or parts of words using orthographic skills with development. The simulations showed that in the early stages of learning to read, phonological skills were relied on to access meaning (i.e., Orthography → Phonology → Semantics) but with print experience, reliance on direct orthography-semantics connections increased. These connections are faster than using the indirect pathway via phonology and also allow the individual to bypass the ambiguity of the English language where there may be many homophones.

Empirical studies support the developmental models above with the finding that children depend on phonological skills in the beginning stages of learning to read and spell, but move on to rely on orthographic skills with increased proficiency with the language (e.g., Kirby, Parrila & Pfeiffer, 2003). A longitudinal study by Kirby et al. (2003) found that phonological skills were a significant predictor of reading for children in Kindergarten and Grade 1, but not in the later years. In addition, de Jong and van der Leij (1999) examined phonological skills in Dutch children from Kindergarten to Grade 2 and also showed that phonological skills did not contribute unique variance to reading after Grade 1 (see also de Jong & van der Leij, 2002). Based on these results, they concluded that the effects of phonological skills on reading were time-limited. However, Wagner et al. (1997) showed that the influence of phonological processing skills on
English word reading is not limited to beginning reading but extends through to Grade 4. Despite having an influence in the later stages of reading acquisition, the variance accounted for by phonological processing did diminish over time (Wagner et al., 1997). Surprisingly, a cross-sectional study using older children in Grades 4, 6 and 8 conducted by Roman, Kirby, Parrila, Wade-Woolley and Deacon (2009), found that the contributions of phonological and orthographic skills to word reading were consistent across the three grades. However, the importance of each skill was dependent on the reading task. Orthographic skills were most important for reading real words and this would suggest that these older children had shifted to using orthographic, and not phonological, skills when reading real words. On the other hand, phonological skills were more important than orthographic skills when children were reading nonwords.

In contrast, other studies have cast doubt on the proposal that individuals shift from using phonological processing skills to orthographic processing skills with increased exposure to and proficiency with English (e.g., Ziegler & Goswami, 2005). For example, Brown and Deaver (1999) showed that when children aged 6 to 10 were shown irregular nonwords (e.g., *dalk*), they were able to read them using either phoneme recoding (e.g., */dælk*/) or a lexical analogy strategy (e.g., */dɔːk*/ rhymes with *talk*). They suggested that children were able to produce two different responses because they were developing both phonological and orthographic skills in parallel and would apply a mixture of both skills for reading. Further evidence comes from Goswami, Porpodas and Wheelwright (1997) who examined the use of orthographic chunks, such as rhymes, in nonword reading in 7- to 9-year-old children. Children were more accurate when the nonword presented was based on a real word (e.g., *bicket* rhymes with *ticket*) than when the nonword was unfamiliar (e.g., *bikket*). In addition, Cassar and Treiman (1997) found that children as young as 5 years do have some form of general orthographic knowledge. When children were presented with pairs of
nonwords and asked to select the nonword that looked most word-like, these children chose nonwords with legal letter patterns (e.g., final-doublet nonwords such as *pess*) more often than nonwords with illegal letter patterns (e.g., initial-doublet nonwords such as *ppes*). These results show that young children are sensitive to consonant doubling, even at an age when it is assumed that children tend to rely only on phonological skills. The conflicting results from studies examining whether children rely on phonological or orthographic skills may be due to different measurements of orthographic skills. It is possible that the methods used in the latter studies compel children to use an orthographic strategy and make orthographic knowledge more explicit. This means that children do have emerging orthographic skills but does not necessarily indicate that children rely predominately on orthographic skills for reading and spelling. Hence, it remains unresolved as to the influence of phonological and orthographic processing skills on English literacy outcomes in English monolingual children and adults over the course of literacy development.

**Phonological and Orthographic Processing Skills in Bilinguals**

As oral and written language input affects children’s development of phonological and orthographic skills, it is reasonable to expect that bilingual children’s underlying skills would be influenced by the linguistic properties of the language they were first exposed to (i.e., their L1). Caravolas and Bruck (1993) compared Czech- and English-speaking children on a nonword spelling task and a variety of phonological tasks. They found that the Czech children had greater awareness of complex onsets (CCV) than the English-speaking children, and were also better at spelling consonant clusters. The difference in performance was attributed to Czech children attending more to consonant sequences as the Czech language has a higher frequency and variety of complex consonant onsets than English. Furthermore, Czech has a transparent orthography (i.e., one-to-one grapheme-phoneme correspondences) compared to
English, which has an opaque orthography (i.e., one-to-many grapheme-phoneme correspondences). The transparent orthography helps Czech children learn the mapping between grapheme and phonemes easily and develop better spelling skills than English-speaking children (see also Durgunoglu & Oney, 1999).

Numerous cross-linguistic studies have shown that when children learn an L2, knowledge and skills gained from the L1 are often applied to the L2 (Durgunoglu, Nagy & Hancin-Bhatt, 1993; Cheung, Chen, Lai, Wong & Hills, 2001; Rickard Liow & Poon, 1998). Hence, it is important to understand the degree of similarity between the L1 and L2 phonology and orthography as it may determine how children process the L2. It is hardly surprising when studies show that children learning structurally similar languages rely on the same skills for reading the L1 and L2. For example, Durgunoglu et al. (1993) assessed Grade 1 Spanish-speaking children who were learning English as an L2 on phonological awareness and word recognition in Spanish, and word recognition in English. Multiple regressions showed that children’s Spanish phonological awareness predicted their performance in English word recognition, indicating children were applying a skill learnt from their L1 to process the L2. Similarly, Comeau, Cormier, Grandmaison and Lacroix (1999), found that phonological awareness in English was highly correlated to phonological awareness and word reading in French for English-speaking children in French immersion classes (see also Cisero & Royer, 1995 on Spanish-English children, D’Angiulli, Siegel & Serra, 2001 on Italian-English children, Geva & Siegel, 2000 on Hebrew-English children). These findings support cross-language facilitation for those learning L1 and L2 alphabetic scripts.

Surprisingly, such facilitation, at least at the phonological level, has also been shown to occur across structurally different languages, such as English and Chinese. A longitudinal study by McBride-Chang and Ho (2005) on 4-year-old Cantonese ESL learners found L1 phonological processing skills to predict L2 English word reading
almost two years later. Gottardo, Yan, Siegel, and Wade-Woolley (2001) also reported that rhyme detection in Cantonese was also significantly correlated with English rhyme detection and English phoneme deletion in Cantonese ESL children. Again, these findings show that phonological skills can be applied across languages and may not be a language-specific process (see also meta-analysis by Branum-Martin, Tao, Garnaat, Bunta & Francis, 2012; Wang, Perfetti & Liu, 2005).

The issue of transfer of orthographic processing skills is less clear. Many studies investigating the cross-language transfer of orthographic processing skills have not found any significant correlations between L1 orthographic skills and L2 orthographic skills, or between L1 skills and L2 reading (Abu Rabia, 2001; Arab-Moghaddam & Senechal, 2001; Wang et al., 2005; Wang, Park & Lee, 2006). For example, Wang et al. (2006) assessed Korean-English bilingual children from Grades 1-3, whose L1 and L2 were both alphabetic, on Korean and English phonological and orthographic processing skills as well as their reading abilities. Their results showed that the children’s phonological skills in Korean and English were highly correlated and that Korean phonological skills predicted unique variance in English reading. However, these children’s orthographic skills in Korean and English were not significantly correlated and orthographic skills in Korean were not a significant predictor of English reading, unlike English orthographic skills which were a significant predictor. Similar findings of limited transfer of orthographic processing skills were found for ESL learners with L1 languages of different script (e.g., Chinese, Wang et al., 2005) and with L1 alphabetic languages using different characters (e.g., Russian, Abu Rabia, 2001). This has led researchers to suggest that orthographic skills may be language-specific.

However, it seems the transfer of orthographic skills may be possible as the distance between the L1 and L2 decreases (e.g., the languages share the same alphabet). English orthographic skills in English-L1 children attending French immersion were
found to predict French word reading (Deacon, Wade-Woolley & Kirby, 2009), while French orthographic skills contributed unique variance to English orthographic skills for French-L1 Grade 8 children learning English as an L2 (Commissaire, Duncan & Casalis, 2011). Sun-Alperin and Wang (2011) also found Spanish-English bilingual children’s performance on a Spanish orthographic task to predict performance on English reading, but not spelling. The above findings suggest that there may be some shared orthographic processes in bilingual reading.

With the focus in bilingual research on the effect of the L1 on learning a L2, very little is known about the influence of the L2 on the L1. According to Cummins’ (1991) linguistic interdependence theory, L1 and L2 literacy skills are interdependent, and hence, input from one language can lead to conceptual and metalinguistic proficiency that facilitates the sharing of cognitive-linguistic skills across languages. This would suggest that learning a second language can have an influence on the first language (see Cook, 2003). A few studies have documented changes in bilinguals’ language use with the acquisition of a L2. These changes occur in concept categorization (Cook, Bassetti, Kasai, Sasaki & Takahashi, 2006), intonation (Mennen, 2004), voice onset time (Chang, 2012), and pragmatics (Pavlenko, 2004). In a study examining Turkish children living in the Netherlands (i.e., Turkish L1-Dutch L2), structural equation modelling conducted by Verhoeven (1994) found that Dutch (L2) reading skills at the word and text level predicted similar Turkish (L1) reading skills for children in the submersion program (e.g., followed curriculum in Dutch with additional Turkish instruction). This interdependence of literacy skills could be due to the transfer of metalinguistic skills between the languages. Further evidence that learning a L2 can impact the L1 reading process comes from a neuroimaging study of Italian-English bilinguals. Nosarti, Mechelli, Green and Price (2010) showed that there was increased activation in the left ventral prefrontal areas, usually associated with lexical and
semantic processing, for L1 reading with increased L2 vocabulary. They suggested that there is a greater reliance on lexical processing (i.e., orthographic processing) for the L1 because new letter-sound mappings are introduced with learning a L2.

**Chinese-English Bilinguals**

The research on bilingual children suggests that the underlying skills developed by Chinese-English bilingual children are influenced by the linguistic structure of Chinese, because this was the language that these bilingual children were first exposed to. Chinese and English are markedly different in terms of both their phonological and writing systems, and this is likely to impact how proficient Chinese-English bilingual children become in their underlying skills, as well as how they apply these skills to process English as a L2.

Chinese has a simple phonological structure and its basic speech unit is the syllable. It has a simple syllabic structure (i.e., CVC or CVV or CVVC with only two legitimate final consonants /n/ or /ŋ/) with mostly open syllables and no consonant clusters. There are well-marked syllable boundaries and even syllable stress (see Hua, 2002). Due to the simple structure of the syllable, the number of syllables in Chinese is far fewer than spoken English. For example, Mandarin, which is one of the dialects of Chinese and is used by a majority of the Chinese population, has approximately 400 possible syllables (Hanley, Tzeng, & Huang, 1999). In addition, Chinese is a tonal language and uses tones to differentiate meaning of characters (e.g., Mandarin has 4 lexical tones, 媛/ma1/ 疤/ma2/ 马/ma3/ 骂/ma4/). However, not all syllables have a full range of tones, resulting in many homophones. This suggests that successful reading in Chinese requires an ability to make visual distinctions between characters. In contrast, Chinese has a rich orthographic system. It has a nonalphabetic script and its basic unit is a character. These characters are complex and are made up of strokes with different visual patterns and structure (Li, 1993). Chinese characters are often divided into simple
characters and compound characters (e.g., 马 vs. 停). Simple characters cannot be divided into components, whereas compound characters can be divided into a phonetic radical and a semantic radical. The phonetic radical can sometimes provide cues to the possible pronunciations of the compound character, while the semantic radical provides cues to the character’s meaning (see Siok & Fletcher, 2001). Despite this phonetic component to Chinese characters, the reliability of the phonetic radical in predicting the pronunciation of the character is inconsistent.

Given the linguistic features of Chinese, it seems that the skills that are important for acquiring Chinese are likely to be different from those of English. The saliency of the syllable in Chinese suggests that phonological processing at the syllable level would be more important than at the phoneme level. A study of Kindergarten and Grade 1 Chinese children from China and Hong Kong showed that Chinese syllable awareness predicted Chinese character reading better than Chinese phoneme awareness (McBride-Chang, Bialystok, Chong, & Li, 2004, see also McBride-Chang et al., 2008). In addition, several studies have found that orthographic skills are crucial to the processing of Chinese characters. This has been attributed to the visual complexity of Chinese characters, such as simple characters that have no phonetic radical and the inconsistency of the phonetic radical in predicting pronunciation of the compound character, as well as the large number of homophones. For example, Yeung et al. (2011) found that orthographic skills made unique contributions to Chinese word reading and spelling in Grade 1 Chinese children from Hong Kong. Similarly, Tong and McBride (2010) found that visual-orthographic skills, defined as the ability to discriminate legal and illegal components of Chinese characters, predicted Chinese reading in Grade 2 and Grade 5 Chinese children (see also Ho, Yau, & Au, 2003).

It becomes apparent that individuals with Chinese as their L1 attain proficiency in specific underlying skills that are most relevant to the learning of Chinese, when
these bilinguals are assessed using English tasks. Several studies have highlighted the difficulties Chinese-L1 children and adults have with phonological awareness at the phoneme level (Cheung et al., 2001; Holm & Dodd, 1996; McBride-Chang et al., 2004; McBride-Chang et al., 2008; McBride-Chang & Kail, 2002; Yeong & Rickard Liow, 2012). For example, only 16% of the Cantonese-L1 children in the study by McBride-Chang et al. (2008) scored above zero on a phoneme onset deletion task. Other studies comparing Chinese-L1 children with English-L1 or English monolingual children have shown that Chinese-L1 children perform more poorly on tasks of phoneme awareness, but better or similarly on tasks of syllable awareness (e.g., Cheung et al., 2001; Yeong & Rickard Liow, 2012). These findings support the notion that the lack of saliency of the phoneme in spoken Chinese affects the phonological skills of Chinese-L1 individuals.

Furthermore, the importance of orthographic skills in learning Chinese has led to the suggestion that Chinese-L1 children may pay more attention to visual-orthographic patterns, which promotes whole word knowledge in English (Rickard Liow & Lau, 2006; Rickard Liow & Poon, 1998; see also Perfetti & Dunlap, 2008). This, in turn, is expected to translate into similar or better proficiency in orthographic skills in Chinese-L1 children compared to English-L1 or English monolingual children. In support of this claim, Wang and Geva (2003) showed that Chinese-L1 children performed better than English monolingual children when shown and asked to recall orthographically illegal unpronounceable letter strings (e.g., PCTH) which required visual-orthographic skills. Moreover, Wang, Koda and Perfetti (2003) demonstrated that adult Chinese ESL learners made more orthographically acceptable errors on a phoneme deletion task compared to Korean ESL learners, who have an alphabetic L1 background (see also Jackson, Lu, & Ju, 1994).
The results above suggest that Chinese-English bilinguals have acquired proficiency in skills relevant to Chinese which may influence the process of learning to read and spell in a second language, especially a contrasting language such as English. Indeed, there have been studies that suggest Chinese-L1 children and adults rely more on a visual-orthographic strategy to process English (Cheung, Chan & Chong, 2007; Haynes & Carr, 1990; Leong et al., 2005; Rickard Liow & Poon, 1998; Tong & McBride-Chang, 2010). For example, a structural equation analysis of performance on tasks assessing the orthographic and phonological skills and English reading and spelling abilities of 10-year-old Cantonese-L1 children showed a greater contribution of orthographic skill than phonological skill to both English reading and spelling in these children (Leong et al., 2005). Even as adults, Chinese-L1 individuals rely less on phonological information to read English words than English monolingual individuals. When presented with pseudowords and unpronounceable letter strings and asked to make same-different judgements, Chinese-L1 adults were no faster at judging the pseudowords than the letter strings as they did not benefit from being able to decode them phonologically, unlike the English monolingual adults who were faster when presented with pseudowords than letter strings (Haynes & Carr, 1990). However, in contrast, some studies have found no transfer of orthographic skills in Chinese-English bilinguals and have suggested that orthographic skills may be language-specific (Wang et al., 2005; Wang et al., 2006; Wang, Yang, & Cheng, 2009). Having said that, the failure of Chinese orthographic skills to predict English word reading in these studies may be because the orthographic tasks used tapped orthographic knowledge specific to Chinese (e.g., knowledge of radicals), suggesting that different visual-orthographic skills may be required for Chinese and English. To overcome this, Tong and McBride-Chang (2010) used an orthographic task that required distinguishing legal and illegal character components, similar to the English wordlikeness task, and found Chinese
visual-orthographic skills to predict English word reading even after accounting for phonological and morphological awareness in 8- to 11-year-old Cantonese-L1 children.

Despite the finding that Chinese-L1 children seem to rely more on orthographic than phonological processing skills for English word reading, phonological skills remain important for Chinese-L1 children learning English. Gottardo, Yan, Siegel & Wade-Woolley (2001) assessed Cantonese and English phonological skills in 9-year-old Cantonese-L1 children and showed that both Cantonese and English phonological skills predicted English L2 reading significantly. Phonological awareness has also been shown to predict English word reading (McBride-Chang & Kail, 2002) and English word spelling approximations in Chinese-L1 kindergarten children (Yeong & Rickard Liow, 2011). This is a reflection of the alphabetic nature of English that even Chinese-L1 children with limited phonological skills rely on those skills to acquire English successfully.

Though the many studies above show that Chinese-L1 children may be similar to English-L1 children in requiring both phonological and orthographic skills to read and spell in English, it remains to be seen if ESL learners, specifically Chinese-English bilinguals, follow similar phases of development to acquiring English as English monolinguals. Studies of bilingual children acquiring English as an L2 suggest that they learn in a similar manner to English monolingual children (Chiappe & Siegel, 1999; Chiappe, Siegel & Gottardo, 2002; McBride-Chang & Treiman, 2003). Chiappe et al. (2002) compared 5-year-old bilingual children who spoke English and one other language at home, ESL children who spoke exclusively another language at home, and English monolingual children on measures of alphabetic knowledge, phonological processing, and English reading and spelling, and found letter-name knowledge and phonological awareness to be important for all three groups of children. They concluded that regardless of language background, children acquired English literacy skills in a
similar manner with the same underlying skills (alphabetic knowledge and phonological processing) predicting English literacy abilities. However, it is possible that Chinese-L1 children follow a different trajectory when developing English literacy skill compared to English-L1 and English monolingual children as their orthographic skills are relatively stronger and perhaps more dominant than phonological skills. A longitudinal study by Yin, Anderson and Zhu (2007) assessing Chinese-L1 children at 7, 10 and 12 years of age showed that although these bilingual children did follow a developmental sequence somewhat similar to English monolingual children (pre-alphabetic, partial alphabetic, and finally, full alphabetic, in line with Ehri’s phase model), orthographic strategies were also available to them from an early age and were not restricted to a distinct phase. Mixed findings such as these illustrate how little we know about how bilingual children approach English reading and spelling as they get older and more proficient in English.

Since Chinese as a L1 can impact the learning of English as a L2 for Chinese-L1 children, we may expect English, the L2, to also influence the knowledge and skills in Chinese, the L1. Bialystok, McBride-Chang and Luk (2005) assessed English and Chinese phonological awareness in Chinese-L1 children living in Canada and Chinese-L1 children living in Hong Kong. Results showed that the Chinese-L1 children living in Canada performed better on both the English and Chinese phoneme onset deletion tasks than the Chinese-L1 children in Hong Kong. Better phonological awareness in the Chinese-L1 children living in Canada was attributed to greater exposure to a more phonologically complex language such as English as their L2. This positive influence of English as an L2, on Chinese the L1, is corroborated by Chen, Xu, Nguyen, Hong and Wang (2010). They found that Chinese children receiving intensive English instruction experienced greater growth in Chinese phonological awareness compared to those who did not receive any English instruction or were in a regular English program. Cross-
lagged correlations conducted by Yeong and Rickard Liow (2012) showed that Chinese-L1 children’s scores on the English phonological awareness task at Time 1 were related to scores on the Chinese phonological awareness task at Time 2 but not vice versa. These results further supported the transfer of phonological skills from the L2 to the L1. However, English is known to be more linguistically complex than Chinese and so, the influence of English, as an L2, on Chinese, the L1, is not entirely surprising as skills that are developed to cope with the more complex L2 can then be applied to the L1.

The more pertinent question is whether English-L1 children are affected by learning Chinese as a L2 as well. As Chinese is more visually complex due to the use of logographic characters, Chinese-L2 learners may become more sensitive to visual-orthographic patterns, therefore resulting in better whole word orthographic skills which can be applied to their L1. A review of neuroimaging studies by Perfetti et al. (2007) found that English learners of Chinese recruit neural areas more suited for Chinese reading, such as right hemispheric areas that are thought to underlie visual character recognition, when reading Chinese. However, these areas were not activated when reading in English, suggesting that Chinese learners’ approach to reading English may not have changed with the learning of Chinese (Nelson, Liu, Fiez & Perfetti, 2005).

**Phonological and Orthographic Processing Skills in English Monolinguals with Dyslexia**

Dyslexia is diagnosed when an individual has severe difficulties in acquiring English reading and spelling skills, despite normal intelligence and appropriate schooling (Shaywitz et al., 1990). These difficulties are persistent and children who are diagnosed with dyslexia typically continue to have the same difficulties in adulthood (Bruck, 1990; Shaywitz et al., 1999). There is widespread consensus that phonological processing deficits are the core problem for individuals with dyslexia (Snowling, 2000; Stanovich & Siegel, 1994; Vellutino, Fletcher, Snowling & Scanlon, 2004), which is no
surprise given the importance of phonological skills for the acquisition of English literacy.

Numerous studies have shown children with dyslexia to have poorer phonological skills compared to typically developing same-age readers (Manis, Custodio & Szeszuls, 1993; Olson, Forsberg, Wise & Rack, 1994; Snowling, 2000) and younger reading-age matched children (Rack, Snowling & Olson, 1992; Stanovich & Siegel, 1994). These studies have found that individuals with dyslexia show delays in rhyme sensitivity, alliteration, and phonemic segmentation, hallmarks of deficits in phonological awareness. In addition, these phonological deficits are stable and persist over time through to adulthood (Bruck, 1992; Manis et al., 1993; Wilson & Lesaux, 2001). Wilson and Lesaux (2001) found that adults with dyslexia, even those who have developed age-appropriate reading abilities, continue to present with deficient phonological skills compared to adults with no reading difficulties. This would suggest that these adults with dyslexia were able to attain average reading abilities by developing other strategies to compensate for their poor phonological skills.

Several researchers have proposed that individuals with dyslexia have a pattern of differential phonological and orthographic processing skills, with poorer phonological skills compared to orthographic skills, and that these individuals use their relatively less impaired orthographic processing skills as compensatory skills to read and write (Siegel et al., 1995; Stanovich & Siegel, 1994). For example, children with dyslexia may focus more on the visual components of written words and become more reliant on orthographic skills because of their difficulty with phonological skills. This is supported by studies that have shown children with dyslexia to perform as well as younger typically developing reading-age-matched children on tasks that measure orthographic skills. Griffiths and Snowling (2002) found that children with dyslexia performed similarly to younger, reading-age-matched readers without dyslexia on tasks
of irregular word reading. Irregular words do not follow common grapheme-to-
phoneme correspondences and hence, must be recognised using whole-word specific
knowledge. Other studies using a range of orthographic tasks, such as the orthographic
choice task and wordlikeness task, have also found similar results (Cassar, Treiman,
Moats, Pollo & Kessler, 2005; Olson, Wise, Conners, Rack & Fulker, 1989; Stanovich
& Siegel, 1994; Stanovich, Siegel & Gottardo, 1997; see also Snowling, Hulme &
Goulandris, 1994, a case study on a reader with dyslexia). In fact, some studies suggest
that children with dyslexia may have better orthographic skills than younger typically
developing reading-age-matched children. Siegel et al. (1995) found that children with
dyslexia performed better than younger reading-age-matched children on a task that
measured probable sequences and positions of letters within words (i.e., nonlexical
choice task, see also Stanovich & Siegel, 1994), suggesting better general orthographic
knowledge. In another study, Martin, Pratt and Fraser (2000) presented children with
either a visual or auditory word, and asked them to remove a letter from the word (e.g.,
look at this word <SNOW> and remove the letter <S>) or to delete a sound (e.g., look at
this word <SNOW> and remove the sound /s/). They found that children with dyslexia
were better at removing a letter than at deleting a sound from the presented word, and
were also better than reading-age controls at this task. The authors concluded that
children with dyslexia had superior orthographic skills relative to reading-age-matched
peers.

However, a number of studies have shown that, when compared to chronological
age matched children, children with dyslexia have poorer orthographic processing skills.
In particular, children with dyslexia have been shown to perform more poorly on tasks
of orthographic processing, such as the orthographic choice task (Manis, Seidenberg,
Doi, McBride-Chang & Peterson, 1996), the homophone verification task (Manis et al.,
1993) and the nonlexical choice task (Stanovich & Siegel, 1994; Stanovich et al., 1997),
than their typically developing peers. They also show impaired reading of irregular 
words (Castles & Coltheart, 1993; Manis et al., 1996; Stanovich et al., 1997). This 
suggests that with dyslexia individuals have poorer word specific and general 
orthographic knowledge than same aged peers. These deficits in orthographic skills 
remain in adolescence (Hultquist, 1997), but may be reduced in adulthood (Pennington, 
Lefly, Van Orden, Bookman & Smith, 1987). Hence, what we know about orthographic skill proficiency in individuals with dyslexia remains incomplete.

Poor orthographic skills in individuals with dyslexia should come as no surprise 
given that phonological skills are often seen as necessary for the development of 
orthographic skills. For example, in Ehri’s (1995) phase model of reading development, 
children start grouping letters into chunks, which include spellings of common rimes, 
morphemes or syllables (e.g., -ight, -ing, -er, etc. are treated as units, Ehri, 2005), only 
when they have acquired sufficient alphabetic knowledge. Similarly, Share’s (1995) 
self-teaching hypothesis espouses the importance of phonological recoding, which is the 
ability to translate print into sound and subsequently blend sounds together, for the 
learning of word-specific orthographic knowledge. Hence, deficits in phonological 
processing skills would result in poor orthographic skills as well. However, studies also 
show that phonological and orthographic skills have a degree of independence 
(Cunningham & Stanovich, 1990; Stanovich & West, 1989), and children with dyslexia 
can learn to read with minimal phonological skills, suggesting that they learn using 
alternative skills such as orthographic skills. In fact, since orthographic skills are closely 
associated with print exposure (Cunningham & Stanovich, 1990; Griffiths & Snowling, 
2002), an alternative explanation for how these children can reach similar levels of 
proficiency in orthographic skills as younger typically developing children but not the 
level of proficiency of same-aged children is that older children with dyslexia have
more exposure to print than younger non-dyslexic children (Stanovich & Siegel, 1994; Stanovich et al., 1997).

The proposal that individuals with dyslexia rely on orthographic skills as a compensatory ability for reading and writing is challenged by the finding that children with dyslexia use phonological strategies in their reading. Manis et al. (1993) assessed children with dyslexia, chronological age-matched typically developing children, and reading-age-matched younger children on tasks of phonological and orthographic skills as well as word identification. A series of hierarchical regressions found that nonword reading performance predicted reading ability over and above performance on the orthographic verification task for both the children with dyslexia and younger children. This suggests that children with dyslexia rely on phonological skills for reading, unlike the chronological age-matched children who were found to rely on orthographic skills. In another study by O’Brien, Van Orden and Pennington (2013), individuals with dyslexia, chronological age-matched and reading-age-matched groups were presented with real words, homophones, and pseudohomophones in a categorisation task (e.g., a flower: <rows> as a homophone, a tree: <oke> as a pseudohomophone). All three groups showed a similar pattern of errors and similar error rates, leading the authors to conclude that individuals with dyslexia do process words and nonwords phonologically instead of over-relying on orthographic knowledge. Bruck (1990) also found that adults with a history of dyslexia make regularity errors in word reading (e.g., reading pint as /pɪnt/ instead of /paɪnt/), an indication of their reliance on phonological skills. This was argued to be a “less mature” strategy, as typical readers have been shown to rely less on phonological skills with development. Given the conflicting reports, there is still much to understand about orthographic skills in individuals with dyslexia: their proficiency in the skill as well as the role orthographic skills play in these individuals’ word reading and spelling.
Present Thesis

As the review of the literature illustrates, less is known about orthographic processing skills than phonological processing skills, especially in specific populations such as bilingual learners with English as a L1 or L2, and individuals with dyslexia. There is much debate about the level of proficiency in orthographic skills these individuals attain compared to typically developing English monolinguals, and if the relationships between phonological and orthographic skills and English word reading and spelling differ in these specific groups compared to those with English as their only language.

For Chinese-English bilinguals, there is a general consensus that orthographic skills are important for acquiring Chinese literacy (e.g., Ho et al., 2003). Yet, there are questions remaining over whether such orthographic skills in Chinese facilitate Chinese-L1 bilinguals to acquire similar skills in an alphabetic L2, and whether such skills can be applied to learning English as an L2. Though it may be argued that the focus on visual-orthographic patterns in Chinese promotes a similar emphasis for English (i.e., attention to whole word knowledge), and therefore the use of a more visual-orthographic strategy to process English (e.g., Leong et al., 2005; Rickard Liow & Poon, 1998; Wang & Geva, 2003), there are suggestions that orthographic skills may be language-specific (e.g., Wang et al., 2006), and that phonological skills remain as important for learning English for Chinese-L1 bilinguals as for English monolinguals (e.g., McBride-Chang & Kail, 2002). The developmental sequence by which bilinguals acquire the skills necessary for English reading and spelling is even less explored, despite the many models of reading acquisition proposed for English monolinguals. With orthographic skills being more dominant for Chinese-L1 bilinguals, it is possible that these bilinguals do not follow the same phases as English monolinguals when learning English reading and spelling (e.g., Yin et al., 2007). There are also questions as
to how learning Chinese as a L2 may affect the learning of English as a L1 for English-L1 bilingual individuals. Studies have documented cross-language facilitation that occurs from the L1 to the L2 (e.g., Comeau et al., 1999; Durgunoglu et al., 1993), but when exposed to a L2, it is also possible for knowledge and/or skills acquired from the L2 to be applied to process the L1 (Bialystok et al., 2005; Chen et al., 2010; Yeong & Rickard Liow, 2012). Hence, it remains to be seen whether there are any effects of learning Chinese as a L2 for English-L1 bilinguals: whether it impacts their proficiency in underlying skills, the way they process English reading and spelling, and/or the developmental sequence in which they acquire English.

For English monolinguals with dyslexia, the findings regarding their proficiency with orthographic skills are inconclusive, which has implications for the proposal that individuals with dyslexia have a differential pattern of poor phonological skills and relatively better orthographic skills (e.g., Stanovich & Siegel, 1994). If individuals with dyslexia do not show relatively better orthographic skills, then there is less support for the argument that they use orthographic skills to compensate for their deficient phonological skills.

This thesis will address the issues highlighted above by exploring phonological and orthographic processing skills in four groups: Chinese-L1 bilinguals, English-L1 bilinguals, English monolinguals and English monolinguals with dyslexia. Of particular interest is the level of proficiency attained by these groups in the two skills and the associations between these skills and English word reading and spelling. The study reported in Chapter 2 focuses on how Chinese-English bilingual adults process English as an L2 compared to those with English as an L1 and English monolingual adults. Only a few studies have investigated phonological and orthographic skills in bilingual adults and these studies have tended to use Chinese-L1 adults who have had less exposure to English or have poorer literacy abilities, which may account for any differences
between the language background groups (e.g., Jackson et al., 1994; Holm & Dodd, 1996). Examining such skills in bilingual and monolingual adults, who have been exposed to English for similar lengths of time and are equally proficient in their literacy abilities, can help to clarify whether early linguistic experience with Chinese as an L1 (i.e., Chinese-L1 bilinguals) or as an L2 (i.e., English-L1 bilinguals), has long-term effects on the acquisition of phonological and orthographic skills, and the use of such skills for English word reading and spelling.

Exploring these issues in adults provides insight as to how skilled individuals approach English, but investigating how bilinguals learn to read and spell in the early stages of English literacy development can add to our understanding of the processes involved at various stages of literacy. Hence, Chapter 3 presents a cross-sectional study conducted with children from three different language backgrounds (i.e., Chinese-L1, English-L1 and English monolingual) and from two age groups. In this study, the children are still learning to be proficient readers and spellers in English and so, an investigation into the proficiency of their phonological and orthographic skills and their reliance on such skills gives direct insight into how exposure to dissimilar languages (i.e., English and Chinese) affects bilingual children’s acquisition of L1/L2 literacy skills. Together, the two studies allow us to address the issue of how bilinguals approach English reading and spelling at different stages of literacy with increased exposure and proficiency in English, and provide a more complete picture of the developmental trajectory bilinguals may take in learning to read English as an L2, or even as an L1.

Chapter 4 examines a different population from the first two studies, but the questions of interest remain similar: understanding the profile of phonological and orthographic skills in children with dyslexia and the extent to which these children depend on such skills for English reading and spelling. The proposal that individuals
with dyslexia have a differential pattern of poor phonological skills and relatively better orthographic skills (e.g., Stanovich & Siegel, 1994) is similar to the profile of Chinese-L1 bilinguals (Wang & Geva, 2003), and yet no direct comparisons have been made. This can be addressed with the inclusion of Chinese-L1 bilingual children in this study, which allows for direct comparisons with the children with dyslexia. In addition, exploring any differences in the way these children approach English compared to typically developing monolingual and bilingual children may help to explain the discrepancies in literacy achievement among the groups, and aid in the formulation of remediation approaches to improve literacy skills in children with dyslexia.

Finally, the results from the three studies contained in this thesis are summarised in the General Discussion. Wider implications for the application of developmental models of reading, derived using English monolingual children, to Chinese-English bilingual learners and children with dyslexia are discussed. In addition, we considered how our findings can advance pedagogical efforts for ESL and atypical learners.

In summary, this thesis aims to shed light on the skills required for English reading and spelling in specific populations such as ESL bilingual learners and atypical learners. In particular, we sought to understand how learning two contrasting languages may affect the phonological and orthographic skills of Chinese-English bilingual individuals, and how these same skills are affected by a learning disability such as in English monolingual children with dyslexia. Furthermore, we investigate the importance of such skills for English reading and spelling for Chinese-English bilingual individuals across age groups, and also for children with dyslexia, as differences in the ways these groups approach the English literacy tasks may have theoretical and practical implications.
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Chapter 2

Impact of Early Home Language Exposure on Phonological and Orthographic Skills and their Contributions to English Literacy Abilities in English Monolingual and Chinese-English Bilingual Adults
Abstract

Relatively little is known about the importance of phonological and orthographic processing skills for reading and spelling in monolingual and bilingual adults. We compared these underlying skills in English monolingual (n=28), English first language (L1)-Chinese second language (L2) bilingual (n=21), and Chinese L1-English L2 bilingual adults (n=22), who were equally proficient in reading and spelling English, and examined the contributions of these skills to English word reading and spelling for each group. Results showed group differences in phonological processing, but not orthographic processing, and the skills relied upon for reading and spelling were dependent on language background. This suggests there may be a long-lasting influence of being exposed to two contrasting languages on bilingual individuals’ underlying skills.
When learning a second language (L2), individuals bring with them the skills learnt from exposure to their first language (L1). Research on bilingual children has shown that the compatibility of the L1 and L2 determines how children process the L2 (Caravolas & Bruck, 1993; Durgunolu & Oney, 1999; Rickard Liow & Poon, 1998), yet recent research suggests that the factors involved in the learning of English as a Second Language (ESL) may actually be similar to those for English monolinguals (Lesaux, Rupp, & Siegel, 2007; McBride-Chang & Kail, 2002; Yeong & Rickard Liow, 2011). For English monolinguals, learning to read and spell in English requires a variety of cognitive and metalinguistic processes (Ehri, 1997; Vellutino, Tunmer, Jaccard, & Chen, 2007). Among these processes, phonological processing ability is known to be heavily relied on by young children (Caravolas, Hulme, & Snowling, 2001, Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001; Wagner & Torgesen, 1987), while other factors such as orthographic knowledge and morphological awareness become more important for older children and adults (Cunningham, Perry, & Stanovich, 2001; Nagy, Berninger & Abbott, 2006; Ouellette & Senechal, 2008; Roman, Kirby, Parrila, Wade-Woolley, & Deacon, 2009). Despite the increase in research on bilingual children’s L2 literacy skills, which offers insights into the cognitive and metalinguistic processes needed for successful L2 literacy development, much less is known about how bilingual adults process the L2: whether the underlying processes identified in childhood are also important in adulthood or whether the skills involved differ for those with ESL relative to English monolinguals and those who learnt English as a L1. Understanding how bilingual adults approach English can help us understand the long-term influence of early linguistic environments, if any, and the implications of such an influence in terms of the reliance on underlying skills. The present study examined whether English monolingual adults, English L1-Chinese L2 adults and Chinese L1-English L2 adults, who were proficient English readers and spellers, differed in their phonological and
orthographic processing skills. In addition, we compared the importance of such skills for English literacy, specifically reading and spelling, for each of these three language background groups.

Comparing the English and Chinese languages is interesting because the two languages contrast in various ways which may influence the various strategies learners use to approach reading and spelling. Chinese is morpho-syllabic and its written language has a logographic script. The smallest unit of meaning is the syllable which maps onto a Chinese character (e.g., 停/τin2/ meaning <stop> /stɒp/). It also has a simpler syllable structure than English (i.e., syllable form of CVC or CVV or CVVC with only two legitimate final consonants /n/ or /ŋ/), with mostly open syllables and no consonant clusters, resulting in syllables being highly salient in the language (Hua, 2002). In addition, the Chinese written script consists of characters that are made up of strokes with different visual patterns and structure (Li, 1993). These characteristics are in contrast with the features of English, which has an alphabetic script and a complex phonological structure (e.g., a variety of consonant clusters).

Given these features in English, knowledge of the alphabetic principle – how individual sounds map onto letters – is vital. Hence, it is no surprise that phonological processing skills are important for the attainment of English reading and spelling (Wagner & Torgensen, 1987). Phonological processing refers to the ability to process the sounds of the language (Wagner et al., 1997), and comprises of multiple component skills. Among these skills, phonological awareness, which is the ability to recognise, identify, and manipulate sound units in the spoken language (Gillon, 2004), is most strongly related to English word reading and spelling ability in young monolingual children (Rack, Hulme, Snowling, & Wightman, 1994; Swanson, Trainin, Necoechea, & Hammill, 2003). Explicit training in phonological awareness can have positive effects on children’s learning of the alphabetic principle (Bradley & Bryant, 1983; Lundberg,
and children showing a lack of phonological awareness usually have difficulties in reading and writing (de Jong & van der Leij, 2003; Vellutino, Fletcher, Snowling, & Scanlon, 2004). In particular, difficulties in phonological awareness can manifest as problems with word decoding, which requires the application of grapheme-phoneme rules to sound out and blend sounds together, thereby hindering the process of reading new and unfamiliar words. Measures of phonological skills include tasks that involve the manipulation of phonemes within a word (e.g., segmentation or deletion) and the ability to read nonwords (e.g., bote-boaf; Hagiliassis, Pratt, & Johnston, 2006).

However, phonological processing skills are not sufficient for the successful acquisition of English. Most reading models propose a shift from phonological processing skills to orthographic processing skills as children get older and have greater exposure to the language (see Ehri, 1995). However, it is only with orthographic learning that children can shift to the use of orthographic skills. Orthographic learning occurs when increased exposure to the print language allows for repeated phonological recoding of words (Share, 1995). This provides children with the opportunity to extract orthographic information on writing conventions (e.g., permissible letter patterns) and/or word-specific orthographic information, which are linked to phonological, semantic, morphological and syntactic information of the language (Cunningham, Nathan & Raher, 2011). Hence, orthographic processing refers to the ability to process the visual attributes of the writing system and the recognition of individual word-specific forms (Hagiliassis et al., 2006). Over the course of literacy development, children rely increasingly on larger orthographic units (i.e., rimes, syllables, morphemes, and even whole words in a more lexical approach) for reading and spelling to help overcome the inaccuracies of relying solely on phonological skills (e.g., grapheme-phoneme recoding) as grapheme-phoneme correspondences in English are inconsistent.
(e.g., a letter can be pronounced in multiple ways; Ehri, 2005; Ziegler & Goswami, 2005). For example, Roman et al. (2009) found that older children (age 9 years) shifted to using orthographic, and not phonological skills, when reading real words. Orthographic skills tend to be measured using tasks that tap recognition of real words, such as knowledge of homophones in a homophone verification task (e.g., eight vs. ate), or awareness of the legality of sublexical clusters (e.g., two letter sequences), such as in a nonlexical choice task (e.g., filv vs. filk, see Olson, Forsberg, Wise, & Rack, 1994).

Due to the simple phonological structure and logographic script in Chinese, Chinese learners rely less on phonological information and more on orthographic information when learning to read and write in Chinese (Wang, Koda & Perfetti, 2003). Because distinct characters map onto morpheme-level syllables, this promotes specific item learning and a whole character approach to reading (Perfetti & Dunlap, 2008). This holistic visual-lexical strategy builds up an understanding of the conventions used in written language, hence strengthening orthographic skills (Roman et al., 2009). Tong, McBride-Chang, Shu and Wong (2009) found that orthographic skills, but not phonological skills, predicted later Chinese word reading in kindergarten children. Similarly, using structural equation modelling, Yeung et al. (2011) found a significant independent contribution of orthographic skills, among other skills, to Chinese word reading in 6-year-old children from Hong Kong. Given that research has shown that exposure to a language influences the learning of skills underpinning literacy (Caravolas & Bruck, 1993; Cheung, Chen, Lai, Wong, & Hills, 2001; Durgunoglu & Oney, 1999; Rickard Liow & Poon, 1998), it is possible that Chinese-L1 bilinguals, English-L1 bilinguals, and English monolinguals will differ in terms of their phonological and orthographic skills due to differences in the phonological structures and orthographies of the Chinese and English languages.
Evidence of differences in phonological skills between Chinese-L1 and English-L1 or English monolingual groups comes mostly from studies on children examining phoneme awareness in these groups. For example, Cheung et al. (2001) found that pre-literate English monolingual children from New Zealand performed significantly better than Chinese children on a sound-matching task. This was attributed to their early spoken language experience which differed in terms of the salience of the phoneme in the language they were first exposed to (i.e., the phoneme is less salient in Chinese but more prominent in English), and suggests that Chinese-L1 children may have difficulty with phoneme awareness. McBride-Chang, Bialystok, Chong, and Li (2004) found Chinese Cantonese-speaking children to have poorer phoneme awareness on an English phoneme onset deletion task compared to English monolingual children even though they had similar levels of syllable awareness. Further evidence is provided by Yeong and Rickard Liow (2012) who followed English-L1 and Chinese-L1 children over a year and consistently found the Chinese-L1 children to have poorer phoneme awareness (at three time points) compared to the English-L1 children even though both groups of bilingual children were attending the same kindergartens and following similar set curricula (see also Yeong, Fletcher & Bayliss, 2014).

With the focus on phonological skills, orthographic skills have received relatively less attention. Since orthographic skills appear to be particularly important for the acquisition of Chinese, Chinese-L1 children and adults might be expected to develop a whole-word lexical approach to English or heightened sensitivity to visual/orthographic patterns in English and hence, to have better orthographic skills compared to English-L1 or English monolinguals. Again, research supporting this has been conducted predominately with bilingual children. Wang and Geva (2003b) assessed 7-year-old Chinese-L1 and English monolingual children on four types of spellings: real words and pseudowords (presented auditorily), and orthographically
legitimate and illegitimate strings (presented visually). Comparing performance on these four types of spellings can help tease apart the types of skills children use as only orthographic skills can ensure correct spelling on the orthographically illegitimate strings (e.g., $PCTH$) whereas phonological skills are required to spell pseudowords (e.g., $POTH$). The Chinese-L1 children were better at spelling the illegitimate letter strings than pseudowords, suggesting that they had stronger orthographic skills, whereas the English monolingual children performed better at pseudowords, suggesting stronger phonological skills. The authors concluded that Chinese-L1 children apply their stronger orthographic skills gained from their L1 to aid them in English L2 learning.

Other studies give further support to the view that Chinese-L1 children and Chinese ESL adults use their relatively stronger orthographic skills to support their learning of English as a L2 (Leong, Hau, Cheng, & Tan, 2005; Wang et al., 2003). Leong, Tan, Cheng and Hau (2005) conducted a structural equation analysis of performance on tasks assessing the orthographic and phonological skills of 10-year-old Cantonese-L1 children. They found a greater contribution of orthographic skill than phonological skill to English reading and spelling in these children. They concluded that this could be due to transfer effects from the influence of learning Chinese, or due to the meaning-based English curriculum of the children. However, phonological skills are important for children with ESL. This is reinforced by studies showing that phonological awareness predicts English word reading (McBride-Chang & Kail, 2002) and word spelling approximations in Chinese-L1 kindergarten children (Yeong & Rickard Liow, 2011). Thus, it appears that ESL learners are sensitive to the structure of the L2 target writing system and may treat English as a new target system rather than merely applying their skills from their L1 (Koda, 1999).

While recent studies have looked at English L2 acquisition throughout childhood, comparing Chinese-L1 children with either English-L1 or English
monolingual children, only a few studies have looked at adult bilinguals’ underlying skills and their relationships to English literacy. For example, Holm and Dodd (1996) found that Cantonese-L1 undergraduates had poorer phonological awareness compared to Australian English monolinguals, while Jackson, Lu, and Ju (1994) found Chinese-L1 graduate students to have better orthographic processing than phonological processing skills (see also Wang et al., 2003). This is consistent with findings from studies on Chinese-L1 children showing that exposure to Chinese affects proficiency in phonological and orthographic skills.

Other studies show that Chinese-L1 adults continue to rely less on phonological abilities than orthographic abilities for English word recognition. Haynes and Carr (1990) had Chinese-L1 and English monolingual undergraduates make visual same-different judgements on pairs of pronounceable pseudowords, unpronounceable letter strings and real words. They found that Chinese-L1 adults were no faster at judging the pseudowords than the unpronounceable letter strings as they did not benefit from being able to decode them phonologically, unlike the English monolingual adults who were faster when presented with pseudowords than letter strings. In another study, Wang et al. (2003) compared Korean-L1 (Korean is alphabetic) and Chinese-L1 adults on a semantic category judgement task and found that while the Korean-L1 adults showed significant homophone interference (e.g., whether “rows” is “a flower”), the Chinese-L1 adults only had significant confusion when words were orthographically similar (e.g., whether “creak” is “a small stream”). In addition, a neuroimaging study by Nelson, Liu, Fiez and Perfetti (2005) found that Chinese-L1 adults showed a bilateral activation for both English and Chinese reading, unlike the pattern of left hemispheric dominance seen for alphabetic scripts. Though these few studies suggest that adults may apply a lexical (i.e., whole-word/ orthographic) strategy gleaned from their L1 to the learning of English as an L2, the Chinese-L1 bilingual adults recruited for those studies either had
less exposure to English than their English monolingual counterparts, or their literacy abilities were not comparable, which could potentially explain the differences found. Hence, the question remains as to whether Chinese-L1 adults who have been exposed to English for as long as their English-L1 or English monolingual peers and who are as skilled in English literacy, continue to have poor phonological skills and to rely more on orthographic skills.

In addition, research on bilingualism shows that bilinguals may have cognitive and linguistic advantages, such as better executive functioning (Poulin-Dubois, Blaye, Coutya, & Bialystok, 2011) and a better understanding of the structure of languages (Galambos & Goldin-Meadow, 1990). Over time, this may lead to differences in how bilinguals learn an L2 and the developmental trajectory bilinguals follow in learning the L2. Though Yin, Anderson and Zhu (2007) suggest that Chinese-L1 children follow similar stages as English monolingual children when learning to read English, it remains to be seen if the skills used by bilingual adults are comparable to English monolingual adults. Hence, learning a second language from childhood, even for the English-L1 adults, may influence the skills they use in English word reading and spelling.

The current study investigates the extent to which phonological and orthographic skills are important for English reading and spelling for three groups of adults with differing language backgrounds (Chinese L1-English L2 vs. English L1-Chinese L2 vs. English monolingual) but with equal proficiency in word reading and spelling in English. The focus on single word reading and spelling provides insight into how proficient bilingual adults approach the simplest task that ESL learners have to face in acquiring English as an L2. Since the adults were equally proficient in English reading and spelling, this ensures that any differences in the skills relied upon by the three groups can be attributed to early linguistic exposure instead of their English literacy abilities. In addition, if bilingual adults rely on different skills than English
monolinguals, yet are able to achieve similar levels of proficiency in English reading and spelling, this could suggest that bilinguals adults follow a different trajectory for English literacy and may have implications for understanding how they approach other more complex tasks such as reading comprehension. This has potential practical implications for ESL learners. The two groups of bilingual adults have contrasting early linguistic experience that has led them to be more dominant in one language, but both groups have been exposed to English and Chinese for a similar length of time, and have relatively similar educational experiences. Hence, comparing these two groups of bilinguals with dissimilar languages (i.e., English and Chinese), may clarify if early linguistic experience has a long-lasting influence on how bilingual adults approach English literacy. Furthermore, comparison with the English monolingual group can address if and how learning a second language from a young age with English as a L1 affects English reading and spelling.

The first objective of this study was to compare the three language background groups on their phonological and orthographic skills. The English monolingual and English-L1 adults were predicted to have better phonological skills than the Chinese-L1 adults but the Chinese-L1 adults were expected to perform either better or similarly on tasks of orthographic skills compared to the English monolingual and English-L1 adults. The second objective was to evaluate the contributions of phonological and orthographic skills in predicting English reading and spelling. Given that the English monolingual and English-L1 adults should have progressed to using a more orthographic/morphological strategy for English reading and spelling (Ehri, 1995) and that Chinese-L1 adults have been shown to rely on their more proficient orthographic L1 skill (Haynes & Carr, 1990; Jackson et al., 1994), it was expected that orthographic skills would be the only significant predictor of reading and spelling for all three groups of adults.
Method

Participants

Eighty-three undergraduate students participated in the study for course credit or were offered reimbursement for their time and travel expenses. As this study was conducted in a country where the predominant language and medium of language instruction is English, participants were divided into the three language background groups based on a questionnaire (see Language Background Questionnaire described below). As low intellectual functioning or difficulties with English reading and spelling may potentially lead to differences in task performance (see review by Vellutino et al., 2004), two participants were excluded due to below average standard scores (< 80) on a measure of nonverbal reasoning and another eight were excluded because of below average standard scores (< 80) on the English literacy measures. Two additional participants were excluded as univariate outliers (> 2 SD from language group sample mean) on the English word spelling measure. Hence, the final sample of 71 participants, with a mean age of 20.2 years, was comprised of 28 English monolingual adults (22 female, age = 19.1 years), 21 English-L1 adults (16 female, age = 20.9 years) and 22 Chinese-L1 adults (13 female, age = 20.9 years). English monolingual adults were found to be significantly younger than both bilingual groups, F(2, 68) = 7.58, p = .001, but no significant differences were found when groups were further compared on their years of education, F(2, 68) = 2.40, p = .099.

Based on the self-report LBQ, the English monolinguals lived in the English-speaking country from birth and reported English as their only language with no exposure to any other languages at home from a young age. The bilingual participants were foreign international students of Chinese descent from Singapore, China and Hong Kong. They were exposed to English and Chinese at home from a young age, and had formal English and Chinese language and literacy education from primary school (about
age 6 – 7 years) to secondary school (about age 17 – 18 years). The bilingual groups were not significantly different in their length of residency in the English-speaking country ($p = .476$; English-L1 $M = 3.6$ years; Chinese-L1 $M = 4.3$ years). Table 1 shows both the English-L1 and Chinese-L1 participants were exposed to their first language significantly earlier than their second language (English-L1: $p = .009$; Chinese-L1: $p = .005$). Though both groups were exposed to English ($p = .075$) and Chinese ($p = .537$) for similar lengths of time, length of exposure is not indicative of amount of exposure to the L1, which would have differed between the groups in the early years. Furthermore, averaged data of current language usage from the English-L1 participants showed a trend of using English more often compared to the Chinese-L1 participants, with all English-L1 participants using only English to parents and friends. Chinese-L1 participants showed a trend of using Chinese more often than English-L1 participants, with about 63.6% of them currently using only Chinese with parents and friends. However, the overall current usage of either English ($p = .129$) or Chinese ($p = .136$) was non-significant between the English-L1 and Chinese-L1 groups. This bias towards the use of English in both bilingual groups could be attributed to the fact that English is the main medium of instruction at university and the participants were living in a predominately English-speaking country. This could also be the reason for the finding that English-L1 and Chinese-L1 adults did not differ in terms of self-ratings of proficiency in English reading and writing proficiency ($p = .657$), though the proficiency scores were in the expected direction (English-L1 > Chinese-L1). However, the Chinese-L1 adults rated themselves as having better proficiency in Chinese than the English-L1 adults ($p = .010$).
Table 1.

Means (SDs) of language background characteristics of English-L1 and Chinese-L1 groups.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Language</th>
<th>Language background</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>English-L1</td>
<td>Chinese-L1</td>
</tr>
<tr>
<td>Age of exposure (in years)</td>
<td>0.24 (.54)</td>
<td>1.59 (1.65)</td>
</tr>
<tr>
<td>Length of exposure (in years)</td>
<td>20.19 (2.20)</td>
<td>18.82 (2.68)</td>
</tr>
<tr>
<td>Overall usage (% of time)</td>
<td>85.33 (14.04)</td>
<td>79.20 (11.84)</td>
</tr>
<tr>
<td>Proficiency in reading and writing (out of 5)</td>
<td>4.50 (.50)</td>
<td>4.23 (.47)</td>
</tr>
<tr>
<td></td>
<td>Chinese</td>
<td>2.29 (.94)</td>
</tr>
</tbody>
</table>

Note: English-L1 N = 21, Chinese-L1 N = 22.

In addition, due to the differences in the education system across the countries, information on early alphabetic exposure through phonics and/or hanyu pinyin (phonetic coding system for Mandarin characters) was collected with the LBQ. Chi-square analyses showed that there were no significant differences across language background groups in alphabetic exposure ($p = .689$).

Materials

Language Background Questionnaire (LBQ). This questionnaire required participants to provide information on the languages they knew, the age at which they were first exposed to each language, and the amount of time (%) spent using particular languages at home during childhood as well as their current usage. Participants who reported only knowing English were assigned to the English monolingual group. The
rest of the participants who reported knowing both English and Mandarin/Cantonese were allocated to the English-L1 or Chinese-L1 groups based on two factors (see Li, Sepanski, & Zhao, 2006): (1) age of exposure to L1 was earlier or at the same time as the L2; and (2) L1 was the language used most at home by parents from infancy.

**Nonverbal Reasoning.** The Matrices subtest from the Kaufman Brief Intelligence Test 2 (KBIT-2; Kaufman & Kaufman, 2004) was used to assess participants’ nonverbal reasoning. Participants were required to select one from six choices to complete the missing part of a given abstract design. This task was administered and scored according to standard procedures in the manual.

**Receptive Vocabulary.** The Peabody Picture Vocabulary Test 4 (PPVT-4; Dunn & Dunn, 2007) was administered as a measure of receptive vocabulary. Participants had to select one from four pictures that matched the target word spoken by the experimenter. This task was administered and scored according to standard procedures in the manual.

**Word Reading and Spelling.** The word reading and spelling subtests from the Wechsler Individual Achievement Test 2: Australian adaptation (Wechsler, 2007) were used as measures of single word reading ability and single word spelling ability respectively. For word reading, participants were required to read as many words as possible from a list of words of increasing difficulty. For spelling, single words of increasing difficulty were presented orally to participants, who were required to spell as many words correctly as possible. Both tasks were administered and scored according to standard procedures in the manual.

**Phonological processing measures.** Three tasks were used to tap two components of phonological processing: phonological awareness and phonological recoding. Phonological awareness was measured using the nonword segmentation and phoneme reversal subtests from the Comprehensive Test of Phonological Processing
(CTOPP; Wagner, Torgesen & Rashotte, 1999). These two supplementary subtests from the CTOPP were chosen to avoid possible ceiling effects as they are relatively more difficult for adult participants than the other subtests. In the nonword segmentation task, participants were presented aurally with nonwords of increasing difficulty and were required to segment each nonword into its respective phoneme components (e.g., say /mæ/ one sound at a time to get /m/ and /æ/). In the phoneme reversal task, participants had to say the real word they would get after reversing the order of phonemes in aurally presented nonwords (e.g., /n(ə)ves/ backwards is seven). Each task was stopped after three consecutive incorrect items. Coefficient alphas obtained from the manual for each task were .88 and .85 respectively. The third phonological processing task was the silent phonological choice task used by Olson et al. (1994), which assesses phonological recoding. Participants were presented with three nonwords side by side on the computer screen (e.g., nite vs. kile vs. hote) and chose, via button press, the nonword that sounded most like a real English word (e.g., nite). As nonwords were used, participants had to apply grapheme-phoneme conversion rules to decode the nonwords phonetically to derive the correct response. The stimuli used were those developed by Olson et al. (1994), and comprised of five practice trials and 60 experimental trials. Cronbach’s alpha of .90 was calculated for this task. Accuracy scores on each phonological measure were standardized within the whole sample to obtain z scores for each participant.

**Orthographic processing measures.** Two components of orthographic processing, word-specific knowledge and general orthographic knowledge, were measured using three tasks. Word specific orthographic knowledge was assessed using the orthographic choice task and homophone verification task. In the orthographic choice task adapted from Olson et al. (1994), participants heard a word and were presented with a letter string on the computer screen. Presented letter strings were either real words (e.g., bloom) or their pseudohomophones (e.g., blume) and participants had
to decide if the letter string presented was the correct real English word that matched the
target word heard. Stimuli used were gathered from Manis, Custodio and Szeszulski
(1993; 22 items), Manis, Seidenberg, Doi, McBride-Chang and Petersen (1996; 12
items), Olson et al. (1994; 66 items), and Sloboda (1980; 8 items). There were a total of
five practice trials and 103 experimental trials. Cronbach’s alpha of .86 was calculated
for this task. The homophone verification task was adapted from Manis et al. (1993).
Participants listened to a sentence (e.g., “The man bought eight books”) and had to
respond appropriately to whether the word presented on the screen was either the
correct word for the sentence (e.g., “eight”) or an incorrect homophone (e.g., “ate”).
Stimuli for this task were taken from Manis et al. (1993; 28 items) and Stanovich and
West (1989; 14 items). Three new items (e.g., knight/night, sum/some, sole/soul) were
included to make a total of five practice trials and 40 experimental trials in this task.
Cronbach’s alpha calculated for this task was .89. Finally, the nonlexical choice task
was used to assess general orthographic knowledge. Participants were presented with a
pair of nonwords on the computer screen, one of which contained letter
sequences/positions that were legal and/or common in words. They had to indicate
which nonword “looked” most like a real English word (e.g., bei vs. bey). Items in this
task were taken from Siegel, Share and Geva (1995; 17 items) and Wang, Perfetti and
Liu (2005; 16 items). Five new items were added as practice trials before the 33
experimental trials. Cronbach’s alpha calculated for this task was .92.

Due to the low number of errors made on the three orthographic measures, a
composite score for each task was calculated using the speed and accuracy scores for
each participant. The median correct reaction time and number of errors obtained on
each task were converted to standardized scores within the whole sample and then
averaged to form the composite score. Other studies investigating orthographic skills
have calculated composite scores in a similar manner (see Stanovich & West, 1989).
Procedure

Participants were tested individually in a session that took one and a half to two hours to complete. Each session was divided into two blocks. One block consisted of the nonverbal reasoning task, word reading and orthographic processing measures, whereas the receptive vocabulary, word spelling and phonological processing measures were administered in the other block. The order of the two blocks was counterbalanced across participants.

Results

Raw scores obtained on the standardized tasks were converted to standard scores using reported normative data before conducting further analyses. Table 2 displays the descriptive statistics for these standardized tasks organized by language background group. A one-way ANOVA was conducted to ensure that the groups were similarly proficient in the English literacy achievement measures. Results showed that there were no significant differences among the groups on the measures of English word reading \( p = .072 \) or English word spelling \( p = .077 \). However, as these differences were approaching significance, pairwise comparisons were conducted. These confirmed that there were no significant differences between any of the language groups (all \( p > .081 \)). English receptive vocabulary was measured to account for possible oral language differences among the groups as past research has shown that bilinguals tend to have poorer vocabulary than monolinguals (e.g., Bialystok, Luk, Peets, & Yang, 2010). Though we found group differences to be in the expected direction (Chinese-L1 bilinguals < monolinguals), these differences did not reach significance \( p = .067 \). However, the groups were significantly different on nonverbal reasoning, \( F(2, 68) = 5.82, p = .005, \) with the English monolingual adults performing significantly lower than the bilingual adults (vs. English-L1: Scheffé = 7.83, \( p = .025 \), vs. Chinese-L1: Scheffé = 8.84, \( p = .016 \)) while the bilingual groups were not significantly different from each
other \((p = .992)\). This is consistent with previous research that has found cognitive advantages attributed to bilingualism (Bialystok & Craik, 2010).

Table 2.

*Descriptive statistics for standardized tasks organized by language background group.*

<table>
<thead>
<tr>
<th>Measures (Reliability)</th>
<th>English monolinguals ((n = 28))</th>
<th>English-L1 ((n = 21))</th>
<th>Chinese-L1 ((n = 22))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonverbal reasoning (.88)</td>
<td>101.39 10.28</td>
<td>111.38 14.51</td>
<td>111.86 12.59</td>
</tr>
<tr>
<td>Receptive vocabulary (.95)</td>
<td>105.50 8.96</td>
<td>108.86 8.78</td>
<td>102.05 10.54</td>
</tr>
<tr>
<td>English word reading (.93)</td>
<td>100.00 4.59</td>
<td>97.10 7.33</td>
<td>96.45 5.38</td>
</tr>
<tr>
<td>English word spelling (.95)</td>
<td>104.75 8.95</td>
<td>110.90 10.63</td>
<td>108.14 8.45</td>
</tr>
</tbody>
</table>

*Note:* Reliabilities for the above tasks are taken from the manuals.

To investigate group differences on phonological and orthographic processing skills, separate MANCOVAs, with language background as a between-subject factor, were conducted using the \(z\) scores for the phonological processing tasks and the composite scores calculated for the orthographic processing tasks. As there were group differences on nonverbal reasoning and the group differences on receptive vocabulary were approaching significance, these scores were entered as covariates in the MANCOVAs. Subsequent pairwise comparisons between language background groups were performed using MANOVAs with \(\alpha = .017\) \((.05/3\) after Bonferroni correction). Table 3 shows the mean performance on these tasks for each language background group.
### Table 3.

**Means (SDs) of phonological and orthographic processing tasks organized by language background group.**

<table>
<thead>
<tr>
<th>Task (maximum score)</th>
<th>Language background</th>
<th>Overall F value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>English monolinguals</td>
<td>English-L1 (n = 21)</td>
</tr>
<tr>
<td></td>
<td>(n = 28)</td>
<td></td>
</tr>
<tr>
<td>Nonword segmentation accuracy (20)</td>
<td>15.71 (3.44)</td>
<td>11.33 (4.73)***</td>
</tr>
<tr>
<td>Phoneme reversal accuracy (18)</td>
<td>12.25 (3.84)</td>
<td>9.43 (4.56)**</td>
</tr>
<tr>
<td>Silent phonological choice accuracy (60)</td>
<td>50.36 (8.27)</td>
<td>45.90 (11.37)</td>
</tr>
<tr>
<td>Orthographic choice errors (103)</td>
<td>3.61 (2.38)</td>
<td>1.81 (1.69)</td>
</tr>
<tr>
<td>Orthographic choice median RT</td>
<td>859 (241)</td>
<td>758 (177)</td>
</tr>
<tr>
<td>Homophone verification errors (40)</td>
<td>0.89 (1.10)</td>
<td>0.29 (0.46)</td>
</tr>
<tr>
<td>Homophone verification median RT</td>
<td>1151 (328)</td>
<td>914 (195)</td>
</tr>
<tr>
<td>Nonlexical choice errors (33)</td>
<td>3.82 (2.68)</td>
<td>3.76 (2.86)</td>
</tr>
<tr>
<td>Nonlexical choice median RT</td>
<td>1561 (601)</td>
<td>1490 (412)</td>
</tr>
</tbody>
</table>

*Note. All RT reported in ms. a Means differed significantly between English monolingual and English-L1 groups. b Means differed significantly between English monolingual and Chinese-L1 groups. *p < .05. **p < .01. ***p < .001.*

A significant main effect of language background group was found for the phonological processing tasks, $F(6, 128) = 6.86, p < .001, \eta^2_{\text{Mult}} = .43$. The English monolingual adults performed significantly better on the phonological processing tasks than both English-L1, $F(3, 43) = 8.68, p < .001, \eta^2_{\text{Mult}} = .38$, and Chinese-L1 adults, $F(3, 44) = 14.90, p < .001, \eta^2_{\text{Mult}} = .50$, but the bilingual groups were not significantly different from each other ($p = .291$). The English monolingual group performed significantly better than the English-L1 group on the phoneme reversal ($p = .001$) and nonword segmentation tasks ($p < .001$), but not on the silent phonological choice task ($p$
The English monolingual group performed significantly better than the Chinese-L1 group on all three phonological processing tasks (phoneme reversal: $p < .001$, nonword segmentation tasks: $p < .001$, silent phonological choice task: $p = .038$). Consistent with our hypothesis, the Chinese-L1 group performed poorly on the phonological processing tasks compared to the English monolingual group. However, the finding that the English-L1 adults performed similarly to the Chinese-L1 adults and poorer than the English monolingual adults was unexpected. In terms of performance on the orthographic processing tasks, as expected, there were no significant language background differences ($p = .067$). However, given that this difference was marginal, pairwise comparisons were investigated and no significant differences between groups were found (all $p > .017$).

Before examining the relationships between phonological and orthographic processing skills and English word reading and spelling, we reduced the number of predictor variables to obtain an overall score representing phonological processing skills by averaging the standardized scores of the three phonological tasks, and similarly, an overall score representing orthographic processing skills was obtained by averaging the composite scores of the three orthographic tasks. An investigation of the distribution of these overall scores showed that they were not skewed nor had excessive kurtosis and that they were normally distributed (all Shapiro-Wilk tests of normality $p > .14$).

Table 4 shows the bivariate correlations between phonological and orthographic processing skills, and English word reading and spelling for each language background group. The pattern of associations suggests that language background affects the relationships between underlying skills and reading and spelling.
Table 4. Correlations of phonological processing skills, orthographic processing skills, English word reading and spelling as a function of language background group.

<table>
<thead>
<tr>
<th></th>
<th>Phonological processing skills</th>
<th>Orthographic processing skills</th>
<th>English word reading skills</th>
<th>English word spelling skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phonological</td>
<td>EM 1.00</td>
<td>EL1 -0.29</td>
<td>CL1 -0.33</td>
<td></td>
</tr>
<tr>
<td>processing skills</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orthographic</td>
<td>EM -0.29</td>
<td>EL1 -0.27</td>
<td>CL1 -0.33</td>
<td></td>
</tr>
<tr>
<td>processing skills</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English word</td>
<td>EM 0.32</td>
<td>EL1 0.62**</td>
<td>CL1 0.43*</td>
<td></td>
</tr>
<tr>
<td>reading</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>English word</td>
<td>EM 0.28</td>
<td>EL1 0.49*</td>
<td>CL1 0.35</td>
<td></td>
</tr>
<tr>
<td>spelling</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: EM = English monolinguals, N = 28; EL1 = English-L1 bilinguals, N = 21; CL1 = Chinese-L1 bilinguals, N = 22. * p < .05. ** p < .01. *** p < .001

For English-L1 and Chinese-L1 adults, phonological, but not orthographic, skills were significantly correlated with reading. Neither phonological nor orthographic skills correlated significantly with reading for the English monolingual adults. Both phonological and orthographic skills were significantly correlated with spelling for the English-L1 adults, however, only orthographic skills correlated significantly with spelling for the English monolingual adults. Neither phonological nor orthographic
skills correlated significantly with spelling for the Chinese-L1 adults. However, group comparisons on these correlations (e.g., phonological skills with reading for English monolinguals vs. English-L1 adults) were non-significant suggesting that the three language background groups may not be different in the skills they rely on for reading and spelling.

To determine the contribution of each skill type to both English word reading and spelling, multiple regression analyses were conducted. However, as the total sample size in this study was considered to be too small (< 100) to detect a moderating effect of group (Aguinis, 2004; see also Aiken & West, 1991), separate regression analyses for each language background group were considered to be more appropriate (see Table 5). Other studies have investigated group differences in a similar manner (e.g., Chiappe, Siegel & Wade-Woolley, 2002; Geva & Zadeh, 2006; Jongejan, Verhoeven, & Siegel, 2007; McBride-Chang, Bialystok, Chong & Li, 2004). Nonverbal reasoning and receptive vocabulary abilities were entered first, followed by either the overall phonological or orthographic score. Due to the small subgroup sample sizes, it was not considered appropriate to include phonological and orthographic processing skills in the same analysis, and so, the following analyses examine the unique contribution of each skill set over and above the contribution of nonverbal reasoning and receptive vocabulary. The degree of collinearity for all regression analyses was found to be acceptable (tolerance > .52, VIF < 1.91).

For reading, phonological processing skills accounted for an additional 15% of variance, over and above nonverbal reasoning and receptive vocabulary, for Chinese-L1 adults, $F(1, 18) = 7.30, p = .015$. Phonological skills also accounted for 15% of variance in reading scores for English-L1 adults, however, this was only marginally significant, $F(1, 17) = 4.31, p = .053$. In contrast, phonological skills did not explain any unique variance in reading for the English monolinguals ($p = .19$).
Table 5.
Hierarchical regression predicting English word reading and spelling from phonological and orthographic processing skills as a function of language background group.

<table>
<thead>
<tr>
<th>Step/Variable</th>
<th>English word reading</th>
<th>English word spelling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>t</td>
</tr>
<tr>
<td></td>
<td>$R^2$</td>
<td></td>
</tr>
<tr>
<td>English monolinguals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n = 28)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonverbal reasoning</td>
<td>.09</td>
<td>.44</td>
</tr>
<tr>
<td>Receptive vocabulary</td>
<td>.37</td>
<td>1.79</td>
</tr>
<tr>
<td>Step 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phonological processing skills</td>
<td>.25</td>
<td>1.35</td>
</tr>
<tr>
<td>Orthographic processing skills</td>
<td>-.06</td>
<td>-.32</td>
</tr>
<tr>
<td>English-L1 (n = 21)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonverbal reasoning</td>
<td>.03</td>
<td>.14</td>
</tr>
<tr>
<td>Receptive vocabulary</td>
<td>.52</td>
<td>2.52*</td>
</tr>
<tr>
<td>Step 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phonological processing skills</td>
<td>.53</td>
<td>2.08</td>
</tr>
<tr>
<td>Orthographic processing skills</td>
<td>-.24</td>
<td>-.14</td>
</tr>
<tr>
<td>Chinese-L1 (n = 22)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonverbal reasoning</td>
<td>.08</td>
<td>.47</td>
</tr>
<tr>
<td>Receptive vocabulary</td>
<td>.66</td>
<td>3.82**</td>
</tr>
<tr>
<td>Step 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phonological processing skills</td>
<td>.41</td>
<td>2.70*</td>
</tr>
<tr>
<td>Orthographic processing skills</td>
<td>-.10</td>
<td>-.59</td>
</tr>
</tbody>
</table>

* $p < .05$.  ** $p < .01$.  *** $p < .001$
Orthographic processing skills was not a significant predictor of English word reading for any of the three groups (English monolinguals: $p = .76$, English-L1: $p = .27$, Chinese-L1: $p = .57$). These findings were unexpected as we hypothesized orthographic skills to be the only significant predictor for all three groups. To check whether the non-significant findings were due to the small sample sizes, power analyses were conducted for all non-significant regression analyses. These revealed that we had sufficient power to find an effect (> .80) for one out of the four non-significant findings, but did not do so. For a further two of the non-significant findings, the power analyses revealed that, based on the obtained effect sizes, between 372 and 471 participants would be required to find a significant effect. The contribution of orthographic skills in the English-L1 group, which would have required 44 participants to achieve significance based on the obtained effect size, was considered underpowered, and so, the results from this analysis should be treated with caution.

For spelling, orthographic processing skills were the only significant predictor, contributing an additional 42% of variance, over and above non-verbal reasoning and receptive vocabulary, for the English monolingual group, $F(1, 24) = 25.13$, $p < .001$, whereas phonological processing skills was not a significant predictor ($p = .30$). Neither phonological nor orthographic processing skills contributed significant additional variance to spelling for the English-L1 (phonological: $p = .72$; orthographic: $p = .16$) or the Chinese-L1 adults (phonological: $p = .14$; orthographic: $p = .10$). Our hypothesis that orthographic skills would be a significant predictor for all three groups was only partially supported as this was only found for the English monolingual group, but not the bilingual groups. Power analyses conducted for all non-significant regression analyses revealed that we had sufficient power to find an effect (> .80) for two of the five non-significant findings, but did not do so. For a further 2 of the non-significant findings, the power analyses revealed that, based on the obtained effect sizes, between
151 and 2671 participants would be required to find a significant effect. The contribution of phonological skills in the English monolingual group, which would have required 40 participants to achieve significance based on the obtained effect size, was considered underpowered, and so, the results from this analysis should be treated with caution.

The results of the regression analyses suggest that phonological processing skills were important for the bilingual groups, especially the Chinese-L1 group, but only for English word reading, while orthographic processing skills were important for the English monolinguals but only for English word spelling. This suggests that different skills may be important depending on language background and on the task requirements of reading and spelling.

**Discussion**

The influence of early home language exposure in shaping how an individual learns a L2 has been demonstrated in children (Caravolas & Bruck, 1993; Cheung et al., 2001; Durgunoglu & Oney, 1999; Rickard Liow & Poon, 1998), but it has not been ascertained whether this influence is also apparent in bilingual adults or if crucial skills relied upon by English monolinguals, such as phonological and orthographic skills, are just as important for bilingual adults who have successfully learnt to read and spell in English. In this study, we compared three groups of adults with differing language backgrounds (English monolinguals vs. English L1-Chinese L2 bilinguals vs. Chinese L1-English L2 bilinguals) on their phonological and orthographic processing skills, and evaluated the contributions of these skills to the adults’ concurrent English word reading and spelling abilities. This study is unique in that it compared adults who were equally proficient in English word reading and spelling, but had contrasting early linguistic exposure. This allowed us to determine the influence of Chinese as an L1 or L2 on English literacy.
One key finding from this study was that performance on the phonological and orthographic processing tasks was dependent on language background. As expected, the Chinese-L1 adults demonstrated the poorest phonological processing, but not orthographic processing, of the three groups. This result is consistent with previous research showing that Chinese-speaking children and adults have poorer phoneme awareness compared to English monolinguals (Cheung et al., 2001; Holm & Dodd, 1996; Wang & Geva, 2003b) or English-L1 children (Yeong & Rickard Liow, 2012; Bialystok, McBride-Chang, & Luk, 2005; see also Wang et al., 2003). It also extends previous research by showing that this effect cannot be attributed to differences in reading ability. Instead, the poorer phonological processing of the Chinese-L1 bilinguals appears to be due to the influence of the nature of the Chinese language, which has a simpler phonological structure and a logographic script, compared to the English language. These characteristics encourage word-specific knowledge and promote a lexical approach to the writing system but not the understanding of fine-grained sound units (i.e., phonemes) in the language (McBride-Chang & Chen, 2003). In addition, the lack of differences between the groups in terms of orthographic skills suggests that despite the fact that Chinese-L1 adults have poorer phonological skills, especially in phonemic awareness that is essential for English literacy acquisition, the holistic visual-orthographic approach encouraged by the Chinese writing system promotes a similar approach to English, hence allowing them to develop their English orthographic processing skills to a similar extent to the English-L1 and English monolingual adults. Though studies have suggested that Chinese-L1 children may have better orthographic skills than English monolinguals or English-L1 children (Wang & Geva, 2003b), exposure to English over time would, arguably, have allowed English monolinguals and English-L1 adults to develop their orthographic skills, building up their store of whole sight words and understanding of visual/orthographic patterns in
English (see Ehri, 2005). Hence, it is not surprising that adults from the three language background groups demonstrated similar proficiencies in orthographic skills.

Though the Chinese-L1 adults were significantly poorer in phonological processing than the English monolinguals, the group difference between the Chinese-L1 and the English-L1 adults was not significant. This suggests that given exposure over time, the Chinese-L1 adults were able to reach the same level of proficiency as the English-L1 adults, but not the English monolingual adults. Chen, Xu, Nguyen, Hong & Wang (2010) compared children in a regular English program with those from an intensive program and found that receiving additional English instruction improved English phonological awareness. Yeong and Rickard Liow (2012) also showed that Mandarin-L1 children continued to show improvements in phoneme awareness over the course of a year while attending preschool with instruction in English. Since the Chinese-L1 adults had English language lessons from the primary school level and were immersed in an English only environment at university, this may have allowed them to acquire and improve their phonological processing skills with continued exposure to the alphabetic language through the years. This implies that L2 learners may attain new skills that are critical for the L2 (Wang et al., 2003). Though it may be surprising that the English-L1 adults did not perform as well as the English monolinguals on phonological processing, Nguyen-Hoan and Taft (2010) found a similar result with adult bilinguals, who referred to English as their dominant language. The Cantonese bilinguals in their study performed poorly on phonological tasks, particularly those involving nonwords. However, unlike the English-L1 bilinguals in our study, the Cantonese bilinguals in the Nguyen-Hoan and Taft (2010) study learnt Cantonese before English and considered Cantonese as their dominant language in childhood, suggesting they may be more similar to the Chinese-L1 bilinguals in the current study. The continued exposure to and usage of the L2 in English-L1 bilinguals could have led
to lower exposure to and usage of English than English monolinguals (as reflected in the LBQ), hence resulting in some interference with the development of the L1, despite the English-L1 adults being exposed to English from birth and their exclusive use of English with parents and friends. Based on the performance of the three groups on the phonological processing and orthographic processing tasks, the results suggest that having two contrasting languages with differing linguistic properties has an impact on the individual’s underlying processing skills, even if English is the L1.

A second important finding was that different skills contribute to English word reading and spelling for each language background group. With regards to the processes underlying reading, an unexpected finding was that the contribution of phonological processing skills was important for both English-L1 and Chinese-L1 adults. Despite their poorer phonological skills, these bilingual groups continued to rely on such skills for reading even in adulthood. These findings are similar to studies conducted with Chinese-L1 children showing that the strongest predictor of English word reading is phonological awareness (McBride-Chang & Kail, 2002). Gottardo, Yan, Siegel and Wade-Woolley (2001) also showed that phonological processing in both the L1 and L2 contributed unique variance to English reading for Cantonese-L1 children. Our results suggest that bilingual adults also rely on decoding strategies through grapheme-phoneme correspondences. For English monolinguals in the current study, neither phonological nor orthographic processing predicted unique variance for reading. According to Ehri’s (2005) and Seymour et al.’s (2003) models of reading development, advanced readers move on to emphasize large units such as morphemes and syllables. This is supported by evidence from studies with older primary school-aged English monolingual children showing morphological (Carlisle, 2003) and grammatical awareness (Muter & Snowling, 1998) to be unique predictors of word reading. Hence,
an important question for future research will be to examine whether these other processes are important for reading in English monolingual adults.

For spelling, the current study showed that orthographic processing skills were important for the English monolingual adults only. Spelling is known to be more difficult than reading because there are more ways to spell a given word than to read it (i.e., phoneme-to-grapheme mappings are more inconsistent than grapheme-to-phoneme mappings, e.g., /sɑːt/ can be spelled as *sight*, *site*, or *cite*, Bosman & Van Orden, 1997). Hence, it may be necessary to learn whole-word strategies or acquire sublexical attributes of the English writing system in addition to applying phoneme-grapheme correspondences to manage the inconsistency of phoneme-grapheme patterns for the English monolingual adults. It is surprising that while phonological skills remained important for reading, neither phonological nor orthographic skills were implicated for spelling in the bilingual adults. Orthographic skills accounted for more variance in spelling than phonological skills for the bilingual adults, suggesting that the bilingual adults were sensitive to the different task demands of spelling similar to the English monolingual adults. However, orthographic skills were not significant, which indicates that other processes were involved for the bilingual adults. For example, vocabulary was a significant predictor for the English-L1 adults suggesting that vocabulary knowledge may be an important factor for bilinguals. The influence of vocabulary for bilinguals’ literacy is less explored but findings from Spanish-English bilingual children suggests that English vocabulary proficiency may be associated with better English nonword spelling performance and more orthographically plausible English spellings (San Francisco, Mo, Carlo, August, & Snow, 2006). More research needs to be done to examine the other processes that may be involved for bilingual individuals.

The group differences in the contribution of skills for different literacy tasks may be due to bilingual learners following a different developmental trajectory for
English literacy, or following a similar developmental path but at a different rate. Though Wang and Geva (2003a) and Yin et al. (2007) suggested that the stages that Chinese children progress through when learning English word reading and spelling were similar to that of monolinguals, the rate of development may depend on the extent to which skills from the L1 can be applied to the L2 (Figueroedo, 2006). Hence, because of the distinct structural differences between the Chinese and English languages, the transfer effect from L1 to L2 may only take place in the early stages of learning English with the importance of phonological skills increasing with improved proficiency in English (Wang et al., 2003). This suggestion is borne out by Yin et al. (2007) who showed that orthographic skills were used concurrently by young Chinese-L1 children who were only starting to learn alphabetic skills. Furthermore, Yeong, Fletcher and Bayliss (2014) found phonological skills, but not orthographic skills, to be the only significant predictor of English word reading in 8- and 11-year-old Chinese-L1 children, suggesting that Chinese ESL learners may rely on phonological skills for a longer period of time as they move from a language with a simple phonological structure (i.e., Chinese) to one that has a complex phonological structure and inconsistent grapheme-phoneme correspondences (i.e., English). Hence, this may account for why Chinese-L1 adults in the current study continue to rely on phonological skills for reading. Alternatively, the reliance on phonological skills for reading may be due to a smaller sight vocabulary in bilinguals compared to English monolinguals, which would make them less able to rely on automatic memory retrieval processes (Ehri, 2005).

However, the small sample size in this study limits strong conclusions of group differences found in the types of skills that contributed to reading and spelling. The relatively small sample-to-variable ratios for the regression analyses would have limited the power to find significant effects and this is reflected in the non-significant group comparisons on the simple correlations. Furthermore, it is important to note that
measures of single word reading and spelling accuracy may not be the most sensitive type of measure as the participants were proficient adult readers and spellers of English. It would be useful in future studies to examine how underlying phonological and orthographic processing skills impact on other aspects of reading such as fluency and meaning access (Share, 2008) in adults proficient in reading and spelling accuracy. Research in this area is rare for bilingual individuals and deserves further investigation. Furthermore, more research is needed to disambiguate the bidirectional effects of associations of cognitive-linguistic skills to English word reading and spelling. As this study examined such skills in adults at a single point in time, we cannot conclude that phonological and orthographic skills influenced the adults’ literacy abilities, or vice versa. In addition, due to the high levels of accuracy found in the orthographic tasks, we combined participants’ error scores and reaction times to obtain composite orthographic scores, which may reflect more than proficiency in orthographic skills. Hagiliassis et al. (2006) suggested that accuracy and speed measures may not be equivalent and that response times from phonological or orthographic tasks may include measures of how fast an individual makes choices. This makes it difficult to ascertain the relationship between orthographic skills, which were based on a combination of accuracy and speed, and word reading and spelling. The low error rates on the orthographic tasks also suggest that more complex tasks assessing orthographic tasks should be developed and used with participants who have become skilled and proficient in English. Perhaps with more complex measures, we can discern the contributions of accuracy and speed components on an orthographic task to English word reading and spelling.

Despite the adult bilinguals being as proficient in English word reading and spelling as the English monolinguals, the differences in performance on the orthographic and phonological tasks, as well as the reliance on different skills for reading and spelling, lead one to question if adult bilinguals are relying on the most
efficient strategy or whether they require more cognitive resources to achieve a similar level of proficiency. If we assume the English monolingual adults to be using the most efficient strategy, which is to rely on phonological and orthographic processing in the early years to build up a sight word vocabulary such that they do not need to rely on such skills later in adulthood, young bilinguals could be helped to establish their underlying skills so that they, in turn, do not need to rely on such strategies when they are older. For example, an explicit phonics training program coupled with teaching of the links between phonemes and graphemes could enhance young bilinguals’ phonological processing skills (see Hatcher, Hulme & Snowling, 2004). This in turn would allow a greater exposure to a variety of orthographic forms, hence improving sight word vocabulary. Also, since the groups in this study were equally proficient in English word reading and spelling, we would expect greater differences with regards to proficiencies in skills and their reliance on them in other bilingual individuals who have not achieved similar levels of English reading and spelling. Consideration of both the proficient and efficient use of skills is essential to understanding how bilinguals achieve English literacy competency and could aid the design of interventions aimed at strengthening the foundation of such skills at an early developmental stage.

This study is unique in that it investigates phonological and orthographic processing skills of proficient adult readers and spellers of English from three language backgrounds. The key finding, that Chinese-L1 bilinguals and even English-L1 bilinguals approach English literacy differently to the English monolinguals, suggests that the influence of linguistic exposure in the home from the early years may continue through to adulthood. Though bilingual Chinese-English adults may have attained similar levels of proficiency in English word reading and spelling as English monolinguals, we cannot assume that phonological and orthographic skills are equally important for literacy in both groups. Hence, an understanding of how bilingual
individuals approach an L2 and the skills they bring can shed light on the different ways individuals learn and the possible ways in which we can help those who may have difficulties with learning the language.
References


Chapter 3

Importance of Phonological and Orthographic Skills for English Reading and Spelling: A Comparison of English Monolingual and Mandarin-English Bilingual Children
Abstract

This cross-sectional study examines the importance of English phonological and orthographic processing skills to English word reading and spelling in three groups of younger (8-9 years) and older (11-12 years) children from different language backgrounds: English monolingual, English first language (L1)-Mandarin second language (L2) and Mandarin L1-English L2. Results showed that performance on tasks of English phonological and orthographic processing was dependent on age and language background status. Both English monolingual and English-L1 children had better phonological processing skills compared to the Mandarin-L1 children, while the younger bilingual children had better orthographic processing skills compared to the English monolingual children. Separate regression analyses found that different skills contributed to English word reading and spelling for each language background group and within each age group. Orthographic processing was the only significant predictor of word reading and spelling for the English monolingual children. In contrast, phonological processing skills were important for word reading for the bilingual children and for spelling for the younger bilingual children. Though the predictors of word reading remained the same across age groups for all language groups, the predictors of spelling were different between the younger and older bilingual children. These findings support previous research on the influence of bilingual children’s early linguistic experience on L2 English literacy acquisition and questions whether bilingual children follow similar stages to learning English as English monolinguals. Educational implications for bilingual learners are discussed.
A wide-ranging set of component skills is needed for the successful acquisition of English literacy (Vellutino, Tunmer, Jaccard, & Chen, 2007). There is general consensus that for alphabetic languages, phonological processing skills are important for learning to read and spell in English (Adams, 1990; Bryne, 1998; McBride Chang, 1995; Wagner & Torgesen, 1987) whereas other skills, such as orthographic processing and morphological awareness, become increasingly important when children get older and as their reading ability develops (Cunningham, Perry, & Stanovich, 2001; Nagy, Berninger & Abbott, 2006; Roman, Kirby, Parrila, Wade-Woolley, & Deacon, 2009; Treiman & Cassar, 1997). Similar skills have been found to be associated with learning to read and spell in English as a Second Language (ESL; Leong, Hau, Cheng, & Tan, 2005; Lesaux, Rupp, & Siegel, 2007; McBride-Chang & Kail, 2002), but the importance of such skills to English word reading and spelling in bilingual learners depends on how linguistic properties of their first language (L1) map onto the characteristics of English (e.g., French-English: Comeau, Cormier, Grandmaison, & Lacroix, 1999; Cantonese-English: Cheung, Chen, Lai, Wong, & Hills, 2001). However, not much is known about how these skills contribute to English word reading and spelling over time as bilingual learners become older and more proficient in the language. Determining the relationships of such skills to English literacy for bilingual learners at different stages of literacy can help further our understanding of the impact of L1 on learning of an L2. To begin to address this gap, we conducted a cross-sectional study investigating the proficiency in English phonological and orthographic processing skills and the relationships between these skills and English word reading and spelling in children from three different language backgrounds (English monolingual, English first language (L1)-Mandarin second language (L2), and Mandarin L1-English L2) and from two age groups (8-9 year olds and 11-12 year olds).
Phonological and orthographic processing skills in English monolingual children

For English monolingual children, phonological processing skills are important for the successful acquisition of English reading and spelling due to the alphabetic script and complex phonological structure of the English language (Wagner & Torgensen, 1987). In particular, phonological awareness, which is the ability to recognise, identify, or manipulate sound units in the spoken language (Gillon, 2004), is strongly related to English reading and spelling ability in young monolingual children, who are beginning to learn about how individual sounds map onto letters (Rack, Hulme, Snowling, & Wightman, 1994; Swanson, Trainin, Necoechea, & Hammill, 2003). There are different levels of phonological awareness and children tend to progress from an understanding of the word-level, to syllable-level, then onset-rime and phoneme-level skills (see Anthony & Francis, 2005). Difficulties in phonological awareness can manifest in problems with word decoding, which requires the application of grapheme-phoneme rules to sound out and blend sounds together, thereby hindering the process of reading new and unfamiliar words. Both phonological awareness and phonological recoding are components of phonological processing skills that are important for English literacy.

The relationship between phonological processing skills and reading is thought to be bidirectional (Perfetti, Beck, Bell, & Hughes, 1987; Wagner, Torgesen, & Rashotte, 1994; Ziegler & Goswami, 2005). Though exposure to oral language facilitates awareness of the sound structure of the language (Caravolas & Bruck, 1993; Durgunoglu & Oney, 1999), it is learning to read and write with exposure to the written language that promotes further growth in phonological skills (Perfetti et al., 1987; Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001). Hence, monolingual children’s proficiency in phonological processing improves as they get older because they begin to learn about the correspondences between graphemes and phonemes as they are taught to read and write. Evidence to support this continued growth in
phonological skills comes from a longitudinal study conducted by Hulslander, Olsen, Willcutt and Wadsworth (2010) that showed that the older children (aged 10 years), who had been exposed to reading and writing for some time, improved significantly on tasks of phoneme awareness and phonological decoding across a five year period. However, with improvement in phonological processing and decoding skills, children start to group letter patterns in words into larger orthographic “chunks” (Adams, 1990). These “chunks” may include spellings of common rimes, morphemes or syllables (e.g., -ight, -ing, -er etc. are treated as units, Ehri, 2005). Over time, as children retain more sight words and pick out familiar letter patterns in different words, their knowledge of individual word-specific forms and the understanding of the attributes of the writing system, also known as orthographic processing skill (Hagiliassis, Pratt, & Johnston, 2006), improves.

The inconsistency of grapheme-phoneme correspondences in English (e.g., a letter can be pronounced in multiple ways) means that both phonological and orthographic processing skills are needed for learning to read and spell English words (Treiman, Mullennix, Bijeljac-Badic & Richmond-Welty, 1995). Hence, English monolingual children need to rely on strategies that use both small (i.e., phoneme in grapheme-phoneme recoding) and large (i.e., rimes, syllables, and even whole words in a more lexical approach) units to acquire English successfully. Evidence for these skills being core skills for English word reading and spelling is provided by several studies. For example, Badian (1994) found that tests of phonological awareness and orthographic processing in Kindergarten children contributed independently to word reading and spelling in Grade 1 while Roman, Kirby, Parrila, Wade-Woolley and Deacon (2009) showed that the same two skill types also made unique contributions to English reading in older children in Grades 4, 6, and 8 (see also Martinet, Valdois & Fayol (2004); Stanovich, West & Cunningham, 1991).
The inclusion of phonological and orthographic processing skills in models of children’s literacy development also attests to their importance in English literacy acquisition. However, most models suggest a shift from an analysis of sound-based phonemic units (i.e., phonological processing) to larger syllabic or sub-syllabic units (i.e., orthographic processing). According to Ehri’s (1995) phase model, English monolingual children go through four phases when learning to read English. The first phase is the prealphabetic phase, where children rely on visual features to recognise words. This is followed by the partial alphabetic phase, where children have learnt some letter names and sounds and use these to read. The full-alphabetic phase is when children have extensive knowledge about phoneme-grapheme correspondences and are able to make connections between the letters and sounds when they read. Finally, the consolidated alphabetic phase refers to when children are able to read using larger units such as familiar letter patterns in rimes, syllables and morphemes.

Longitudinal studies support the findings from cross-sectional studies showing that phonological processing influences early word reading and spelling in children (de Jong & van der Leij, 1999; Stuart & Masterson, 1992; Wagner et al., 1997). However, the findings in relation to the effects of phonological processing abilities on English word reading and spelling over time remain inconclusive. Wagner et al. (1997) and Stuart and Masterson (1992) found phonological processing abilities to predict later reading outcomes over six years in English readers from 4 to 10 years of age, while de Jong and van der Leij (1999; see also de Jong & van der Leij, 2002) found the effects of phonological skills to be time-limited, as their influence decreased after 6 years of age in Dutch readers, in line with Ehri’s phase model. In addition, Roman et al. (2009) found that older children (age 9 years) shifted to using orthographic, and not phonological skills, when reading real words. Hence, the use of phonological processing
skills may be affected by the emergence of an alternative strategy such as the use of orthographic skills (Scarborough, Ehri, Olsen & Fowler, 1998).

Other researchers have argued for the development and use of both types of skills in parallel as English monolingual children learn to read and write in English (e.g., Ziegler & Goswami, 2005). Studies have found that children do show a reliance on orthographic abilities at an early age, even though it has been assumed that children at that age tend to rely on phonological skills only. For example, Brown and Deaver (1999) found that when children between the ages of 6 to 10 were presented with irregular nonwords (e.g., dalk), they were able to read them using either phoneme recoding (e.g., /dælk/) or a lexical analogy strategy (e.g., /dɔːk/ rhymes with talk). Cassar and Treiman (1997) also found that children as young as 5 years were sensitive to consonant doubling, and Ouellette and Senechal (2008) showed that orthographic skills predicted children’s (age 5 years) invented spellings. Given the mixed results from the above studies, it remains unresolved as to how phonological and orthographic processing skills influence English literacy outcomes over time as children get older and become more proficient in the language.

**Phonological and orthographic processing skills in Mandarin-English bilingual children**

Unlike English, Mandarin is morphosyllabic and has a logographic script. The simplest unit of the Mandarin writing system is the character and these characters are complex, made up of strokes with different visual patterns and structure (Li, 1993). Each Mandarin character maps onto syllables, which are the smallest units of meaning. In addition, spoken Mandarin has a simple syllable structure, with mostly open syllables and no consonant clusters, resulting in syllables being highly salient in the language (Hua, 2002). Given the simple phonological structure and complex orthographic characters of Mandarin, we might expect the phonological and orthographic skills of
children speaking and learning Mandarin as an L1 to develop differently from English monolinguals. There may also be differences as to how such skills are applied to an alphabetic L2 like English for Mandarin-English bilingual children.

Several studies have shown that the linguistic properties of a child’s language impact the development of phonological and orthographic skills (Caravolas & Bruck, 1993; Cheung, Chen, Lai, Wong, & Hills, 2001; Durgunoglu & Oney, 1999; Rickard Liow & Poon, 1998). With the lack of saliency of the phoneme in spoken Mandarin, Mandarin-L1 children have been shown to perform poorly on phoneme awareness tasks compared to English-L1 or English monolingual children. For example, Cheung et al. (2001) found that pre-literate English monolingual children from New Zealand performed significantly better than Chinese children on a sound-matching task, and McBride-Chang, Bialystok, Chong, and Li (2004) found Chinese Cantonese-speaking children to have poorer phoneme awareness on an English phoneme onset deletion task compared to English monolingual children, even though they had similar levels of syllable awareness. Cantonese is similar to Mandarin in that it is also a morphosyllabic and tonal language with simple phonological structure. Consistent with the longitudinal studies showing English monolingual children improving in their phonological skills over time, Yeong and Rickard Liow (2012) found that Mandarin-L1 children also showed improvement in English phoneme awareness with increasing aural exposure to English, though their performance was still poorer than English-L1 children after a year in kindergarten (see also Tong & McBride-Chang, 2010).

In addition, given the nonalphabetic nature of the Mandarin writing system, which is made up of logographic characters, orthographic skills are essential to rote learn the large number of characters (e.g., Shu & Anderson, 1999) and these skills improve with age (Tong & McBride-Chang, 2010). Though a few studies found orthographic skills to be language-specific (Keung & Ho, 2009; Wang, Perfetti & Liu,
2005; Wang, Yang & Cheng, 2009), suggesting that Mandarin orthographic skills may not be applied to English, the importance of orthographic skills in learning Mandarin may encourage Mandarin-L1 children to pay more attention to visual-orthographic patterns and promote whole word knowledge in English (Rickard Liow & Lau, 2006; see also Perfetti & Dunlap, 2008). Hence, Mandarin-L1 children may be expected to have better orthographic skills compared to English-L1 or English monolingual children. In support of this, Wang and Geva (2003a) showed that Chinese-L1 children performed better than English monolingual children when shown and asked to recall orthographically illegal unpronounceable letter strings (e.g., PCTH) which required visual-orthographic skills. Another study by Wang, Koda and Perfetti (2003) demonstrated that adult Chinese ESL learners made more orthographically acceptable errors on a phoneme deletion task compared to Korean ESL learners, who have an alphabetic L1 background. Both studies concluded that Chinese-L1 individuals rely on their orthographic skills, even when learning an alphabetic L2, due to the emphasis on a visual-orthographic strategy for Chinese character recognition.

Other cross-linguistic studies provide further support that Mandarin-L1 children do apply their relatively stronger orthographic skills to support their learning of English as an L2 (Leong, Tan, Cheng & Hau, 2005; Rickard Liow & Poon, 1998; Tong & McBride-Chang, 2010). Leong, Tan, Cheng and Hau (2005) conducted a structural equation analysis of performance on tasks assessing the orthographic and phonological skills of 10-year-old Cantonese-L1 children. They found a greater contribution of orthographic skill than phonological skill to English reading and spelling in these children. In addition, Tong and McBride-Chang (2010) found Chinese visual-orthographic skills to predict English word reading even after accounting for phonological and morphological awareness in 8- to 11-year-old Cantonese-L1 children. These two studies, however, did not have comparison groups of English monolinguals
or English-L1 children and so, it is uncertain if the contribution of orthographic skills to English L2 learning is specific to children with a logographic L1 or if these skills are also important for English monolinguals or those with English L1.

Despite the use of orthographic skills in support of English L2 learning, phonological skills remain important for Mandarin-L1 children learning English. Gottardo, Yan, Siegel & Wade-Woolley (2001) assessed Cantonese and English phonological skills in 9-year old Cantonese-L1 children and showed that both L1 and L2 phonological skills contributed unique variance to English L2 reading. Similarly, phonological awareness has been shown to predict English word reading (McBride-Chang & Kail, 2002) and word spelling approximations in Chinese-L1 kindergarten children (Yeong & Rickard Liow, 2011). This suggests that, because of the alphabetic nature of English, even Mandarin-L1 children with limited phonological skills require both phonological and orthographic skills to acquire English successfully.

Though it may be established that both phonological and orthographic skills are important for Mandarin-L1 bilinguals to learn to read and spell in English, it is unclear if these bilingual children use similar skills to English monolingual children as they get older and more proficient in English. Early studies with ESL children acquiring English suggest that they learn in a similar manner to English monolingual children (Chiappe & Siegel, 1999; Chiappe, Siegel & Gottardo, 2002; McBride-Chang & Treiman, 2003). In comparing 5-year old bilingual children who spoke English and one other language at home, ESL children who spoke exclusively another language at home, and English monolingual children on measures of alphabetic knowledge, phonological processing, and English reading and spelling, Chiappe et al. (2002) concluded that the three groups of children acquired English literacy skills in a similar manner with the same underlying skills (alphabetic knowledge and phonological processing) strongly associated with English literacy acquisition. However, it is important to note that the bilingual and ESL
children were from various language backgrounds, including both alphabetic and nonalphabetic L1s, which may have concealed differences in the way various L1s affect English literacy acquisition.

Since orthographic skills are relatively stronger and perhaps more dominant than phonological skills in Mandarin-L1 children, it is possible that there are differences in the way Mandarin-L1 children acquire English literacy compared to English-L1 and English monolingual children. A longitudinal study by Yin, Anderson & Zhu (2007) assessing Chinese-L1 children at 7, 10 and 12 years of age showed that these children did follow a developmental sequence somewhat similar to English monolingual children (pre-alphabetic, partial alphabetic, and finally, full alphabetic, in line with Ehri’s phase model), but, unlike English monolingual children, they also found that orthographic strategies were available at all ages and not restricted to a distinct phase. Furthermore, research on bilingualism has shown that bilinguals may have cognitive and linguistic advantages, such as a better understanding of the structure of languages (Galambos & Goldin-Meadow, 1990), which may affect the way in which bilingual children acquire a L2. Hence, it has not been clearly established whether learning a second language from childhood, even for English-L1 children, influences the way in which Mandarin-English bilinguals learn English word reading and spelling.

The present study

Despite the increase in research on bilingual children’s emerging literacy skills, it is difficult to interpret results obtained from the various studies. These studies have either grouped bilinguals from various language backgrounds (e.g., Lesaux et al. (2007) had English L2 children from 33 different L1s) in comparison with English monolinguals or examined underlying skills in Chinese-L1 bilinguals without comparison groups of English monolinguals or English-L1 children (Gottardo et al., 2001; Leong et al., 2005; Tong & McBride-Chang, 2010). In addition, as the relative
importance of the processes involved in literacy may change over time (Jongejan, Verhoeven & Siegel, 2007; Kirby, Parrila & Pfeiffer, 2003), a cross-sectional study will be important in informing researchers if the types of processes involved at various stages of literacy differ for different groups of children with varied language backgrounds, which will advance our understanding of how the L1 affects learning a L2. Comparing children across ages will also give insight to the pathways bilingual children of different ages take to acquiring English literacy. To address these issues, the present study compares three groups of children (English monolingual, English-L1, and Mandarin-L1) with contrasting early linguistic experience from two age groups (8-9 year olds and 11-12 year olds). This can help us determine if exposure to dissimilar languages (i.e., English and Mandarin) affects children’s underlying skills (i.e., phonological and orthographic processing skills) in English, how they approach English literacy, and if this varies at different stages of literacy with increased exposure and proficiency in English.

The first objective of this study was to compare the three language background groups on their English phonological and orthographic skills and how their proficiency levels compare across the age groups. It was predicted that the English monolingual and English-L1 children would have better phonological skills than the Mandarin-L1 children, but the Mandarin-L1 children were expected to perform either better or similarly on tasks of orthographic skills compared to the English monolingual and English-L1 children. These differences in performance on the phonological and orthographic tasks were expected to be evident in both age groups. Older children, regardless of language background, were also predicted to have better phonological and orthographic skills than the younger children due to increased exposure to aural and written English.
The second objective was to evaluate the relative contributions of English phonological and orthographic skills in predicting English word reading and spelling in each language group and to determine if these contributions differ from the younger to the older children. According to Ehri’s (1995) model, the younger children (8-9 years) in this study should possess letter-sound knowledge and should use phonological awareness to help them read and spell words. However, the older children (11-12 years) should be recognizing letter patterns and consolidating them into larger units, hence using orthographic skills to read and spell words. Given this shift in skill usage proposed by Ehri, the younger English monolingual and English-L1 children were predicted to rely on their phonological skills for English word reading and spelling, but the older English monolingual and English-L1 children were predicted to use their orthographic skills. Given that phonological skills remain important for Mandarin-L1 children (Gottardo et al., 2001; McBride-Chang & Kail, 2002), and orthographic skills are available as a strategy for Mandarin-L1 children at any age (Yin et al., 2007) and can be applied to reading and spelling in English (Leong et al., 2005; Tong & McBride-Chang, 2010), it was predicted that both phonological and orthographic skills, would contribute significantly to English word reading and spelling for both younger and older Mandarin-L1 children.

**Method**

**Participants**

A total of 182 children participated in this study with the consent of their parents. The children were divided into three language background groups based on a questionnaire completed by their parents (see Language Background Questionnaire described below). Three children were excluded as their first language was neither English nor Mandarin. Children were also excluded if their performance on tasks indicated a possibility of low intellectual functioning or difficulties with English reading
and spelling as these children may perform differently than typically developing children (see review by Vellutino et al., 2004). This meant that of the remaining children, seven were excluded due to below average standard scores (< 80) on the nonverbal reasoning measure and another 13 were excluded because of below average standard scores (< 80) on the English literacy measures. The final sample of 159 children was comprised of 84 Grade 2 – 3 children (N = 29 English L1, N = 27 Mandarin-L1, N = 28 English monolinguals) with a mean age of 8;2 years, and 75 Grade 5 – 6 children (N = 25 English L1, N = 25 Mandarin-L1, N = 25 English monolinguals) with a mean age of 11;0 years. There were no significant age differences across language background groups in the younger age group (p = .121) or older age group (p = .847).

The English monolingual children were recruited from five schools in Perth, Australia. Based on the LBQ, the English monolingual children’s parents reported English as the only language their children were exposed to at home from a young age. In Perth, only English is read and spoken in schools and children attend two years of preschool prior to six years of primary school. The English-Mandarin children were ethnic Chinese children recruited from six schools in Singapore, where both English and Mandarin tend to be spoken at home from a young age but in varying amounts. English-L1 children’s parents reported English as the language their children were exposed to earlier than Mandarin, and Mandarin-L1 children’s parents reported having exposed their children to Mandarin before English (see Table 1). Averaged data from the LBQ showed that the English-L1 children’s parents spoke English significantly more often than Mandarin to their children (p < .001), whereas the Mandarin-L1 children’s parents reported speaking Mandarin significantly more often than English (p < .001). Parents also rated their children as having significantly better proficiency in their L1 than L2 (English-L1: p < .001, Mandarin-L1: p = .001). In Singapore, schools follow a similar
curriculum to each other and the main medium of instruction in schools is English with only one hour of Mandarin instruction every day. Children attend two years of kindergarten before six years of primary school. Information was also collected on mother’s level of education (less than or equal to/more than 12 years of education) and whether or not children had early alphabetic exposure through phonics and/or hanyu pinyin (phonic coding system for Mandarin characters). Chi-square analyses showed that there were no significant differences across language background groups for mother’s level education ($p = .132$) and no significant differences in alphabetic exposure ($p = .522$).

Table 1.

**Means (SDs) of language background characteristics of English-L1 and Mandarin-L1 groups.**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Language</th>
<th>Language background</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>English-L1</td>
</tr>
<tr>
<td>Age of exposure (in years)</td>
<td>English</td>
<td>0.43 (1.02)</td>
</tr>
<tr>
<td></td>
<td>Mandarin</td>
<td>1.71 (1.78)</td>
</tr>
<tr>
<td>Amount of exposure (% of time)</td>
<td>English</td>
<td>69.44 (27.41)</td>
</tr>
<tr>
<td></td>
<td>Mandarin</td>
<td>29.38 (27.67)</td>
</tr>
<tr>
<td>Proficiency (rating out of 5)</td>
<td>English</td>
<td>3.68 (.88)</td>
</tr>
<tr>
<td></td>
<td>Mandarin</td>
<td>2.90 (.63)</td>
</tr>
</tbody>
</table>

*Note: English-L1 $N = 54$, Mandarin-L1 $N = 52$.*

**Materials**

**Language Background Questionnaire (LBQ).** On the LBQ, parents were asked to provide information about the languages their child knew, their child’s age of
first exposure to the languages, the languages used by their child’s primary caregiver, the amount of time (%) spent using particular languages with the child, and their child’s proficiency (understanding and speaking) in the languages. Children whose parents reported only knowing English were allocated to the English monolingual group. The other children, whose parents reported exposure to both English and Mandarin, were allocated to the English-L1 or Mandarin-L1 groups based on three factors (see Li, Sepanski, & Zhao, 2006): (1) age of exposure to L1 was earlier or at the same time as the L2; (2) L1 was the language spoken most of the time by parents and/or caregivers; and (3) the proficiency of the child’s L1 was rated better or as good as the L2.

**Nonverbal Reasoning.** The Matrices subtest from the Kaufman Brief Intelligence Test 2 (KBIT-2; Kaufman & Kaufman, 2004) was used to assess children’s nonverbal reasoning. Children were required to select one from six choices to complete the missing part of a given abstract design. This task was administered and scored according to standard procedures in the manual.

**Receptive Vocabulary.** The Peabody Picture Vocabulary Test 4 (PPVT-4; Dunn & Dunn, 2007) was administered as a measure of receptive vocabulary. Children had to select one from four pictures that matched the target word spoken by the experimenter. This task was administered and scored according to standard procedures in the manual.

**Word Reading.** The word reading subtest from the Wechsler Individual Achievement Test 2: Australian adaptation (Wechsler, 2007) was used as a measure of single word reading ability. Children were required to read as many words as possible from a list of words of increasing difficulty. This task was administered and scored according to standard procedures in the manual.

**Word Spelling.** The spelling subtest from the Wechsler Individual Achievement Test 2: Australian adaptation (Wechsler, 2007) was used as a measure of single word
spelling ability. Single words of increasing difficulty were presented orally to children, who were required to spell as many words correctly as possible. This task was administered and scored according to standard procedures in the manual.

**Phonological processing measures.** Three tasks were used to tap two components of phonological processing: phonological awareness and phonological recoding. Blending and deleting syllables and phonemes are often used to evaluate phonological awareness (see Yopp, 1988, for review), hence the elision and blending words subtests from the Comprehensive Test of Phonological Processing (CTOPP; Wagner, Torgesen & Rashotte, 1999) were used as measures of phonological awareness. In the elision task, children were required to remove either a syllable or phoneme from orally presented words and say what was left (e.g., say /kæt/ without saying /k/). In the blending words task, children heard words in small parts and had to put the parts together to make a whole word (e.g., /m/ and /æp/ together make map). Each task was stopped after three consecutive incorrect responses. Coefficient alphas obtained from the manual for each task were .86 to .89 for the elision task and .79 to .85 for the blending task. As per the manual, concurrent validity for the elision task and blending task was established by their correlation with the Lindamood Auditory Conceptualization Test (LAC; Lindamood & Lindamood, 1971), which was .75 and .58 respectively. The third phonological processing task was the silent phonological choice task used by Olson, Forsberg, Wise and Rack (1994), which assesses phonological recoding. In this task, children were presented with three nonwords side by side on the computer screen (e.g., nite vs. kile vs. hote) and chose, via button press, the nonword that sounded most like a real English word (e.g., nite). As nonwords were used, children had to apply grapheme-phoneme conversion rules to decode the nonwords phonetically to derive the correct response. This task has been used in other studies as a measure of phonological processing (e.g., Cunningham & Stanovich, 1990; Olson, Kliegel,
Davidson & Foltz, 1985) and was also found to load highly on the same factor as other phonological awareness tasks in a factor analysis conducted by Hagiliassis et al. (2006). The stimuli used were those developed by Olson et al. (1994), which included five practice trials and 60 experimental trials. Cronbach’s alpha of .95 and moderate correlations (> .48) with the other two phonological processing measures were calculated for this task.

**Orthographic processing measures.** Three tasks were used to measure the two components of orthographic processing: word-specific knowledge and general orthographic knowledge. Word specific orthographic knowledge was assessed using an orthographic choice task and homophone verification task. In the orthographic choice task adapted from Olson et al. (1994), children heard a word and were presented with a letter string on the computer screen. As presented letter strings were either real words (e.g., *rain*) or their pseudohomophones (e.g., *rane*), children had to decide if the letter string presented was the correct real English word that matched the target word heard. Stimuli for this task were gathered from Manis, Custodio and Szeszulsaki (1993; 22 items), Manis, Seidenberg, Doi, McBride-Chang and Petersen (1996; 12 items), Olson et al. (1994; 63 items), and Sloboda (1980; 7 items), making a total of five practice trials and 99 experimental trials. Cronbach’s alpha of .97 and moderate to high correlations (> .47) with the other two orthographic processing measures were calculated for this task. The homophone verification task was adapted from Manis et al. (1993). Children listened to a sentence (e.g., “Grandmother is old and weak”) and had to indicate whether the word presented on the screen was either the correct word for the sentence (e.g., “weak”) or an incorrect homophone (e.g., “week”). Stimuli for this task were taken from Manis et al. (1993; 28 items) and Stanovich and West (1989; 14 items). Three new items (e.g., knight/night, sum/some, sole/soul) were included to make a total of five practice trials and 40 experimental trials in this task. Cronbach’s alpha calculated for
this task was .92 and this task had moderate to high correlations (> .34) with the other two measures. The final orthographic processing measure was the nonlexical choice task, which assessed general orthographic knowledge. Children were presented with a pair of nonwords on the computer screen, of which one contained letter sequences/positions that were legal and/or common in words. They had to indicate which nonword “looked” most like a real English word (e.g., visn vs. vism). Items in this task were taken from Siegel, Share and Geva (1995; 17 items) and Wang, Perfetti and Liu (2005; 16 items). Five new items were added as practice trials before the 33 experimental trials. Cronbach’s alpha calculated for this task was .93 and this task had moderate correlations (> .34) with the other two orthographic processing measures. The above three tasks have been used as measures of orthographic processing in previous studies (e.g., Bekebrede, van der Leij & Share, 2009; Cunningham, Perry, Stanovich & Share, 2002; Leong, Tan, Cheng & Hau, 2005). In addition, factor analyses carried out by both Leong et al. (2005) and Hagiliassis et al. (2006) found that the tasks loaded highly on a component separate from phonological processing tasks, suggesting these tasks assess orthographic skills that are distinct from phonological skills.

**Procedure**

Children were tested individually over two sessions. Each session took about an hour to complete. One session consisted of the nonverbal reasoning task, word reading and orthographic processing measures, whereas the receptive vocabulary, word spelling and phonological processing measures were administered in the other session. The order of the two sessions was counterbalanced across children.

**Results**

Raw scores obtained on the standardized tasks (i.e., nonverbal reasoning, receptive vocabulary, English word reading and spelling) were converted to standard scores using reported normative data before conducting further analyses. Table 2
displays the descriptive statistics for these tasks organized by language background group and age.

For the younger children, the groups were significantly different on nonverbal reasoning, $F(2, 81) = 6.22, p = .003$, with the English monolingual children performing significantly poorer than the bilingual children (vs. English-L1: Scheffé $p = .032$, vs. Mandarin-L1: Scheffé $p = .006$), while the bilingual groups were not significantly different from each other. The groups were also significantly different on receptive vocabulary, $F(2, 81) = 19.38, p < .001$, with the English monolingual children performing significantly better than both bilingual groups (vs. English-L1: Scheffé $p = .014$, vs. Mandarin-L1: Scheffé $p < .001$), and the English-L1 children significantly better than the Mandarin-L1 children (Scheffé $p = .006$). These group differences on receptive vocabulary were expected and were a reflection of the amount of exposure to English at home. However, there were no significant differences among the groups on English word reading ($p = .061$) and spelling ($p = .159$).

A similar pattern of results was obtained for the older children. The groups were significantly different on both nonverbal reasoning, $F(2, 72) = 4.91, p = .010$, and receptive vocabulary, $F(2, 72) = 6.79, p = .002$, but no significant group differences were obtained on English word reading ($p = .076$) or spelling ($p = .076$). The English-L1 children were significantly better on nonverbal reasoning than the English monolingual children (Scheffé $p = .015$), while the Mandarin-L1 children were not significantly different from either of those two groups (English monolingual: Scheffé $p = .078$; English-L1: Scheffé $p = .785$). In addition, the Mandarin-L1 children were significantly poorer on receptive vocabulary compared to English monolingual (Scheffé $p = .003$) and English-L1 children (Scheffé $p = .029$), while the English-speaking groups were not significantly different from each other (Scheffé $p = .732$).
Table 2.

*Descriptive statistics for standardized tasks organized by language background group and age.*

<table>
<thead>
<tr>
<th>Measures</th>
<th>Reliability/Validity</th>
<th>Younger</th>
<th>Other</th>
<th>Younger</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>EM (n = 28)</td>
<td>EL1 (n = 29)</td>
<td>ML1 (n = 27)</td>
<td>EM (n = 25)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Nonverbal reasoning</td>
<td>.86-.88 / .53</td>
<td>108.43</td>
<td>11.75</td>
<td>117.69</td>
<td>15.38</td>
</tr>
<tr>
<td>Receptive vocabulary</td>
<td>.97 / .80</td>
<td>108.93</td>
<td>10.64</td>
<td>98.48</td>
<td>16.68</td>
</tr>
<tr>
<td>English word reading</td>
<td>.95-.97 / .73</td>
<td>106.21</td>
<td>7.93</td>
<td>105.83</td>
<td>8.96</td>
</tr>
<tr>
<td>English word spelling</td>
<td>.93-.95 / .78</td>
<td>101.61</td>
<td>9.30</td>
<td>106.76</td>
<td>11.48</td>
</tr>
</tbody>
</table>

*Note: Reliabilities and validities for the above tasks are taken from the manuals. All scores reported above are standard scores.*

EM = English monolinguals, EL1 = English-L1 bilinguals, ML1 = Mandarin-L1 bilinguals
In addition, there were no significant differences between the younger and older children on nonverbal reasoning (English monolingual: \( p = .745 \); English-L1: \( p = .878 \), Mandarin-L1: \( p = .092 \)). No significant differences between the age groups were found in English receptive vocabulary for the English monolingual \( (p = .665) \) and English-L1 \( (p = .081) \) children, but the older Mandarin-L1 children were better in English receptive vocabulary than the younger Mandarin-L1 children, \( t(50) = 1.72, p = .001 \). This was expected as older children had greater exposure to English and more years of schooling that translated to better English receptive vocabulary than the younger children.

**Group differences in phonological and orthographic processing skills**

A MANCOVA, with language background and age as between-subject factors and nonverbal reasoning and receptive vocabulary as covariates, was conducted using raw scores obtained on the three English phonological tasks (i.e., elision, blending words and silent phonological choice) as dependent variables. A second MANCOVA was carried out with the same between-subject factors and covariates but with raw scores from the three English orthographic processing tasks (i.e., orthographic choice, homophone verification and nonlexical choice) as dependent variables. Subsequent pairwise comparisons between language background groups were performed with alpha \( = .017 \) (.05/3 after Bonferroni correction). Prior to running the MANCOVAs, preliminary analyses evaluating the assumptions for analysis of covariance were met. Specifically, both nonverbal ability and receptive vocabulary were significantly correlated with phonological and orthographic skills (nonverbal ability with phonological: \( p = .032 \), nonverbal ability with orthographic: \( p = .045 \), vocabulary with phonological: \( p < .001 \), vocabulary with orthographic: \( p < .001 \)), suggesting the covariates had a linear relationship with the dependent variables. The Box’s M test were both non-significant for phonological skills \( (p = .617) \) and orthographic skills \( (p = .061) \), which fulfills the homogeneity of covariance assumption. The interaction terms between
the covariates and fixed factors (age and language background) were also non-significant (all \( p > .169 \)), fulfilling the homogeneity of regression assumption. Table 3 shows mean performance on these tasks as a function of language background group and age.

For the phonological processing tasks, no significant interaction between language background and age was found (\( p = .28 \)). There was a main effect of language background group, \( F(6, 298) = 12.49, p < .001, \eta^2_{\text{Mult}} = .36 \). English monolingual children were significantly better in phonological skills than English-L1, \( F(3, 101) = 14.69, p < .001, \eta^2_{\text{Mult}} = .30 \), and Mandarin-L1 children, \( F(3, 99) = 18.59, p < .001, \eta^2_{\text{Mult}} = .36 \). However, these significant differences were only found on the blending words (vs. English-L1, \( p < .001 \), vs. Mandarin-L1, \( p < .001 \)) and silent phonological choice tasks (vs. English-L1, \( p < .001 \), vs. Mandarin-L1, \( p = .004 \)), but not the elision task (vs. English-L1, \( p = .477 \), vs. Mandarin-L1, \( p = .768 \)). In addition, English-L1 children were also significantly better than the Mandarin-L1 children, \( F(3, 100) = 4.36, p = .006, \eta^2_{\text{Mult}} = .12 \), but only the blending words task was significant (\( p = .008 \)). A main effect of age was also obtained, \( F(3, 149) = 10.42, p < .001, \eta^2_{\text{Mult}} = .17 \). Older children were significantly better than younger children on the elision (\( p < .001 \)) and silent phonological choice tasks (\( p < .001 \)), but not the blending words task (\( p = .056 \)).

For the orthographic processing tasks, a significant interaction between language background and age was found, \( F(6, 298) = 2.43, p = .026, \eta^2_{\text{Mult}} = .09 \). Post-hoc analyses showed that the effect of language background on orthographic processing skills depended on age: there were significant language background group differences for the younger children, \( F(6, 158) = 3.51, p = .003, \eta^2_{\text{Mult}} = .22 \), but not for the older children (\( p = .074 \)). Both groups of younger bilingual children were significantly better in orthographic skills than the English monolingual children (vs. English-L1, \( F(3, 52) = 12.86, p < .001, \eta^2_{\text{Mult}} = .43 \), vs. Mandarin-L1, \( F(3, 50) = 6.54, p = .001, \eta^2_{\text{Mult}} = .28 \),

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Table 3.

Means (SDs) and score ranges of phonological and orthographic processing tasks organized by language background group and age.

<table>
<thead>
<tr>
<th>Skill</th>
<th>Task (maximum score)</th>
<th>Younger</th>
<th>Older</th>
<th>F value for main effect of group</th>
<th>F value for age x group interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>EM (n = 28)</td>
<td>EL1 (n = 29)</td>
<td>ML1 (n = 27)</td>
<td>EM (n = 25)</td>
</tr>
<tr>
<td>Phonological</td>
<td>Elision (20)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M (SD)</td>
<td>(4.16) (4.79) (5.13)</td>
<td>(4.00)</td>
<td>(5.05)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Score range</td>
<td>7 – 18 3 – 19 3 – 19</td>
<td>8 – 19</td>
<td>5 – 20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blending words (20)</td>
<td>14.00 (10.83) ***</td>
<td>(7.89) ***</td>
<td>15.08 (10.88) ***</td>
<td>(9.60) ***</td>
<td>12.49 ***</td>
</tr>
<tr>
<td>M (SD)</td>
<td>(2.52) (3.06) (2.64)</td>
<td>(2.48) (3.53) (3.27)</td>
<td>(6.34) (6.46) (6.83)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Score range</td>
<td>8 – 18 4 – 17 4 – 13</td>
<td>9 – 19 5 – 19 5 – 16</td>
<td>36 – 59 31 – 54 26 – 52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silent phonological choice (60)</td>
<td>42.14 (35.90) ***</td>
<td>(33.63) **</td>
<td>50.32 (40.76) ***</td>
<td>(40.24) **</td>
<td></td>
</tr>
<tr>
<td>M (SD)</td>
<td>(9.72) (7.76) (7.30)</td>
<td>(6.34) (6.46) (6.83)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Score range</td>
<td>21 – 57 17 – 48 22 – 49</td>
<td>36 – 59 31 – 54 26 – 52</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orthographic</td>
<td>Orthographic choice (99)</td>
<td>72.54 (80.90) ***</td>
<td>(79.19) ***</td>
<td>87.44 (89.40) ***</td>
<td>(90.32)</td>
</tr>
<tr>
<td>M (SD)</td>
<td>(10.86) (9.89) (9.31)</td>
<td>(4.86) (4.13) (5.14)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Score range</td>
<td>50 – 88 57 – 96 62 – 94</td>
<td>76 – 95 80 – 97 81 – 96</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Homophone verification (40)</td>
<td>30.89 (34.28) ***</td>
<td>(31.78) ***</td>
<td>36.76 (38.16) ***</td>
<td>(37.92)</td>
<td>6.54 ***</td>
</tr>
<tr>
<td>M (SD)</td>
<td>(4.56) (3.95) (3.78)</td>
<td>(2.45) (1.49) (1.91)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonlexical choice (33)</td>
<td>27.89 (28.59)</td>
<td>(28.33) (28.33)</td>
<td>30.48 (29.36) (29.88)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M (SD)</td>
<td>(3.08) (2.44) (2.56)</td>
<td>(2.18) (2.48) (2.03)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Score range</td>
<td>19 – 33 24 – 33 24 – 33</td>
<td>25 – 33 23 – 32 25 – 33</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: EM = English monolinguals, EL1 = English-L1 bilinguals, ML1 = Mandarin-L1 bilinguals. All scores reported above are raw scores. * Means differed significantly between EM and EL1 groups. b Means differed significantly between EM and ML1 groups. * p <.05. ** p <.01. *** p <.001.
but were not significantly different from each other ($p = .021$). However, group differences in performance were only evident on the orthographic choice (English monolinguals vs. English-L1, $p < .001$; vs. Mandarin-L1, $p < .001$) and homophone verification tasks (English monolinguals vs. English-L1, $p < .001$; vs. Mandarin-L1, $p < .001$), and not on the nonlexical choice task (English monolinguals vs. English-L1, $p = .354$; vs. Mandarin-L1, $p = .412$). In addition, there were main effects of language background, $F(6, 298) = 6.54, p < .001, \eta^2_{\text{Mult}} = .22$, and age, $F(3, 149) = 34.45, p < .001, \eta^2_{\text{Mult}} = .41$. Older children were significantly better on all orthographic processing tasks (orthographic choice: $p < .001$, homophone verification: $p < .001$, nonlexical choice: $p < .001$) compared to the younger children.

The above group differences provide support that early language exposure influences the proficiency of English phonological and orthographic processing skills. However, results suggest that these effects were dependent on the type of phonological and orthographic task used. Better phonological and orthographic skills shown in older children also supported our hypothesis that increased aural and print exposure to English over time may lead to improved phonological and orthographic skills.

**Relationships between phonological and orthographic processing skills and English word reading and spelling**

To reduce the number of predictor variables, raw scores on each phonological and orthographic processing task were standardized using the sample as a whole and composite phonological and orthographic scores were obtained by averaging the standardized scores of the three phonological and orthographic tasks respectively. The creation of the composite scores was justified by a factor analysis conducted on the raw scores obtained from the phonological and orthographic processing tasks. A maximum likelihood extraction with Promax rotation was performed and, as expected, the three phonological processing tasks loaded moderately to highly (.50-.84) on one factor,
while the three orthographic tasks loaded moderately to highly (.47-.99) on a second factor, justifying the grouping of tasks in deriving composite scores (see Table 4).

### Table 4.

**Factor matrix of the phonological and orthographic processing tasks.**

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Factor I</th>
<th>Factor II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elision</td>
<td>.84</td>
<td>-.05</td>
</tr>
<tr>
<td>Blending words</td>
<td>.50</td>
<td>.39</td>
</tr>
<tr>
<td>Phonological choice</td>
<td>.73</td>
<td>.33</td>
</tr>
<tr>
<td>Orthographic choice</td>
<td>-.00</td>
<td>.99</td>
</tr>
<tr>
<td>Homophone verification</td>
<td>.12</td>
<td>.84</td>
</tr>
<tr>
<td>Nonlexical choice</td>
<td>.12</td>
<td>.47</td>
</tr>
</tbody>
</table>

Before further analyses were conducted, an investigation into the distribution of the composite scores showed that Shapiro-Wilk tests of normality were non-significant (all $p > .12$) except for the orthographic composite score in young English-L1 children ($p = .018$). However, further examination showed this distribution was not skewed (statistic = -.612) nor had excessive kurtosis (statistic = -.673), and so, these composite scores were used in the following analyses.

Bivariate correlations were first carried out to determine the associations between underlying sub-skills and English word reading and spelling. As Table 5 shows, the pattern of associations between phonological and orthographic skills, and word reading and spelling differed across groups and ages, suggesting that the type of skill used depends on language background and may change over time.
Table 5.

Correlations of phonological processing skills, orthographic processing skills, English word reading and spelling as a function of age and language background group.

<table>
<thead>
<tr>
<th></th>
<th>Phonological skills</th>
<th>Orthographic skills</th>
<th>English word reading</th>
<th>English word spelling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EM</td>
<td>EL1</td>
<td>ML1</td>
<td>EM</td>
</tr>
<tr>
<td>Phonological skills</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EM</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>.34</td>
</tr>
<tr>
<td>EL1</td>
<td>.34</td>
<td>.46*</td>
<td>.34</td>
<td>.52**</td>
</tr>
<tr>
<td>ML1</td>
<td>.34</td>
<td>.46*</td>
<td>.34</td>
<td>.69***</td>
</tr>
<tr>
<td>English word reading</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EM</td>
<td>.44*</td>
<td>.52**</td>
<td>.69***</td>
<td>.47*</td>
</tr>
<tr>
<td>EL1</td>
<td>.53**</td>
<td>.34</td>
<td>.47*</td>
<td>.18</td>
</tr>
<tr>
<td>ML1</td>
<td>.73***</td>
<td>.56**</td>
<td>.18</td>
<td>.57**</td>
</tr>
<tr>
<td>English word spelling</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EM</td>
<td>.35</td>
<td>.34</td>
<td>.65***</td>
<td>.47*</td>
</tr>
<tr>
<td>EL1</td>
<td>.34</td>
<td>.65***</td>
<td>.47*</td>
<td>.58**</td>
</tr>
<tr>
<td>ML1</td>
<td>.75***</td>
<td>.71***</td>
<td>.73***</td>
<td>.78***</td>
</tr>
</tbody>
</table>

Note: Correlations above the diagonal represent associations for younger children, whereas correlations below the diagonal represent those for older children. Younger English monolinguals (EM) N = 28, older EM N = 25; younger English-L1 bilinguals (EL1) N = 29, older EL1 N = 25; younger Mandarin-L1 bilinguals (ML1) N = 27, older ML1 N = 25.

* p < .05.  ** p < .01.  *** p < .001.
Both phonological and orthographic processing skills were significantly correlated with word reading for young English monolingual and English-L1 children, whereas only phonological skills were significantly correlated for the Mandarin-L1 children. The older English-speaking children showed lower correlations between both skills and word reading. Only phonological processing skills were significantly correlated for the English-L1 children, while both phonological and orthographic processing skills were significant for the English monolingual children. Unlike the English-speaking children, the older Mandarin-L1 children showed higher correlations between both skills and word reading with both phonological and orthographic skills found to be significantly correlated with reading. Both phonological and orthographic processing skills had significant correlations with spelling for all three groups of younger children. Again, the older English-speaking children showed lower correlations between skill type and spelling with orthographic skills the only significant association for these children. The older Mandarin-L1 children showed larger correlations and both skill types were significantly correlated with spelling. However, when group comparisons on these correlations (e.g., phonological skills with reading for English monolinguals vs. English-L1 adults) were conducted, only the correlation between orthographic skills and reading for the younger English monolingual children was significantly larger than the correlation for younger Mandarin-L1 children ($p = .009$). This suggests that the younger English monolingual children may rely more on orthographic skills than the younger Mandarin-L1 children for English word reading.

To determine the contribution of each skill type to English word reading and spelling, regression analyses were conducted for each language background group as a function of age for word reading (see Table 6) and spelling (see Table 7) separately. Nonverbal reasoning and receptive vocabulary abilities were entered first, followed by the composite scores representing either phonological or orthographic processing skill.
Due to the small sample size, it was not considered appropriate to include phonological and orthographic processing skills in the same analysis, and so, the following analyses examine the unique contribution of each skill set over and above the contribution of nonverbal reasoning and receptive vocabulary. The degree of collinearity for all regression analyses was found to be acceptable (tolerance > .52, VIF < 1.81).

**Predicting English word reading.** For the younger children, phonological processing skills, but not orthographic skills, accounted for 15% of unique variance in word reading for the English-L1 group, $F(1, 25) = 8.10, p = .009$, and 22% for the Mandarin-L1 group, $F(1, 23) = 6.91, p = .015$, over and above non-verbal reasoning and receptive vocabulary. Though phonological processing did not explain any unique variance in word reading for the English monolingual children, orthographic processing skills did account for 36% of unique variance, $F(1, 24) = 20.60, p < .001$. A similar pattern emerged for the older children, with phonological, but not orthographic processing skills, accounting for significant unique variance for the bilingual children (English-L1: 12%, $F(1, 21) = 5.17, p = .034$; Mandarin-L1 children: 24%, $F(1, 21) = 12.98, p = .002$), whereas orthographic, but not phonological processing skills, uniquely explained 25% of variance in word reading for the English monolingual children, $F(1, 21) = 9.79, p = .005$. These results suggest that the subskills relied upon for word reading differ according to language background: phonological skills are more important for bilingual than monolingual children and orthographic skills are more important for monolingual than bilingual children. This pattern of reliance may not change across the two age groups assessed in this study.

Power analyses were conducted for all non-significant regression analyses. These revealed that for reading, we had power to find an effect (> .80) for 2 out of the 6 non-significant findings, but did not do so. For the remaining 4 non-significant findings, power analyses revealed that for effect sizes of this magnitude, between 85 to 810
Table 6.

Hierarchical regression predicting English word reading from phonological and orthographic processing skills as a function of age and language background group.

<table>
<thead>
<tr>
<th>Step/Variable</th>
<th>Younger age group</th>
<th>Older age group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \beta )</td>
<td>( t )</td>
</tr>
<tr>
<td>English monolinguals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Nonverbal reasoning</td>
<td>.03</td>
<td>.16</td>
</tr>
<tr>
<td>2. Phonological processing skills</td>
<td>.45</td>
<td>1.92</td>
</tr>
<tr>
<td>2. Orthographic processing skills</td>
<td>.65</td>
<td>4.54</td>
</tr>
<tr>
<td>English-L1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Nonverbal reasoning</td>
<td>-.05</td>
<td>-.28</td>
</tr>
<tr>
<td>2. Phonological processing skills</td>
<td>.50</td>
<td>2.85</td>
</tr>
<tr>
<td>2. Orthographic processing skills</td>
<td>.29</td>
<td>1.55</td>
</tr>
<tr>
<td>Mandarin-L1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Nonverbal reasoning</td>
<td>.12</td>
<td>.53</td>
</tr>
<tr>
<td>2. Phonological processing skills</td>
<td>.56</td>
<td>2.63</td>
</tr>
<tr>
<td>2. Orthographic processing skills</td>
<td>.11</td>
<td>.48</td>
</tr>
</tbody>
</table>

* Similar results were obtained when phonological and orthographic skills were entered as separate blocks in the same regression model and with the order of entry reversed.

Younger English monolinguals \( N = 28 \), older \( N = 25 \); younger English-L1 bilinguals \( N = 29 \), older \( N = 25 \); younger Mandarin-L1 bilinguals \( N = 27 \), older \( N = 25 \).

\( * p < .05 \) \( ** p < .01 \) \( *** p < .001 \).
participants would be required to find a significant contribution of either phonological skills or orthographic skills.

**Predicting English word spelling.** For the younger children, the significant predictors of English word spelling were similar to that for English word reading. Phonological processing skills, but not orthographic processing skills, uniquely explained 11% of variance in spelling for the English-L1 children, \( F(1, 25) = 5.25, p = .031 \), and 18% for the Mandarin-L1 children, \( F(1, 23) = 7.00, p = .014 \). The only significant predictor for the younger English monolingual children, however, was orthographic processing skills which accounted for an additional 23% of variance in English word spelling, \( F(1, 24) = 8.48, p = .008 \), over and above non-verbal reasoning and receptive vocabulary. For the older children, both phonological and orthographic processing skills were significant predictors for the Mandarin-L1 children, with phonological skills accounting for an additional 25% of variance, \( F(1, 21) = 10.71, p = .004 \), and orthographic skills accounting for an additional 24% of variance, \( F(1, 21) = 9.80, p = .005 \). Orthographic processing skills were also important for the older English monolingual children, accounting for 23% of variance, \( F(1, 21) = 6.99, p = .015 \). However, neither phonological nor orthographic processing skills accounted for any unique variance in English word spelling for the older English-L1 children. Again, the significant predictors found for the different language background groups suggests the extent to which phonological and orthographic skills are used for English word spelling depends on the L1: phonological skills were more important for the bilingual than the monolingual children, whereas orthographic skills appear more important for the monolingual than bilingual children, particularly in the younger age group. Unlike reading, our results suggest that the skills relied on for spelling may change over time, specifically for the bilingual children as orthographic skills were found to be more
Table 7.

*Hierarchical regression predicting English word spelling from phonological and orthographic processing skills as a function of age and language background group.*

<table>
<thead>
<tr>
<th>Step/Variable</th>
<th>Younger age group</th>
<th></th>
<th></th>
<th></th>
<th>Older age group</th>
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<tbody>
<tr>
<td></td>
<td>β</td>
<td>t</td>
<td>Adj. R²</td>
<td>Δ R²</td>
<td>β</td>
<td>t</td>
<td>Adj. R²</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Receptive vocabulary</td>
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<td>1.61</td>
<td>.05 .12</td>
<td>.18 .86</td>
<td>.61 .01 .09</td>
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<td></td>
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<tr>
<td>2. Phonological processing skills</td>
<td>.42</td>
<td>1.72</td>
<td>.12 .10</td>
<td>.30 1.39</td>
<td>.05 .08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2. Orthographic processing skills</td>
<td>.52</td>
<td>2.91**</td>
<td>.27 .23**</td>
<td>.49 2.64*</td>
<td>.22 .23*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>English-L1</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1. Nonverbal reasoning</td>
<td>-.08</td>
<td>-.47</td>
<td>.22 1.10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Receptive vocabulary</td>
<td>.62</td>
<td>3.56**</td>
<td>.30 .35**</td>
<td>.47 2.37*</td>
<td>.31 .37**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Phonological processing skills</td>
<td>.44</td>
<td>2.29*</td>
<td>.40 .12</td>
<td>.58 .29</td>
<td>.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2. Orthographic processing skills</td>
<td>.23</td>
<td>1.14 .31</td>
<td>.29 1.74</td>
<td>.37 .08</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Mandarin-L1</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>1. Nonverbal reasoning</td>
<td>.22</td>
<td>1.09</td>
<td>-.16 -.79</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Receptive vocabulary</td>
<td>.34</td>
<td>1.67 .17</td>
<td>.23* .56</td>
<td>2.75* .20</td>
<td>.26*</td>
<td></td>
<td></td>
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<tr>
<td>2. Phonological processing skills</td>
<td>.51</td>
<td>2.65*</td>
<td>.34 .18*</td>
<td>.54 3.27**</td>
<td>.44 .25**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2. Orthographic processing skills</td>
<td>.33</td>
<td>1.78 .24</td>
<td>.9 .65</td>
<td>3.13**</td>
<td>.43 .24**</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Similar results were obtained when phonological and orthographic skills were entered as separate blocks in the same regression model and with the order of entry reversed.


* p < .05. ** p < .01. *** p < .001.
important for the older than younger children, though this was only significant for the older Mandarin-L1 children.

Power analyses conducted for the non-significant regression analyses for spelling revealed that for 3 out of the 6 non-significant findings, we did have power to find an effect (>0.80), but did not do so. For a further 2 of the non-significant findings, the power analyses revealed that, based on the obtained effect sizes, between 155 and 491 participants would be required to find a significant contribution of either phonological skills or orthographic skills. The contribution of orthographic skills in the older English-L1 group, which would have required 57 children to achieve significance based on the obtained effect size, was considered underpowered, and so, the results from this analysis should be treated with caution. Future research would benefit from exploring the contribution of orthographic skills in this group further.

**Discussion**

Phonological and orthographic skills are important for English monolingual children for the successful acquisition of English (Vellutino et al., 2007). Though similar skills have been implicated for ESL bilinguals (McBride-Chang & Kail, 2002), gaining an understanding of the growth of such skills in bilingual children and determining whether the types of skills that are important differ at various stages of literacy may shed light on the influence of early linguistic experience on learning an L2. In this cross-sectional study, we investigated the contribution of English phonological and orthographic skills to English word reading and spelling in three groups of younger (8-9 years) and older (11-12 years) children from different language backgrounds (English monolingual, English-L1 and Mandarin-L1). Our first objective was to compare the proficiency of such skills between age groups and across the three language background groups. The second objective was to determine the contribution of
each skill to English word reading and spelling for each age group and language background group.

The results showed that performance on the English phonological and orthographic tasks depended on children’s age and language background. As expected, the older children performed better on both the phonological and orthographic tasks than the younger children. With greater aural and print exposure in English, it is no surprise that children gradually pick up extensive letter-sound knowledge, as well as retain more sight words that allow them to recognize familiar patterns in the writing system (see Ehri, 2005). The finding that the older children showed better phonological and orthographic processing skills across all language background groups suggests that as children become more proficient in English, they become sensitive to the structure of the language they are learning, with even Mandarin-L1 children able to pick up on target skills required for L2 learning. However, this does not imply that the Mandarin-L1 children were able to reach proficiency levels similar to the English-speaking children in those target skills.

In fact, results obtained in this study suggest that the early linguistic experience of an L1 with contrasting linguistic properties may have an impact on the development of underlying sub-skills that support L2 literacy, and that this influence may still be evident at later stages of literacy even after continued exposure to the L2. The Mandarin-L1 children performed the poorest of the three groups on phonological processing, but not orthographic processing. This is consistent with previous cross-linguistic research showing that Chinese-speaking children have poorer phoneme awareness compared to English monolinguals (Cheung et al., 2001; Wang & Geva, 2003a) or English-L1 children (Yeong & Rickard Liow, 2012; Bialystok, McBride-Chang, & Luk, 2005) but stronger visual-orthographic skills (Wang & Geva, 2003a). Characteristics of the Chinese language, such as the simple phonological structure and
logographic script, encourage word-specific knowledge and an emphasis on visual-orthographic patterns but not the understanding of sound units in the language (McBride-Chang & Chen, 2003). Furthermore, the differences in proficiency in phonological skills were consistent across both younger and older children, suggesting that the influence of the L1 may persist late into childhood despite the continued exposure to English in the school curriculum (see Yeong & Rickard Liow, 2012).

Though English-L1 children were found to have significantly better phonological processing skills than the Mandarin-L1 children, their performance was not on par with the English monolingual children. This was unexpected, but could be explained by English-L1 children’s lower usage and exposure to English (as reflected in the LBQ) compared to English monolinguals. Hence, for the English-L1 children, having a certain amount of exposure to an L2 (i.e., Mandarin) may reduce the particular benefits gained from the dominant L1 (i.e., English) compared to the English monolinguals who have no exposure to any L2. However, learning an L2 may have its advantages as research suggests that cross-language transfer can be bidirectional (Bialystok et al., 2005; Chen, Xu, Nguyen, Hong & Wang, 2010). Transfer of a skill often takes place from the more complex language to the simpler language (Caravolas & Bruck, 1993; Durgunoglu & Oney, 1999). This may account for the superior orthographic processing skill in the younger English-L1 compared to English monolingual children, since Mandarin has a logographic script with a greater complexity of characters which encourages a reliance on visual-orthographic skills.

Another possible reason for why both bilingual groups demonstrated better orthographic skills is that being bilingual confers an advantage in understanding the structure of languages (Galambos & Goldin-Meadow, 1990), which may lead to better recognition of common letter patterns, rimes and morphemes in English. However, the older bilingual children did not show this advantage in orthographic skills, suggesting that
English monolingual children are able to consolidate such skills over time with exposure and improved proficiency in English.

It is worth noting that language background differences were found in certain phonological and orthographic tasks but not others. For example, the bilingual children were poorer on the blending words and the silent phonological choice tasks than the monolingual children. Though blending phonemes is considered to be an easier task than deleting phonemes (Yopp, 1988), our results suggest that the English-Mandarin bilingual children found both tasks equally difficult and perhaps even found the deletion task to be easier than blending. A possible explanation is that as real words were used, children may be using the alternative strategy of removing letters that represent phonemes from the spellings of words to derive the correct responses. In addition, poorer performance on the silent phonological choice task is to be expected as it is a more complex task that requires both sounding out and blending.

As for the orthographic tasks, the differences in performance highlight the multidimensional construct of orthographic processing skills (Hagiliassis et al., 2006). The younger English-L1 and Mandarin-L1 children were better in tasks assessing orthographic processing at the word-specific/lexical level (i.e., orthographic choice and homophone verification tasks), but performed similarly to English monolingual children on the task measuring general orthographic knowledge at the sublexical letter-patterns level (i.e., nonlexical choice task; see Apel, 2011). These performance differences lend further support to the suggestion of better whole-word visual-orthographic skills in the English-Mandarin bilinguals as a result of exposure to a logographic language such as Mandarin.

The results of the regression analyses suggest that certain subskills contribute more than others to English word reading and spelling for children from different language background groups and that this may change at a later developmental stage,
such as over time with age and increased proficiency in English. Surprisingly, orthographic skills, but not phonological skills, contributed to English word reading and spelling for both the younger and older English monolingual children. Although this may seem contrary to the ages associated with Ehri’s (1995) phase model of literacy development, the younger English monolingual children in our study may have already possessed extensive letter-sound knowledge (i.e., past the full-alphabetic phase) and so, become reliant on an alternative strategy, such as the use of orthographic skills, for word reading and spelling (Scarborough, et al., 1998). Rittle-Johnson and Siegler (1999) showed that by 8 years of age, children showed increasing use of analogy and retrieval (i.e., large-unit orthographic processing skills) to aid spelling accuracy. This is not to imply that children no longer use their phonological skills (see Sprenger-Charolles, Siegel, Bechennec & Serniclaes, 2003), but may lend credence to the proposal that phonological and orthographic skills develop in parallel and orthographic skills are available at a much younger age (Cassar & Treiman, 1997; Ziegler & Goswami, 2005) than that proposed by the phase model.

On the other hand, the more important predictor of word reading and spelling for the younger English-L1 and Mandarin-L1 children, compared to the English monolingual children, was phonological skills. Despite their poorer phonological skills, these young bilingual children continued to rely on such skills for reading and spelling English. These findings are similar to studies conducted with Chinese-L1 children where the strongest predictor of English word reading and word spelling approximations was phonological awareness (Gottardo, et al., 2001; McBride-Chang & Kail, 2002; Yeong & Rickard Liow, 2011). Furthermore, our findings showed that the same relationship between phonological skills and reading was evident for the older bilingual children. The importance of phonological skills as a predictor of English literacy, especially English word reading, for bilingual children and adults attests to the
importance of the alphabetic principle for acquiring alphabetic languages. Wang et al. (2003) suggested that because of the distinct structural differences between English and Mandarin, Chinese ESL learners may treat English as a separate language system and pick up skills (i.e., phonological skills) that are essential to acquiring English rather than relying on the transfer of skills (i.e., orthographic skills) from Mandarin. Given the greater reliance on phonological skills and the lack of a significant contribution of orthographic skills, it is possible that the transfer of orthographic skills only occurs at the beginning stages of learning English and its reliance is reduced once phonological skills improve with increasing proficiency in English (Wang et al., 2003). Another reason for the mixed findings in the literature regarding the influence of orthographic skills is that there has been no consistency in the types of orthographic processing measures used across studies. Hence, different measures of orthographic processing involving various other factors (e.g., semantic and syntactic) have been used across studies (e.g., Leong et al., 2005). Moreover, some studies have only measured orthographic processing skill in Mandarin (e.g., Tong & McBride-Chang, 2010; Wang et al., 2005) which makes it difficult to compare results with studies that have used English-based measures of orthographic processing.

Although the predictors for English word reading were the same in middle primary and upper primary for bilingual children, our results showed that the skills underlying spelling were different for the older compared to the younger bilingual children. While both groups of bilingual children relied more on phonological skills for English word spelling when younger, orthographic skills were just as important for older Mandarin-L1 children. Though orthographic skills contributed more variance than phonological skills to English word spelling for the older English-L1 children, neither phonological nor orthographic processing was a significant predictor of spelling for the older English-L1 children. This seems to suggest that bilingual children are sensitive to
the different task requirements for spelling compared to reading as other skills besides phonological processing are required. Spelling is known to be more difficult than reading because there are more ways to spell a given word than to read it (e.g., /sæt/ can be spelled as *sight*, *site*, or *cite*), that is, phoneme-to-grapheme mappings are more inconsistent than grapheme-to-phoneme mappings (Bosman & Van Orden, 1997). For older Mandarin-L1 children with poor phonological processing, relying on whole-word or sublexical attributes of the English writing system is considered an adaptive behaviour (Figueredo, 2006) and is likely to be in response to the inconsistency of phoneme-grapheme patterns. For reading, however, it may be easier to still use decoding strategies through grapheme-phoneme correspondences.

The finding that different skills predicted English word reading and spelling, depending on the language background of the children, raises further questions as to whether bilingual children, even English-L1 children, are similar to English monolingual children in terms of the skills that are used at various stages of literacy development. Cross-linguistic studies have shown that bilingual children tend to rely on their L1 knowledge and that this reliance decreases over time as children gain L2 knowledge (Wang & Geva, 2003a, b). With increasing knowledge of the importance of letter-sound correspondences for reading and spelling in English, young bilingual children may tend to rely on phonological processing skills over a longer period of time than English monolingual children. Older bilingual children may continue to use or fall back on phonological processing skills, especially for English word reading, due to a smaller sight vocabulary compared to English monolinguals, which would make bilingual children less able to rely on automatic memory retrieval processes (Ehri, 2005). Figueredo (2006) proposed that frequency of strategy use and rate of learning English rules for reading and spelling would depend on language proficiency levels and the linguistic distance between the L1 and L2. As an objective measurement of L1
proficiency in the Mandarin-L1 children was not available in this study, future research should consider L1 proficiency to determine if this influenced any transfer of underlying skills as well as reliance on certain skills (Cummins, 1991). The inclusion of Mandarin phonological and orthographic measures in future studies would also add to our understanding of whether children apply their L1 skills to their L2. It should also be noted that the sample size of each language background group was small, which may, potentially, have restricted the variability in scores within each group. Small sample-to-variable ratios for the regression analyses would have limited the power to find significant effects and contributed to some of the non-significant findings. Hence, conclusions about group differences found in the types of skills that contributed to reading and spelling should be treated with caution as all but one of the correlations between skills and reading or spelling did not differ significantly among the three groups. Further research is needed to corroborate the findings of the current study. It might also be useful to consider a longitudinal study to verify that bilingual children’s English literacy development may be different from that of English monolingual children. As the 8- to 9-year-old English monolingual children showed a reliance on the use of orthographic skills, starting with preschool children in the longitudinal study may provide insight as to the age when these children shift from the use of phonological skills to the more dominant strategy of orthographic processing. Longitudinal studies can also help disambiguate the bidirectional effects between cognitive-linguistic skills, such as phonological and orthographic skills, and literacy skills.

Despite the above limitations, the findings reported in this study reinforce the view that the language a child is first exposed to in the home can influence the development of English literacy, and that this impact may continue through to late childhood. More importantly, not only does early linguistic exposure affect the proficiency of underlying skills critical for English literacy, but it may also affect the
extent to which different skills are important at different stages of English literacy for bilingual children. Though the children in this study may be equally proficient in English word reading and spelling, the difference in proficiency in underlying skills and the reliance on different skills for the children from different language backgrounds and at different stages of literacy, suggest that children may take different routes to attain similar outcomes. However, the question remains as to which pathway is the most efficient. Furthermore, underlying skills, such as phonological and orthographic processing, are also important for other outcomes such as reading comprehension (e.g., Bell & Perfetti, 1994; Nassaji, 2003; Stanovich, 2000) and reading fluency (e.g., Georgiou, Parrila, Kirby & Stephenson, 2008). Thus, it is important to assess an individual’s proficiency in underlying skills, which may impact more complicated literacy tasks. The fact that the older bilingual children did not reach levels of proficiency in phonological processing skills that were equal to English monolinguals, despite continued exposure to English, has implications for the education of ESL/bilingual learners of English. If we assume that English monolingual children are using the most efficient strategy, young bilinguals could be helped to establish their pre-linguistic skills so that they, in turn, can move past phonological processing and make use of orthographic processing skills. This could be in the form of an explicit phonics training program to enhance their phonological processing skills at an early age (Stuart, 1999). Improvements to their phonological skills may allow greater access and exposure to varied texts, hence at the same time improving children’s sight word vocabulary. There would also be a need for teachers to appreciate differences in bilingual children’s task approaches, such as any application of skills from their L1 onto English, but also explicitly teach structures and knowledge that is appropriate to English as not all L1 skills are advantageous to learning English (Figueroedo, 2006). Hence, the relationship between the L1 and L2 and the cognitive-linguistic processing abilities brought by the
ESL/bilingual children to learning of the L2 need to be considered for these children to have a secure foundation for English literacy.
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Appendix A

Pattern matrix obtained for the phonological and orthographic processing tasks.

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<th>Tasks</th>
<th>Factor I</th>
<th>Factor II</th>
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<tbody>
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<td>Elision</td>
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<td>Blending words</td>
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<td>Phonological choice</td>
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</tr>
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<td>Orthographic choice</td>
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<td>1.02</td>
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<tr>
<td>Homophone verification</td>
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<td>.84</td>
</tr>
<tr>
<td>Nonlexical choice</td>
<td>.08</td>
<td>.46</td>
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</table>
Appendix B

*Structure matrix obtained for the phonological and orthographic processing tasks.*

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<tr>
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</tr>
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</tr>
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<tr>
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<td>.40</td>
</tr>
<tr>
<td>Orthographic choice</td>
<td>.19</td>
<td>.99</td>
</tr>
<tr>
<td>Homophone verification</td>
<td>.28</td>
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<td>Nonlexical choice</td>
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Chapter 4

Phonological and Orthographic Skills in English Children with Dyslexia: Are They Similar in Profile to Mandarin-English Bilingual Children?
Abstract

Research suggests that children with dyslexia have a differential pattern of phonological and orthographic skills with phonological skills weaker than orthographic skills (e.g., Stanovich & Siegel, 1994), similar to Mandarin-English bilinguals. Our study compared the phonological and orthographic skills of English monolingual children with dyslexia to chronological age (CA) matched and reading age (RA) matched children from different language backgrounds (English monolingual, Mandarin first language (L1)-English second language (L2), English L1-Mandarin L2 children), to determine if children with dyslexia share a similar cognitive profile with the bilingual children, who do not have literacy difficulties. We also examined the contributions of phonological and orthographic skills to English reading and spelling in the children with dyslexia to understand how they approach literacy tasks. Results showed that the children with dyslexia were similar to the RA matched English monolinguals in terms of phonological and orthographic skills, had better phonological skills than the RA and CA matched bilingual children, but were poorer than the CA matched English monolingual children. They showed poorer orthographic skills than the Mandarin-L1 RA matched children, yet were similar to the English-L1 RA matched children. They also had poorer orthographic skills than all three groups of CA matched children. Regression analyses found only orthographic skills to be significant for word reading and spelling in the children with dyslexia. These results are inconsistent with proposals that children with dyslexia have relatively better orthographic than phonological skills, suggesting they may be more similar to typically developing English monolinguals than expected.
It is well established that a phonological processing deficit, in particular, poor phonological awareness, is the core problem in dyslexia that leads to poor literacy skills (see Vellutino, Fletcher, Snowling & Scanlon, 2004, for a review). Cross-linguistic research shows that certain English Second Language (ESL) bilinguals, those with a nonalphabetic first language (L1), resemble English monolinguals with dyslexia in having poor phonological awareness and yet do not have the same difficulty with English reading and spelling (e.g., Yeong, Fletcher & Bayliss, 2014). It has been suggested that such bilinguals rely on compensatory skills, such as orthographic processing, acquired from their L1 to aid in their acquisition of their second language (L2), English (Leong, Tan, Cheng & Hau, 2005; Tong & McBride-Chang, 2010; Wang & Geva, 2003). Similar claims have been made with regards to children with dyslexia, in particular, that they rely on their relatively better orthographic processing skills to make up for their poor phonological processing skills (e.g., Siegel, Share & Geva, 1995). However, though much research has focused on phonological processing in children with dyslexia, less is known about orthographic processing in these children. Hence, there is a need to examine orthographic processing skills in children with dyslexia to determine if their cognitive profile is similar to ESL bilinguals with a nonalphabetic L1. In addition, comparing the approach to English literacy taken by children with dyslexia relative to bilinguals with English as a L2 may further our understanding as to why children with dyslexia have poor literacy skills while ESL bilinguals do not. This has implications for how educators can remediate literacy difficulties. In this study, we compare a group of children with dyslexia with chronological age (CA) matched and reading age (RA) matched children from three different language backgrounds (English monolingual, English L1-Mandarin L2, and Mandarin L1-English L2) on their phonological and orthographic processing skills and explore the relationships between these skills and English reading and spelling in the English children with dyslexia.
**Phonological and orthographic processing skills in English monolingual children**

Phonological processing is crucial for learning to read and spell in English (Adams, 1990; Byrne, 1998; McBride Chang, 1995; Wagner & Torgesen, 1987). In particular, phonological awareness, which is the ability to recognise, identify, and manipulate sound units in the spoken language (Gillon, 2004), is a robust predictor of English word reading and spelling ability in young monolingual children (Rack, Hulme, Snowling, & Wightman, 1994; Swanson, Trainin, Necoechea, & Hammill, 2003). Given the alphabetic nature of the English language, it is hardly surprising that understanding the correspondences between graphemes and phonemes is important. However, because of the inconsistency in English, where a phoneme can have multiple spellings or a letter or group of letters can have multiple pronunciations, the successful acquisition of English also requires knowledge of larger orthographic units (i.e., rimes, syllables, and even whole words, Treiman, Mullennix, Bijeljac-Badic & Richmond-Welty, 1995, see also Ziegler & Goswami, 2005). This knowledge of individual word-specific forms or chunks of orthographic units, coupled with an understanding of the attributes of the writing system that are linked to phonological, semantic, morphological and syntactic information of the language, is known as orthographic processing (Hagiliassis, Pratt, & Johnston, 2006).

Many studies have highlighted the importance of both phonological and orthographic processing for English word reading and spelling. Roman, Kirby, Parrila, Wade-Woolley and Deacon (2009) showed that these two skills made unique contributions to English reading in older children in Grades 4, 6, and 8, and Badian (1994) found that both skills measured at Kindergarten predicted Grade 1 reading and spelling independently (see also, Stanovich, West & Cunningham, 1991). However, there are mixed findings as to whether children develop and use both types of skills in parallel or shift from the use of phonological skills to orthographic skills as they get
older and more proficient in reading. According to Ehri’s (1995) phase model, children begin by relying on their phonological skills in learning how to read, but as they make connections between the letters and sounds, they start to recognise familiar letter patterns in rimes, syllables and morphemes, hence acquiring orthographic skills. Evidence for this comes from de Jong and van der Leij (1999; see also, de Jong & van der Leij, 2002) who found that phonological skills were less important in Dutch readers after 6 years of age, and Roman et al. (2009) who found that older English monolingual children (age 9 years) shifted to a greater reliance on orthographic than phonological skills when reading real words. In contrast, Brown and Deavers (1999) found that children between the ages of 6 to 10 were able to use both phonological skills and orthographic skills when reading, and Ouellette and Senechal (2008) showed that orthographic skills predicted young children’s (age 5 years) invented spellings. This suggests that both skills are available for use even in young beginning readers.

**Phonological and orthographic processing skills in Mandarin-English bilingual children**

Unlike English, Mandarin has a simpler phonological structure (i.e., CVC or CVV or CVVC with only two legitimate final consonants /n/ or /ŋ/) with mostly open syllables and no consonant clusters, but with complex orthographic characters made up of strokes with different visual patterns and structure (Hua, 2002; Li, 1993). The linguistic properties of a child’s language are known to impact the development of phonological and orthographic skills (Caravolas & Bruck, 1993; Cheung, Chen, Lai, Wong, & Hills, 2001; Durgunoglu & Oney, 1999; Rickard Liow & Poon, 1998), and several studies have shown that Mandarin-L1 children develop and rely on phonological and orthographic skills differently from English monolinguals.

For example, Mandarin-L1 children show poorer phoneme awareness compared to English-L1 or English monolingual children, which has been attributed to the lack of
saliency of phonemes in Mandarin. Cheung et al. (2001) found that pre-literate English monolingual children from New Zealand performed significantly better than Chinese children from China and Hong Kong on a sound-matching task, and McBride-Chang, Bialystok, Chong, and Li (2004) found Chinese Cantonese-speaking children to have poorer phoneme awareness on an English phoneme onset deletion task compared to English monolingual children, even though they had similar levels of syllable awareness (see also meta-analysis by Branum-Martin, Tao, Garnaat, Bunta & Francis, 2012; Tong & McBride-Chang, 2010; Yeong, et al., 2014; Yeong & Rickard Liow, 2012). In contrast, given the importance of orthographic skills in learning the large number of complex characters in Mandarin, it has been suggested that Mandarin-L1 children pay more attention to visual-orthographic patterns which in turn promotes a whole word approach to learning English (Rickard Liow & Lau, 2006; see also, Perfetti & Dunlap, 2008). This is substantiated by Wang and Geva (2003) who found Chinese-L1 children to have better visual-orthographic skills than English monolingual children as shown by their better performance when recalling orthographically illegal unpronounceable letter strings (e.g., PCTH, see also, Wang, Koda & Perfetti, 2003).

Despite the differences between Mandarin-L1 and English-L1 or English monolingual children in their proficiency in phonological and orthographic skills, both skills are important for Mandarin-L1 children when learning English. For example, phonological awareness was shown to predict English word reading (McBride-Chang & Kail, 2002) and word spelling approximations in Mandarin-L1 kindergarten children (Yeong & Rickard Liow, 2011), while orthographic skills made a unique contribution to English word reading and spelling even after accounting for phonological skills in 8- to 11-year-old Cantonese-L1 children (Leong et al., 2005; Tong & McBride-Chang, 2010). However, recent findings by Yeong et al. (2014), suggest that Mandarin-L1 children may take different pathways in acquiring literacy from English monolingual children.
They found that phonological skills were more important for 8- and 11-year-old Mandarin-L1 children than for same-aged English monolingual children for English word reading, whereas orthographic skills were found to be more important for the English monolingual children than the Mandarin-L1 children. An additional finding was that though the skills relied on for English word reading were the same for both younger and older children, for English word spelling, phonological skills were the only significant contributor for younger Mandarin-L1 children while both phonological and orthographic skills contributed significantly for the older Mandarin-L1 children (see also, Yin, Anderson & Zhu, 2007). This is in contrast to the finding that orthographic skills were the only significant contributor to English word spelling for both younger and older English monolingual children (Yeong et al., 2014).

**Phonological and orthographic processing skills in English monolingual children with dyslexia**

Given the compelling evidence for the importance of phonological processing skills for reading acquisition in English, it is unsurprising that deficits in phonological processing skills are seen as the main problem for children with dyslexia (Snowling, 2000; Stanovich & Siegel, 1994, Vellutino et al., 2004). There have been many studies showing that children with dyslexia perform poorly on tasks assessing phonological skills compared to typically developing same-age readers (Manis, Custodio & Szeszulski, 1993; Olson, Forsberg, Wise & Rack, 1994; Snowling, 2000) and reading-level controls (Rack, Snowling & Olson, 1992; Stanovich & Siegel, 1994). These phonological deficits are stable and persist over time through to adulthood (Bruck, 1992; Manis et al., 1993; Wilson & Lesaux, 2001). Of all the tasks involving phonological skills, nonword reading is especially difficult for children with dyslexia, requiring both the use of grapheme-phoneme correspondences and the ability to blend sounds. However, this might be due to the nature of the nonword reading task. Stanovich and
Siegel (1994) found that children with dyslexia performed poorly on tasks that required overt production (e.g., pronunciation of nonwords in a nonword reading task) but were comparable with children matched on reading-age on tasks without overt production (e.g., nonword recognition).

Unlike the consensus on the presence of phonological deficits in children with dyslexia, there is mixed evidence with regards to their proficiency in orthographic skills. According to Ehri’s (1995) approach, children start off with phonological skills which allow them to acquire orthographic skills. Hence, children who have limited phonological skills will have difficulty acquiring orthographic skills. Share’s (1995) self-teaching hypothesis also argues for the importance of phonological skills, in particular phonological recoding which is the ability to translate print into sound and subsequently blend sounds together, for the acquisition of word-specific orthographic knowledge. Indeed, several studies have shown that children with dyslexia do have poorer orthographic processing skills than typically developing English monolingual children. When compared to typically developing chronological-age matched readers, readers with dyslexia show poorer exception word reading (Castles & Coltheart, 1993; Manis, Seidenberg, Doi, McBride-Chang & Peterson, 1996; Stanovich, Siegel & Gottardo, 1997), poorer performance in selecting the correct spelling of a word from pseudohomophones (i.e., orthographic choice task, e.g., *rane* vs. *rain*, Manis, et al., 1996), and poorer knowledge of legal and illegal letter patterns (i.e., nonlexical choice task, e.g., *filv* vs. *filk*, Stanovich & Siegel, 1994; Stanovich et al, 1997). These deficits in orthographic skills remain in adolescence (Manis, Szczuczulski, Holt, & Graves, 1990), but may be reduced in adulthood (Pennington, Lefly, Van Orden, Bookman & Smith, 1987).

However, when compared to reading-age matched controls, there is no evidence of an orthographic skill deficit. Children with dyslexia perform as well as younger
children at the same reading level in exception word reading (Griffiths & Snowling, 2002) and a range of orthographic processing tasks (Cassar, Treiman, Moats, Pollo & Kessler, 2005; Olson, Wise, Conners, Rack & Fulker, 1989; Stanovich & Siegel, 1994; Stanovich et al, 1997, see also Snowling, Hulme & Goulandris, 1994, a case study on a reader with dyslexia). When compared on their spelling errors, children with dyslexia were also found to have similar difficulties as younger spelling-matched typically developing children (e.g., consonant clusters; Cassar et al., 2005). In fact, children with dyslexia may have better orthographic skills, particularly a well-developed knowledge of permissible letter patterns, than younger typically developing children. Siegel, Share and Geva (1995) found that children with dyslexia performed better than younger reading-matched children on a task that measured probable sequences and positions of letters within words (i.e., nonlexical choice task), as did Stanovich and Siegel (1994) using a similar task.

This proficiency trade-off in phonological and orthographic processing may be an indication of the use of compensatory skills by children with dyslexia (Nation & Snowling, 1998). For example, they may be more aware of the visual components of written words and more reliant on orthographic skills because of their difficulty with phonological skills (Siegel et al., 1995; Stanovich & Siegel, 1994). Another possible explanation is that older children with dyslexia have had more exposure to print compared to younger typically developing children, but not when compared to children of their own age, thus enabling children with dyslexia to reach levels of proficiency in orthographic skill similar to the younger typically developing children (Stanovich & Siegel, 1994; Stanovich et al., 1997). This is supported by research suggesting that orthographic skill is not stable over time (Manis et al., 1993) as it is related to environmental variables such as print exposure (Cunningham & Stanovich, 1990; Griffiths and Snowling, 2002).
However, the proposal that children with dyslexia tend to rely on their orthographic skills because of relatively poorer phonological skills, was not supported by Manis et al. (1993; see also O’Brien, Van orden & Pennington, 2013). In their study, children with dyslexia were found to rely on phonological skills for word reading, similar to younger reading-age matched children. Bruck (1990) also found that adults with a history of dyslexia make regularity errors in word reading (e.g., reading pint as /pɪnt/ instead of /paɪnt/), an indication of their reliance on phonological skills. This was argued to be a “less mature” strategy, as typical readers have been shown to rely less on phonological skills with development.

**Present study**

With conflicting reports on the proficiency of orthographic skills and the role they play in word reading in individuals with dyslexia, it is important to understand the extent to which this skill is relied on by English monolingual children with dyslexia for word reading and spelling. The pattern of poor phonological skills and relatively better orthographic skills that has been described in relation to individuals with dyslexia is remarkably similar to the profile of certain English second language (ESL) bilinguals, such as Mandarin-L1 children (e.g., Wang & Geva, 2003; Yeong, et al., in press). Yet, children with dyslexia continue to have persistent difficulties with word reading through to adulthood (Vellutino et al., 2004), whereas ESL bilingual children have been shown to be able to reach similar levels of proficiency in word reading and spelling as English monolinguals (see report on L2 learners, Lesaux & Geva, 2006). Given this discrepancy in literacy achievement between English monolingual children with dyslexia and Mandarin-L1 children despite their apparent similarities in underlying skills, the question of how English monolingual children with dyslexia approach English word reading and spelling relative to Mandarin-L1 bilinguals is critical. Any differences in the proficiency of or extent to which phonological and orthographic skills are relied
upon by English monolingual children with dyslexia and bilingual children may have implications for how best to intervene and help children with dyslexia to improve their literacy skills.

To explore these issues, a group of English monolingual children with dyslexia were compared to three groups of children from different language backgrounds (English monolingual, English-L1, and Mandarin-L1), who were matched for chronological age (CA), and younger children from the same three language background groups, who were matched for reading age (RA), on their phonological and orthographic skills. Including the bilingual children allowed us to make direct comparisons with children with dyslexia in terms of their proficiency in phonological and orthographic skills. This enabled us to ascertain whether these children do have a pattern of differential phonological and orthographic skills similar to that of Mandarin-ESL learners, reflecting their ability to build orthographic skills even in the absence of proficient phonological skills. The RA groups were included to establish whether children with dyslexia resemble the profile of younger children who have underlying skills commensurate with their reading ability. This was found in previous studies (e.g., Stanovich & Siegel, 1994) where children with dyslexia did not show an orthographic skill deficit when compared to younger English monolingual readers. Determining if the profile of skills in children with dyslexia is similar to younger typical readers, whether English monolingual or Mandarin-English bilingual children, can provide answers as to whether dyslexia resembles some form of developmental delay in terms of reading achievement (see Stanovich, Nathan & Zolman, 1988).

Finally, we looked at the associations between phonological and orthographic skills and word reading and spelling for English monolingual children with dyslexia to identify the extent to which these two skills are relied upon by these children. Previous studies have examined only word reading (e.g., Manis et al., 1993), but spelling is more
difficult than reading (Bosman & Van Orden, 1997) and such problems in children with dyslexia appear to be more severe (e.g., Pennington, et al., 1986). Given the severity of spelling difficulties faced by children with dyslexia, it is imperative to find out whether these children depend on either phonological or orthographic skills for word spelling, and if they are applying “less mature” strategies similar to those used by younger typical readers. Thus, this paper aims to shed light on the proficiency of phonological and orthographic skills in English monolingual children with dyslexia, and to verify if these children show a cognitive profile similar to that of Mandarin-English bilingual children. Furthermore, we investigate the skills that children with dyslexia rely on for English word reading and spelling to clarify if these children have poor literacy skills because they approach English literacy differently from other typically developing groups of children.

Method

Participants

A total of 171 children participated in this study with the consent of their parents. The typically developing children were recruited from schools in Perth, Australia, and Singapore, and were divided into three language background groups based on a questionnaire completed by their parents (see Language Background Questionnaire, LBQ, below). These children were participants in an earlier cross-sectional study (see Yeong, et al., 2014). Children with dyslexia were recruited from independent learning and assessment clinics in Perth, Australia, and reported English to be their native language.

Children with dyslexia. There were 19 Grade 5 – 6 children with dyslexia who took part in this study. A diagnosis of dyslexia in Australia typically requires poor performance in reading and/or spelling tasks (>1SD below the normative sample mean on a standardized reading/spelling measure), and poor phonological processing skills.
(>1SD below the normative sample mean on measures of phonological awareness and/or rapid naming), but having an average intelligence score (either verbal or non-verbal ability). Children in this study were assessed and diagnosed with dyslexia by registered psychologists at least one year prior to participating in this study. These children attended mainstream schools but had additional literacy support tutors for their reading and/or spelling difficulties. This group of children had a mean age of 11.2 years and a reading age of 9.0 years, measured with a standardized word reading task (see Word Reading below).

**Chronological age (CA) matched children.** This group consisted of 73 Grade 5 – 6 children \((N = 25\) English-L1, \(N = 24\) Mandarin-L1, \(N = 24\) English monolinguals) with a mean age of 11.0 years and reading age of 10.7 years. Based on the LBQ, for the English monolingual children, parents reported English as the only language children were exposed to from birth. The English-Mandarin bilingual children were ethnic Chinese children from Singapore, who were exposed to both English and Mandarin from a young age but to varying degrees, and hence considered one language more dominant (L1) than the other. Parents of the bilingual children reported their children being exposed to their L1 significantly earlier than their L2 (English-L1: \(p < .001\); Mandarin-L1: \(p < .001\)), and that their children’s proficiency in the L1 was significantly better than in their L2 (English-L1: \(p < .001\); Mandarin-L1: \(p < .001\)). English was spoken significantly more often by parents to the English-L1 children compared to the Mandarin-L1 children \((p < .001)\), whereas Mandarin was spoken significantly more often to Mandarin-L1 children than to English-L1 children \((p < .001);\) see Yeong et al., 2014, for more details).

**Reading age (RA) matched children.** There were 79 Grade 2 – 3 children \((N = 26\) English L1, \(N = 25\) Mandarin-L1, \(N = 28\) English monolinguals) with a mean age of 8.4 years and a reading age of 8.5 years. Based on the LBQ, the English monolingual
children were exposed to only English from birth, while the English-Mandarin bilingual children reported one dominant language over the other despite exposure to both languages at an early age. The English-L1 children were exposed to English significantly earlier than Mandarin ($p < .001$), whereas the Mandarin-L1 children had exposure to Mandarin significantly before English ($p < .001$). Children’s proficiency in the L1 was reported to be significantly better than in their L2 (English-L1: $p < .001$; Mandarin-L1: $p < .001$). English was used significantly more often by English-L1 children’s parents with their children ($p < .001$), and Mandarin was used significantly more often by Mandarin-L1 children’s parents with their children ($p < .001$, see Yeong et al., 2014, for more details).

**Materials**

**Language Background Questionnaire (LBQ).** Parents provided information about the languages their child knew, their child’s age of first exposure to the languages, the languages spoken by their child’s primary caregiver, the amount of time (%) the child was exposed to particular languages by the caregivers, and their child’s proficiency (understanding and speaking) in the languages. The English monolingual group consisted of children whose parents reported only knowing English. The other children, whose parents reported exposure to both English and Mandarin, were either allocated to the English-L1 or Mandarin-L1 groups. Allocation was based on: (1) the child was first exposed to L1 earlier or at the same time as the L2; (2) L1 was the language spoken most of the time by parents and/or caregivers; and (3) the child had better or similar proficiency in the L1 as in the L2. (see Li, Sepanski, & Zhao, 2006).

**Nonverbal Reasoning.** This was measured using the Matrices subtest from the Kaufman Brief Intelligence Test 2 (KBIT-2; Kaufman & Kaufman, 2004). Children were required to select one from six choices to complete the missing part of a given
abstract design. Administration and scoring were according to standard procedures in the manual. Coefficient alphas of .86-.88 were obtained from the manual.

**Receptive Vocabulary.** This was measured using the Peabody Picture Vocabulary Test 4 (PPVT-4; Dunn & Dunn, 2007). Children had to select one from four pictures that matched a spoken target word. Administration and scoring were based on standard procedures in the manual. A coefficient alpha of .97 was obtained from the manual.

**Word Reading.** The word reading subtest from the Wechsler Individual Achievement Test 2: Australian adaptation (Wechsler, 2007) was used as a measure of single word reading ability. Children read as many words as possible from a list of words of increasing difficulty. Administration and scoring were based on standard procedures in the manual. The manual reports coefficient alphas of .95-.97.

**Word Spelling.** The spelling subtest from the Wechsler Individual Achievement Test 2: Australian adaptation (Wechsler, 2007) was used as a measure of single word spelling ability. Single words of increasing difficulty were presented orally to children, who had to spell as many words correctly as possible. Administration and scoring were based on standard procedures in the manual. The manual reports coefficient alphas of .93-.95.

**Phonological processing measures.** Three tasks were used to tap two components of phonological processing: phonological awareness and phonological recoding.

**Elision.** The elision subtest from the Comprehensive Test of Phonological Processing (CTOPP; Wagner, Torgesen & Rashotte, 1999) was used as a measure of phonological awareness. Children were asked to remove either a syllable or phoneme from orally presented words and say what was left (e.g., say /bæt/ without saying /b/).
The task was stopped after three consecutive incorrect responses. This task was reported to have coefficient alphas of .86 to .89.

**Blending words.** This task was taken from the CTOPP (Wagner et al., 1999) and was used as a measure of phonological awareness. Children heard words in small parts and had to put the parts together to make a whole word (e.g., /t/ and /æp/ together make *tap*). The task was stopped after three consecutive incorrect responses. Coefficient alphas obtained from the manual were .79 to .85.

**Silent phonological choice.** This task, used by Olson et al. (1994), assesses phonological recoding. Children were presented with three nonwords side by side on the computer screen (e.g., *nite* vs. *kile* vs. *hote*) and chose the nonword that sounded most like a real English word (e.g., *nite*). They were required to apply grapheme-phoneme conversion rules to decode the nonwords phonetically to derive the correct response. Stimuli for this task were taken from Olson et al. (1994), with five practice trials and 60 experimental trials. Cronbach’s alpha of .87 was calculated for this task.

**Orthographic processing measures.** Three tasks were used to measure two components of orthographic processing: word-specific knowledge and general orthographic knowledge.

**Orthographic choice task.** This task was adapted from Olson et al. (1994) and was used to assess word specific orthographic knowledge. Children heard a word and were presented with a letter string on the computer screen. Letter strings were either real words (e.g., *rain*) or their pseudohomophones (e.g., *rane*), and children had to decide if what was presented was the correct real English word that matched the target word heard. Stimuli were from Manis et al. (1993; 22 items), Manis et al. (1996; 12 items), Olson et al. (1994; 63 items), and Sloboda (1980; 7 items), making a total of five practice trials and 99 experimental trials. Cronbach’s alpha of .90 was calculated for this task.
**Homophone verification task.** This task was adapted from Manis et al. (1993) and was used to measure word specific orthographic knowledge. Children listened to a sentence (e.g., “Grandmother is old and weak”) and indicated whether the word presented on the screen was either the correct word for the sentence (e.g., “weak”) or an incorrect homophone (e.g., “week”). Stimuli were taken from Manis et al. (1993; 28 items) and Stanovich and West (1989; 14 items). Three new items (e.g., knight/night, sum/some, sole/soul) were included, making a total of five practice trials and 40 experimental trials. Cronbach’s alpha calculated was .80.

**Nonlexical choice task.** This task was used to assess general orthographic knowledge. A pair of nonwords was presented, of which one contained letter sequences/positions that were legal and/or common in words, while the other had illegal sequences/positions (e.g., visn vs. vism). Children indicated which nonword “looked” most like a real English word (e.g., vism). Items used were from Siegel et al. (1995; 17 items) and Wang, Perfetti and Liu (2005; 16 items). Five new items were added as practice trials before 33 experimental trials. Cronbach’s alpha calculated was .76.

**Procedure**

All children were tested individually over two sessions. The nonverbal reasoning task, word reading and orthographic processing measures were carried out in one session, and the remaining measures were administered in the other session. The order of the two sessions was counterbalanced across children.

**Results**

Before further analyses were carried out, one-way ANOVAs were used to compare the children with dyslexia to the typically developing English monolingual, English-L1, and Mandarin-L1 children on age as well as on the reading, spelling, receptive vocabulary and nonverbal reasoning measures. Tests of receptive vocabulary and nonverbal reasoning were included to account for any possible differences between
the groups as these variables are often related to reading ability (e.g., Scarborough, 2009). Means and standard deviations of the above tasks are shown in Table 1.

**CA group comparisons.** The dyslexia group was not significantly different in age to the other three language background groups ($p = .702$). However, as expected, significant group differences were obtained on the reading age equivalents, $F(3, 88) = 11.17, p < .001$, and standard scores, $F(3, 88) = 17.94, p < .001$, and the spelling age equivalents, $F(3, 88) = 20.51, p < .001$, and standard scores, $F(3, 88) = 36.76, p < .001$. The children with dyslexia were significantly weaker in reading and spelling, and achieved lower reading and spelling age equivalents than the other three groups of children (all Scheffé $p < .001$), whereas the typically developing children from the three language backgrounds were not significantly different from each other on the literacy tasks (all Scheffé $p > .104$). Though there were significant group differences on the receptive vocabulary task, $F(3, 88) = 5.34, p = .002$, this was due to the Mandarin-L1 children performing more poorly than the English-L1 (Scheffé $p = .045$) and English monolingual children (Scheffé $p = .003$) as expected from receiving less exposure to the English language. Children with dyslexia were not significantly different from the children in the other three groups (all Scheffé $p > .211$). There were also significant group differences on the nonverbal reasoning measure, $F(3, 88) = 10.37, p < .001$. The group of children with dyslexia performed more poorly than both bilingual groups (vs. English-L1: Scheffé $p < .001$, vs. Mandarin-L1: Scheffé $p = .001$), but not the English monolingual group ($p = .258$). The English monolingual children also performed more poorly than the English-L1 children but were similar to Mandarin-L1 children (vs. English-L1: Scheffé $p = .027$, vs. Mandarin-L1: Scheffé $p = .110$), while the bilingual children were not significantly different from each other ($p = .952$). This is consistent with previous research that has found cognitive advantages attributed to bilingualism (Bialystok & Craik, 2010).
Table 1.

Means (SDs) for the nonverbal reasoning, receptive vocabulary and literacy tasks as a function of group.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Children with dyslexia (n = 19)</th>
<th>Reading-age matched</th>
<th>Chronological-age matched</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EM (n = 28)</td>
<td>EL1 (n = 26)</td>
<td>ML1 (n = 25)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EM (n = 24)</td>
<td>EL1 (n = 25)</td>
</tr>
<tr>
<td>Age</td>
<td>11.17 (0.54)</td>
<td>8.29 (0.51)</td>
<td>8.50 (0.51)</td>
</tr>
<tr>
<td>Nonverbal reasoning a</td>
<td>99.47 (12.19)</td>
<td>108.43 (11.75)</td>
<td>116.73 (15.37)</td>
</tr>
<tr>
<td>Receptive vocabulary a</td>
<td>103.74 (10.63)</td>
<td>108.93 (10.64)</td>
<td>96.38 (15.59)</td>
</tr>
<tr>
<td>Word reading</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard scores</td>
<td>85.84 (10.29)</td>
<td>106.21 (7.93)</td>
<td>104.54 (8.54)</td>
</tr>
<tr>
<td>Age equivalent</td>
<td>9.04 (1.16)</td>
<td>8.58 (0.98)</td>
<td>8.62 (0.92)</td>
</tr>
<tr>
<td>Word spelling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard scores</td>
<td>80.74 (9.05)</td>
<td>101.61 (9.30)</td>
<td>104.62 (9.39)</td>
</tr>
<tr>
<td>Age equivalent</td>
<td>8.21 (1.24)</td>
<td>8.30 (1.32)</td>
<td>8.86 (1.33)</td>
</tr>
</tbody>
</table>

Note: *Scores reported are standard scores. EM = English monolinguals, EL1 = English-L1 bilinguals, ML1 = Mandarin-L1 bilinguals
**RA group comparisons.** Significant group differences were found for age, $F(3, 94) = 126.78, p < .001$, as the children with dyslexia were significantly older than children in the other groups (all Scheffé $p < .001$). Consistent with the definition of the groups, there were no significant group differences in reading ($p = .094$) and spelling age equivalents ($p = .351$). However, the groups were significantly different when compared on reading, $F(3, 94) = 23.03, p < .001$, and spelling standard scores, $F(3, 94) = 31.58, p < .001$. The children with dyslexia obtained lower reading and spelling standard scores than the other children (all Scheffé $p < .001$). As in the comparisons with the CA groups, significant group differences on the receptive vocabulary task, $F(3, 94) = 31.58, p < .001$, were due to the weaker performance of Mandarin-L1 children (vs. English-L1: Scheffé $p = .060$, vs. English monolinguals: Scheffé $p < .001$, vs. children with dyslexia: Scheffé $p < .001$). The children with dyslexia were not significantly different from the English monolingual ($p = .277$) and English-L1 children ($p = .571$). Again, there were significant group differences in the nonverbal reasoning measure, $F(3, 94) = 11.55, p < .001$. The dyslexia group performed more poorly than both bilingual groups (vs. English-L1: Scheffé $p < .001$, vs. Mandarin-L1: Scheffé $p < .001$), but not the English monolingual group ($p = .149$). The English monolingual children also performed more poorly than the Mandarin-L1 children but were no different to the English-L1 children (vs. English-L1: Scheffé $p = .142$, vs. Mandarin-L1: Scheffé $p = .011$), while the bilingual children were not significantly different from each other ($p = .766$).

**Group differences in phonological and orthographic skills**

To examine whether there were any group differences in phonological and orthographic skills, two separate MANCOVAs, with group membership as a between-subjects factor and nonverbal reasoning and receptive vocabulary as covariates, were conducted using raw scores obtained on the phonological tasks (i.e., elision, blending...
words and silent phonological choice) and on the orthographic processing tasks (i.e., orthographic choice, homophone verification and nonlexical choice) as dependent variables. Nonverbal reasoning and receptive vocabulary were entered as covariates because group differences were found on these variables. As we were only interested in comparing the performance of the children with dyslexia with the other typically developing children, subsequent pairwise comparisons between the group of children with dyslexia and the other three language background groups were performed with alpha = .017 (.05/3 after Bonferroni correction). Table 2 shows mean performance on these tasks as a function of group.

**CA group comparisons.** A significant group effect was found for phonological skills, $F(9, 258) = 6.06, p < .001, \eta^2_{\text{Mult}} = .46$. Subsequent planned comparisons showed that performance of the dyslexia group was significantly different to each of the other three groups on the phonological tasks. Children with dyslexia had poorer phonological skills than the English monolingual children, $F(3, 37) = 4.13, p = .013, \eta^2_{\text{Mult}} = .25$, but this was only evident on the silent phonological choice task ($p = .002$), and not on elision ($p = .057$) or blending words ($p = .950$). However, children with dyslexia performed better than both the English-L1, $F(3, 38) = 6.11, p = .002, \eta^2_{\text{Mult}} = .33$, and Mandarin-L1 children, $F(3, 37) = 3.87, p = .017, \eta^2_{\text{Mult}} = .24$. The children with dyslexia performed better than the English-L1 group on the silent phonological choice ($p = .013$) and blending words ($p = .001$) tasks, but not on the elision task ($p = .817$), and outperformed the Mandarin-L1 group on the blending words task only ($p = .003$; elision: $p = .953$, silent phonological choice: $p = .106$).

As for orthographic skills, a significant group difference was found, $F(9, 258) = 6.89, p < .001, \eta^2_{\text{Mult}} = .55$. Children with dyslexia had poorer orthographic skills than all the other groups (vs. English monolinguals, $F(3, 37) = 9.24, p < .001, \eta^2_{\text{Mult}} = .43$, vs. English-L1, $F(3, 38) = 11.70, p < .001, \eta^2_{\text{Mult}} = .48$, vs. Mandarin-L1, $F(3, 37) = 14.95$, vs. Mandarin-L1, $F(3, 37) = 14.95$,
The difference between children with dyslexia and typical English monolingual children was evident on all three orthographic tasks (orthographic choice: \( p < .001 \), homophone verification: \( p < .001 \), nonlexical choice: \( p = .015 \)), whereas the children with dyslexia performed more poorly than the bilingual children only on the orthographic choice (vs. English-L1, \( p < .001 \), vs. Mandarin-L1, \( p < .001 \)) and homophone verification tasks (vs. English-L1, \( p < .001 \), vs. Mandarin-L1, \( p < .001 \)), but not on the nonlexical choice task (vs. English-L1, \( p = .816 \), vs. Mandarin-L1, \( p = .855 \)).

**RA group comparisons.** When the dyslexia group was compared with the reading-age matched groups on phonological skills, a significant group difference was found, \( F(9, 276) = 4.76, p < .001, \eta^2_{\text{Mult}} = .39 \). Planned group comparisons showed that the dyslexia group was not significantly different from the English monolingual children (\( p = .181 \)), but was significantly better than the English-L1, \( F(3, 39) = 4.89, p = .006, \eta^2_{\text{Mult}} = .27 \), and Mandarin-L1 children, \( F(3, 38) = 9.43, p < .001, \eta^2_{\text{Mult}} = .43 \). The dyslexia group performed better than the English-L1 children on the silent phonological choice (\( p = .006 \)) and blending words (\( p = .001 \)) tasks, but not the elision task (\( p = .159 \)). However, the dyslexia group showed better performance on all three phonological tasks (silent phonological choice: \( p < .001 \), elision: \( p = .033 \), blending words: \( p < .001 \)) relative to the Mandarin-L1 group.

There was also a significant group difference for orthographic skills, \( F(9, 276) = 3.97, p < .001, \eta^2_{\text{Mult}} = .33 \). The dyslexia group was significantly weaker in terms of their orthographic skills relative to the Mandarin-L1 children, \( F(3, 38) = 4.82, p = .006, \eta^2_{\text{Mult}} = .28 \), but this was only evident on the homophone choice task (\( p = .037 \)) and not the other two tasks (orthographic choice: \( p = .209 \), nonlexical choice: \( p = .063 \)). There were no significant differences between the dyslexia group and the English
Table 2.

Mean (SDs) scores obtained on the phonological and orthographic tasks by group.

<table>
<thead>
<tr>
<th>Tasks (max score)</th>
<th>Children with dyslexia (n = 19)</th>
<th>Reading-age matched</th>
<th>Chronological-age matched</th>
<th>F value for group effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EM (n = 28)</td>
<td>EL1 (n = 26)</td>
<td>ML1 (n = 25)</td>
<td></td>
</tr>
<tr>
<td>Phonological tasks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elision (20)</td>
<td>11.79 (4.32)</td>
<td>13.04 (4.16)</td>
<td>10.19 (4.61)</td>
<td>4.76***</td>
</tr>
<tr>
<td>Blending words (20)</td>
<td>14.63 (3.37)</td>
<td>14.00 (2.52)</td>
<td>10.46 (2.90)**</td>
<td>15.04 (2.53)</td>
</tr>
<tr>
<td>Silent phonological choice (60)</td>
<td>41.53 (7.40)</td>
<td>42.14 (9.72)</td>
<td>35.77 (7.92)**</td>
<td>50.38 (6.47)**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orthographic tasks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orthographic choice (99)</td>
<td>74.05 (10.70)</td>
<td>72.54 (10.86)</td>
<td>79.73 (9.77)</td>
<td>87.63 (4.87)***</td>
</tr>
<tr>
<td>Homophone verification (40)</td>
<td>30.16 (5.07)</td>
<td>30.89 (4.56)</td>
<td>33.85 (3.95)</td>
<td>36.83 (2.48)**</td>
</tr>
<tr>
<td>Nonlexical choice (33)</td>
<td>28.32 (3.32)</td>
<td>27.89 (3.08)</td>
<td>28.69 (2.40)</td>
<td>30.58 (2.17)**</td>
</tr>
</tbody>
</table>

Note: All scores reported above are raw scores. EM = English monolinguals, EL1 = English-L1 bilinguals, ML1 = Mandarin-L1 bilinguals. a Means differed significantly between dyslexia and EM groups. b Means differed significantly between dyslexia and EL1 groups. c Means differed significantly between dyslexia and ML1 groups. 1 refers to reading-age matched comparisons, 2 refers to chronological-age matched comparisons. * p <.05. ** p <.01. *** p <.001.
monolinguals \((p = .707)\), or between the dyslexia group and the English-L1 children \((p = .028)\).

The group differences described above indicate that the children with dyslexia in our study do not show a pattern of relatively stronger orthographic skills to phonological skills similar to that of Mandarin-L1 children. Instead, our results suggest that children with dyslexia may be more comparable in profile to younger typically developing English monolingual children.

**Relationships between phonological and orthographic skills and English word reading and spelling in English monolingual children with dyslexia**

Before conducting analyses to determine the contributions of phonological and orthographic skills to English word reading and spelling in English monolingual children with dyslexia, raw scores on each phonological and orthographic task were standardized using the dyslexia group only and composite phonological and orthographic scores were obtained by averaging the standardized scores of the three phonological and orthographic tasks respectively. Using composite scores allowed us to reduce the number of predictor variables in later analyses. The grouping of tasks to derive the composite scores was justified by factor analyses conducted by other researchers (Leong et al., 2005; Hagiliassis et al., 2006; Yeong et al., 2014) who have used similar tasks and found the three phonological tasks to load on a separate component from the three orthographic tasks.

To establish the importance of either phonological or orthographic skills for English word reading and spelling in the dyslexia group, bivariate correlations were first conducted, followed by regression analyses for word reading and spelling separately. For the regression analyses, nonverbal reasoning and receptive vocabulary abilities were entered first, then the composite scores representing either phonological or orthographic skills. Phonological and orthographic processing skills were not included in the same
analysis because of the small sample size. Hence, only the unique contribution of each skill set over and above the contribution of nonverbal reasoning and receptive vocabulary was examined.

As Table 3 shows, both phonological and orthographic skills showed moderate to high correlations with word reading and spelling for the English monolingual children with dyslexia. These correlations were all significant except for the association between phonological skills and spelling \((p = .083)\). The differential strength of these correlations may indicate that these children use a different type of skill for reading than for spelling.

**Table 3.**

*Correlations of phonological and orthographic skills with word reading and spelling for the dyslexia group \((N = 19)\).*

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Phonological</td>
<td>-</td>
<td>.44</td>
<td>.61**</td>
<td>.41</td>
</tr>
<tr>
<td>2. Orthographic</td>
<td>-</td>
<td>.66**</td>
<td>.80***</td>
<td></td>
</tr>
<tr>
<td>3. Word reading</td>
<td>-</td>
<td></td>
<td>.71**</td>
<td></td>
</tr>
<tr>
<td>4. Word spelling</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^{*}p < .05. \quad ^{**}p < .01. \quad ^{***}p < .001.\)

Further examination of this question using regression analyses suggests otherwise (see Table 4). For word reading, orthographic skills, but not phonological skills, accounted for unique variance (27%) for the children with dyslexia, \(F(1, 15) = 10.44, p = .006\), over and above non-verbal reasoning and receptive vocabulary. Similar results were obtained for spelling, with orthographic skills, but not phonological skills, accounting for significant unique variance (55%) for the children, \(F(1, 15) = 24.13, p < .001\). It
appears that children with dyslexia are reliant on orthographic skills for both word reading and spelling. Though this may support beliefs that children with dyslexia rely on orthographic skills as a compensatory measure, it is inconsistent with previous studies (e.g., Manis et al., 1993) that have found phonological skills to be the dominant strategy used by these children. These results are also different from what was found for Mandarin-English bilingual children (see Yeong et al., 2014, for results of the other three groups).

Table 4.

*Hierarchical regression predicting word reading and spelling from phonological and orthographic skills for the dyslexia group (N = 19).*

<table>
<thead>
<tr>
<th>Step/ Variable</th>
<th>Word reading</th>
<th></th>
<th>Word spelling</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>t</td>
<td>Adj. R²</td>
<td>β</td>
</tr>
<tr>
<td>Step 1</td>
<td>.26</td>
<td>.34</td>
<td>.01</td>
<td>.11</td>
</tr>
<tr>
<td>Nonverbal reasoning</td>
<td>.40</td>
<td>1.98</td>
<td>.21</td>
<td>.88</td>
</tr>
<tr>
<td>Receptive vocabulary</td>
<td>.43</td>
<td>2.12*</td>
<td>.25</td>
<td>1.07</td>
</tr>
<tr>
<td>Step 2</td>
<td>.33</td>
<td>.10</td>
<td>.02</td>
<td>.08</td>
</tr>
<tr>
<td>Phonological skills</td>
<td>.42</td>
<td>1.65</td>
<td>.37</td>
<td>1.18</td>
</tr>
<tr>
<td>Step 2</td>
<td>.53</td>
<td>.27**</td>
<td>.59</td>
<td>.55***</td>
</tr>
<tr>
<td>Orthographic skills</td>
<td>.55</td>
<td>3.23**</td>
<td>.78</td>
<td>4.91***</td>
</tr>
</tbody>
</table>

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

Results obtained were similar when phonological and orthographic skills were included in the same regression model.

One child was found to perform more than 2SDs below the group mean on orthographic skills. Analyses were then performed without this child and results were consistent with the main analyses (for reading: $F(1, 14) = 7.94, p = .014, \Delta R^2 = .25$; for spelling: $F(1, 14) = 18.92, p = .001, \Delta R^2 = .53$).
Power analyses conducted for the non-significant regression analyses revealed that for 1 out of the 2 non-significant findings, we did have power to find an effect (>.80), but did not do so. The contribution of phonological skills for reading, which would have required 28 children to achieve significance based on the obtained effect size, was considered underpowered, and so, the results from this analysis should be treated with caution.

**Discussion**

There is widespread consensus that individuals with dyslexia have phonological processing deficits (Vellutino et al., 2004), but there is less agreement as to their proficiency in orthographic processing skills. Even less is known about the extent to which children with dyslexia depend on phonological and/or orthographic skills for word reading and spelling. It has been proposed that English monolingual children with dyslexia have a pattern of differential phonological and orthographic skills (e.g., Stanovich & Siegel, 1994), which appears to be similar to that of Mandarin-English bilinguals (e.g., Wang & Geva, 2003), yet no study has conducted direct comparisons between the groups. The present study aimed to shed light on the proficiencies of skills (i.e., phonological and orthographic skills) in children with dyslexia by comparing them to CA matched and RA matched typically developing children from three different language backgrounds (English monolingual, English-L1 and Mandarin-L1), and to examine the extent to which these skills contribute to English word reading and spelling for children with dyslexia.

**Phonological and orthographic skills in English monolingual children with dyslexia**

Our findings show that the cognitive profile of phonological and orthographic processing skills in English monolingual children with dyslexia is more similar to younger English monolingual children than to either age-matched or reading-matched Mandarin-English bilingual children. Comparisons of phonological and orthographic
skills among the groups of children did not reveal a profile of poor phonological skills with relatively better orthographic skills in children with dyslexia such as that of the Mandarin-L1 children. Given that the children with dyslexia in our study were performing at a level that was expected of their reading ability (similar to RA matched English monolinguals), on the surface, our results appear to support the developmental lag model (Stanovich et al., 1988). However, these children did not show deficits across all tasks when compared to the CA matched children as might be expected if they were indeed developmentally delayed.

On the phonological tasks, the children with dyslexia in our study performed as well as the young RA matched English monolinguals. This may be hard to reconcile as previous studies have found children with dyslexia to have poorer phonological skills even when compared with reading-level controls (e.g., Stanovich & Siegel, 1994). However, our findings may be affected by the fact that the children with dyslexia in our sample had received literacy support for at least a year since they were diagnosed. Children at-risk for reading difficulties do improve in terms of their phonological awareness skills after remediation (Hatcher, Hulme & Snowling, 2004; National Reading Panel, 2000). On the other hand, the children with dyslexia did perform worse than the CA matched English monolingual children, particularly in the silent phonological choice task. The silent phonological choice task is a complex phonological task that requires application of grapheme-phoneme correspondences and the ability to blend phonemes, also known as phonological recoding. Individuals with dyslexia have poor phonological recoding skills and this has been found across languages (English: Rack, Snowling & Olson, 1992; German: Landerl & Wimmer, 2000; Dutch: van der Leij & Morfidi, 2006). Phonological recoding is implicated in learning to read as repeated application of phonological recoding to unfamiliar words strengthens the connections between the orthographic form of the word and its phonology (Share, 1995),
hence it is unsurprising that children with dyslexia have both poor phonological recoding skills and difficulties in reading. Poor performance on the silent phonological choice task may also be due to orthographic demands of the task (Geva & Williows, 1994). Performance in this task may be aided by knowledge of letter patterns; hence, children with dyslexia would have difficulty if they had both poor phonological recoding skills and poor orthographic knowledge. The above results suggest that with phonological training and literacy support, children with dyslexia may be able to improve phonological skills to a level commensurate with their reading level, but yet remain below the levels of CA matched English monolinguals.

Our finding that the children with dyslexia had better phonological skills than both the RA matched and CA matched bilingual children was unexpected. Though this may be partly due to improvements in these children’s phonological skills resulting from the literacy support that they received, it also has implications for the bilingual children, suggesting that exposure to a non-alphabetic language (i.e., Mandarin) influences the development and proficiency of underlying skills (i.e., poorer phonological skills). Furthermore, it was surprising to find that this difference between the groups remained in comparison with the CA matched bilingual children. Both children with dyslexia (Manis et al., 1993) and bilingual children (Yeong & Rickard Liow, 2012) improve in phonological processing over time and with exposure to the English language, but our results showed that the English monolingual children with dyslexia continued to perform better than same-aged bilingual children in terms of phonological skills.

As for orthographic skills, the children with dyslexia performed at a similar level to the younger RA matched English monolingual and English-L1 children. This was expected given past research showing that these children’s orthographic skills were comparable to younger typically developing English-speaking children (e.g., Olson et
al., 1989). However, if children with dyslexia compensate for weak phonological skills by becoming more aware of the visual components of words, then their orthographic skills could reasonably be expected to be on par with those of the Mandarin-L1 children, but this was not found. The dyslexia group performed more poorly than the RA matched Mandarin-L1 children, though this difference was only present in the homophone choice task. Our results reinforce the notion that Mandarin-L1 children have enhanced visual-orthographic skills, which are influenced by the linguistic properties of their L1, Mandarin, and applied to the learning of their L2, English (e.g., Wang & Geva, 2003). Indeed, the earlier study by Yeong et al. (2014) showed that 8-year-old Mandarin-L1 children had better orthographic skills than same-aged English monolinguals, and this was found in both the orthographic choice and homophone verification tasks.

In relation to the CA matched children, the children with dyslexia displayed poorer orthographic skills than the other three groups. These differences were evident on all orthographic tasks when compared to the English monolingual children, but were only found on the orthographic choice and homophone verification tasks when compared to the bilingual groups. Our results suggest that children with dyslexia have poorer orthographic skills compared to their same-age peers, but they also appear to have particular difficulties with the orthographic choice and homophone verification tasks. There is growing consensus that orthographic skill is a multi-dimensional construct that consists of word-specific/lexical knowledge and general orthographic knowledge at the sublexical letter-patterns level (see Apel, 2011; Conrad, Harris & Williams, 2013). Previous studies have found that children with dyslexia have a well-developed understanding of general orthographic knowledge (i.e., permissible letter sequences and positions of letters within words, e.g., Siegel et al., 1995). We too found that the children with dyslexia in our study performed similarly to both groups of CA matched bilingual children on a task that measures general orthographic knowledge,
which lends some credence to the proposal that children with dyslexia are relatively more sensitive to visual orthographic information than to phonological input, albeit only certain orthographic information. The two tasks that the children with dyslexia seemed to perform poorly on (i.e., orthographic choice and homophone verification) tap another aspect of orthographic skill: word-specific/lexical knowledge. Similar results were found by O’Brien and colleagues (2013) who suggested that these children not only lack sufficient orthographic knowledge of known words but are also misled by the phonology of homophones (e.g., *eight* vs. *ate*). O’Brien et al. (2013) argued that children with dyslexia have a less efficient verification process (i.e., they are less able to choose between similar-sounding words) because of weaker connections between the meaning of a word and how it is spelled. For this reason, and the fact that less skilled readers require more exposures to a given word to build up the orthographic image for the word (Ehri & Saltmarsh, 1995; Share & Shalev, 2004), children with dyslexia need greater repeated exposure to words to improve their word-level orthographic knowledge.

**Reliance on phonological and orthographic skills for reading and spelling in English monolingual children with dyslexia**

Results of the regression analyses revealed that orthographic processing skills, but not phonological processing skills, contributed significantly to word reading and spelling for the English monolingual children with dyslexia. This is at odds with findings showing that children with dyslexia are more reliant on phonological skills for reading (Manis et al., 1993). In an earlier study by Yeong et al. (2014), both younger (8-9 years) and older (11-12 years) English monolingual children were found to rely more on orthographic than phonological skills for reading and spelling, whereas phonological skills were more important for the bilingual children for reading and for the younger bilingual children for spelling. Based on these results, the children with dyslexia appear
to approach word reading and spelling in a similar manner to typically developing English monolinguals. In addition, we found that receptive vocabulary accounted for significant variance in reading in children with dyslexia, which is consistent with evidence suggesting that oral language plays a role in literacy outcomes (Scarborough, 1998). Though oral language may be used by these children to support their reading and spelling, it was not sufficient for children with dyslexia to develop age-appropriate literacy skills. The other notable finding was that orthographic skills explained 55% of the variance in word spelling, and only 27% of the variance in reading, for the children with dyslexia. This may be in response to the variability in phoneme-to-grapheme mappings, which, as a consequence, requires a precise retrieval of the orthographic form from memory for accurate spelling (Fletcher-Flinn, Shankweiler & Frost, 2004). Children with dyslexia, therefore, were sensitive to the requirements of spelling, and were applying the appropriate skill set to the task.

Though the results above support the proposal that children with dyslexia rely on their orthographic skills because of relatively poorer phonological skills, the children with dyslexia in this study did not have poorer phonological skills relative to the RA matched English monolingual children, so this explanation does not seem adequate. Perhaps the level of phonological skills attained by the children with dyslexia in this study enabled them to acquire and adopt a predominantly orthographic approach commensurate with their reading level. This would be consistent with the finding that typically developing children reduce their dependence on phonological skills as their proficiency in literacy increases (Roman et al., 2009). The children with dyslexia in this study had a reading age of 9.0 years, which meant that they were not beginning readers and may have been past relying on phonological skills. However, it should be noted that these children had received literacy support in the classroom, which may have improved their phonological skills to the level of the RA matched children, and this may have
affected our results. In addition, given the bidirectional effects between such cognitive-linguistic skills and literacy skills, it is difficult to discern if phonological and orthographic skills influenced these children’s literacy abilities, or vice versa. Future research should assess younger children with dyslexia or children with dyslexia who have not had remediation to determine if these children also rely mainly on orthographic skills for reading and spelling. It is also important to note that because of the small sample size in the group of children with dyslexia, small sample-to-variable ratios for the regression analyses limited the power to find significant effects, and further examination of the relationships between skills and word reading and spelling is needed to corroborate our results.

**Implications**

It is unsurprising that the children with dyslexia failed to reach literacy levels that matched their CA monolingual peers, or even age-matched bilingual children, as they were relying on orthographic skills in which they were not competent in. As the Chinese bilingual children were likely to have had orthographic skills available to them from the earliest stage of learning English (Yin et al., 2007), this may have boosted their ability to acquire English before learning the necessary phonological skills in response to the alphabetic nature of English. Hence, Chinese bilingual children do not show literacy difficulties associated with having poor phonological skills such as in dyslexia. However, if English monolingual children with dyslexia start out with weak phonological skills, this would have hindered their ability to build competency in orthographic skills, therefore making it difficult for them to attain similar levels of reading and spelling achievement to their CA matched peers. This is despite remediation efforts that improved their phonological skills to a level similar to RA English monolingual children.
Nevertheless, with our results showing that children with dyslexia rely on orthographic skills for reading and spelling, it is essential that any form of remediation program not only include teaching of phoneme awareness combined with links between phonemes and print (Blachman, Tangel, Ball, Black & McGraw, 1999; Hatcher et al., 2004), but also repeated orthographic exposure and training. Orthographic spelling training (e.g., the learning of orthographic spelling rules) has been shown to improve spelling deficits in children with dyslexia, though studies have been mainly conducted in transparent orthographies (German: Ise & Schulte-Korne, 2010; Dutch: Timjs & Hoeks, 2005). Computational modelling by Harm and Seidenberg (2001) suggests that the orthographic-semantic pathway takes longer to develop, and poor readers are further disadvantaged as they require more exposures to learn unfamiliar words than skilled readers. Hence, children with dyslexia should be given explicit orthographic training (e.g., letter clusters that map spelling rules/patterns; Posner & McCandliss, 2000) with opportunities for repeated exposure to a variety of words to build up their orthographic skills.

Our study is unique in that it examines the underlying skills important for literacy among English monolingual children with dyslexia, and compares them to English monolinguals and English-Mandarin bilingual children matched for reading age or chronological age. Our results contradict previous suggestions that children with dyslexia may be similar to English-Mandarin bilingual children in their profile of skills and the skills they rely on for reading and spelling, instead they show that children with dyslexia approach English word reading and spelling much like younger typically developing children. This understanding is valuable in terms of improving remediation efforts to boost the literacy skills of children with dyslexia.
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Chapter 5

General Discussion
Literacy research has focused mostly on English monolinguals, but less is known about the processes involved for English literacy when it comes to specific populations such as English as Second Language (ESL) bilingual learners and English monolinguals with dyslexia. With an increasing number of individuals learning English in combination with another language, and a growing awareness of the specific skill deficits that underlie dyslexia, it is crucial to understand how these individuals acquire the underlying skills necessary for English word reading and spelling and how they approach English literacy tasks. This thesis explores phonological and orthographic processing skills in Chinese-English bilinguals, English monolinguals and English monolinguals with dyslexia. In particular, we were interested in the proficiency of phonological and orthographic processing skills in Chinese-English bilingual children and adults, English monolingual children and adults, and English monolingual children with dyslexia, and the role such skills play in these individuals’ English word reading and spelling.

Summary of findings on Chinese-English bilingual individuals

The study reported in Chapter 2 focused on adults from three different language backgrounds (English-L1, Chinese-L1, and English monolinguals) who had acquired English reading and spelling skills successfully. The second study reported in Chapter 3 assessed children, who were not yet proficient readers and spellers in English, from the same three language backgrounds and from two age groups. Across language background groups, children and adults were exposed to English for similar lengths of time and were equally proficient in reading and spelling, but were different in terms of their early linguistic exposure. This meant that any differences between the groups could be attributed to the influence of Chinese as a L1 or L2 on English literacy, and not due to differences in English proficiency or length of exposure to the language.
Findings from both studies showed that early linguistic exposure to Chinese influences the acquisition of English phonological and orthographic skills and the extent to which the individual relies on such skills for English reading and spelling. We found that the English monolingual children had better phonological skills than both groups of bilingual children, and that the English-L1 children had better phonological skills than the Chinese-L1 children. Similarly, English monolingual adults were found to have better phonological processing skills than the bilingual adults. In contrast, the younger bilingual children had better orthographic processing skills compared to the English monolingual children but there were no group differences for the older children or the adults. Furthermore, orthographic processing skills were important for word reading and spelling for the English monolingual children and adults. However, phonological processing skills were important for word reading for the bilingual children and adults, and though both phonological and orthographic processing skills were implicated for word spelling for the bilingual children, neither skill contributed significantly for the bilingual adults. Hence, the impact of learning another language with English may be long-lasting, as evidenced by the finding that differences related to early language exposure were still present in adults.

The finding that the younger Chinese-L1 children performed better than the younger English monolingual children on the orthographic tasks supports the proposition that Chinese-L1 individuals place greater emphasis on the use of visual-orthographic skills due to the logographic nature of Chinese, which results in enhanced English orthographic processing skills in these individuals. However, this advantage of better English orthographic skills in Chinese-English bilinguals than English monolinguals was only evident in the early stages of learning English. Given that print exposure is associated with orthographic skills (Cunningham & Stanovich, 1990; Griffiths & Snowling, 2002), it is likely that the English monolingual children and
adults were able to consolidate such skills over time with exposure to the written language and improved proficiency in English. Therefore, any advantage the Chinese-L1 children had in English orthographic skills may have diminished over time.

Furthermore, this advantage was only apparent in tasks that assessed whole word orthographic knowledge, and not general orthographic knowledge. It seems that the Chinese-L1 bilinguals’ use of a holistic visual-lexical whole word approach to English (L2) as a result of their experience in Chinese (L1) influenced only one specific type of English orthographic skill, whole word orthographic knowledge. This would suggest that there are different types of orthographic skills and knowledge specific to different writing systems, which would lend credence to the hypothesis that orthographic skills are language-specific. However, if there were common visual-orthographic skills shared across orthographies, then it is possible that these skills could be transferred across languages (see Tong & McBride-Chang, 2010). The use of whole word orthographic strategies may be one example of a visual-orthographic skill that is shared across English and Chinese, which would account for such skills being enhanced in Chinese-English bilinguals compared to English monolinguals.

It is noteworthy that the advantage of enhanced English orthographic skills was not confined to the Chinese-L1 bilinguals, but was also present in the English-L1 bilinguals. This suggests that cross-linguistic facilitation may have been occurring from L2 to L1. According to Cummins’ (1991) linguistic interdependence theory, general metalinguistic processes gained from one language can facilitate the learning of another language. Hence, much research has examined if skills attained in the L1 are applied to the L2, but little is known about the influence of the L2 on the L1. Studies that have illustrated effects of the L2 on the L1 have been conducted mostly on bilinguals’ language use (see Cook, 2003). For example, Pavlenko (2003) found tense violations, wrong use of prepositions, and lexical borrowing from the L2 to the L1 in Russian-
English bilingual adults who learned English as a L2 in late childhood or adulthood. Yeong and Rickard Liow (2012) also found that exposure to English as a L2 stimulated growth in Mandarin-L1 children’s English phoneme awareness, which then predicted their later Mandarin phoneme awareness. This suggests that there is an influence of the L2 on the L1, especially if the L2 has a more complex linguistic structure that encourages the development of certain skills. A functional imaging study by Nosarti, Mechelli, Green and Price (2010) using Italian-English bilinguals also showed that neural activation when reading in the L1 changes with learning of a L2. There is increased activation in the area that is commonly associated with lexical/semantic processing as new grapheme-phoneme mappings are learnt in the L2. The above studies suggest that cross-linguistic facilitation can occur from a less dominant language to the more dominant language, such as in our case of orthographic skills from the L2 (Chinese) being applied to the L1 (English) for the English-L1 children.

Although Chinese ESL learners do acquire phonological skills from their English L2 (Wang, Koda, & Perfetti, 2003; Yeong & Rickard Liow, 2012), it is apparent from the results of the first two studies that Chinese-L1 individuals do not reach similar levels of proficiency in phonological skills as the English monolinguals. This difference in skill proficiency remains even in adulthood after years of exposure to English. Hence, having a L1 that requires a different set of skills may be detrimental to the acquisition of underlying skills for the L2. However, the Chinese-L1 adults did attain similar proficiency in phonological skills to the English-L1 adults. This suggests that although the Chinese-L1 children may initially be behind both groups of English-speaking children in terms of phonological skill proficiency, it is possible for Chinese-L1 children to reach a similar level of phonological skill proficiency to the English-L1 bilinguals, though not to English monolinguals, with exposure to oral and written English over time. However, it appears that achievement of this level of proficiency for
Chinese-L1 individuals may only occur many years later in adulthood, despite exposure to English from early childhood, which provides some indication of the difficulty in acquiring a skill nonessential to the L1 and reaffirming the long-lasting impact of the L1 on learning a L2.

On the other hand, the English-L1 children and adults in these studies had poorer phonological skills than the English monolinguals, despite having English as a dominant language. English-L1 individuals did not have the same amount of exposure as the English monolinguals, even though they were exposed to English from birth. This can be attributed to the use of the L2 in various interactions throughout their lifetime, which means that proportionately, English-L1 individuals would have had less exposure to English than English monolingual individuals. Since oral exposure affects one’s sensitivity to the sounds of a language (e.g., Caravolas & Bruck, 1993), this difference in exposure could have affected their acquisition of phonological processing skills. Alternatively, as learning a L2 impacts the usage and processing of the L1 (Cook, 2003), the exposure to a nonalphabetic L2 (i.e., Chinese) may also have interfered with the acquisition of skills from the dominant L1 (i.e., English).

The group differences in the reliance on phonological and orthographic skills for English reading and spelling further strengthens our proposal that early linguistic exposure to another language, whether as a L1 or L2, results in differences in the way bilinguals and monolinguals develop their English literacy skills. Despite the English-L1 and Chinese-L1 bilingual children and adults having poorer phonological skills than the English monolingual children and adults, phonological skills were more important than orthographic skills for English word reading for both bilingual groups. This is in opposition to the English monolinguals who were found to rely on orthographic skills, not phonological skills, for English word reading. The importance of the alphabetic principle in acquiring alphabetic languages is evident here as Chinese ESL children are
required to learn and rely on phonological skills rather than depend on orthographic
skills, for which they have an early advantage due to the logographic nature of their L1.
Previous studies have also found that phonological skills, not visual-orthographic skills,
contribute significant variance to English reading in Chinese-L1 children (Gottardo,
Yan, Siegel, & Wade-Woolley, 2001; McBride-Chang & Kail, 2002). This corroborates
our findings but it is surprising that phonological skills continue to be important for
adult bilinguals who have been exposed to English from birth, and raises questions
regarding the developmental trajectory of English literacy for Chinese-English
bilinguals.

There were similar group differences in the phonological and orthographic skills
used for English word spelling. Both bilingual groups relied more on phonological skills,
rather than orthographic skills, in early childhood. Orthographic skills played a bigger
role for both bilingual groups in later childhood, though neither phonological nor
orthographic skills were significant for either group of bilingual adults. These results
were in contrast with those found for the English monolinguals, where orthographic
skill, but not phonological skill, was important for English spelling in childhood as well
as adulthood. Again, these differences between the Chinese-English bilinguals and
English monolinguals suggest that learning another language influences how English is
acquired for bilinguals and has an impact on the pathways these bilinguals take to
achieving English word spelling skills. Previous research supports our findings with
phonological skills predicting word spelling sophistication in younger Mandarin-
English children (5 year olds; Yeong & Rickard Liow, 2011), whereas orthographic
skills were found to predict spelling skills in older Cantonese-English bilingual children
(10- to 12- year olds; Leong, Tan, Cheng, & Hau, 2005).

For the English monolinguals, the finding that older children and adults relied on
orthographic skills and not phonological skills for both reading and spelling was not
surprising, but it was unexpected to find that orthographic skills were more important than phonological skills for the younger children as well. This may point to orthographic skills developing in parallel to phonological skills or that orthographic skills are available at a much younger age (Cassar & Treiman, 1997) than that proposed by Ehri’s (1995) phase model of literacy development. As the use of phoneme-grapheme correspondences and phonetic strategies are often difficult and time-consuming (e.g., Ehri & Snowling, 2004), English monolingual children may prefer to use orthographic skills, which are more efficient than phonological skills, once they have attained sufficient proficiency in phonological skills and have emerging orthographic skills.

English word reading and spelling also appear to involve different skills (e.g., Bryant & Bradley, 1980), and bilingual children are sensitive to the different processes that are required in the two tasks. Spelling is often said to be a more difficult task than reading. This is because phoneme-to-grapheme mappings are more inconsistent than grapheme-to-phoneme mappings, hence there are more ways to spell a given word than to read it (e.g., /sart/ can be spelled as sight, site, or cite, Bosman & Van Orden, 1997). To overcome this, one would use strategies that require minimal phonology, such as the use of orthographic skills which allows for the use of the direct semantic-orthography route without phonological mediation. The older English-L1 and Chinese-L1 bilingual children appear to have adapted to this by relying on whole-word or sublexical attributes of the English writing system (i.e., orthographic skills) more for spelling than for reading. The explanation that bilingual children were able to adapt to the different task requirements of reading and spelling would be further supported if bilingual adults continued to use orthographic skills more for spelling than for reading. However, this was not found to be the case. This may have been because of the way orthographic skills were calculated for the adults (i.e., a combination of speed and accuracy), which
could reflect more than just orthographic skill proficiency (Hagiliassis, Pratt, & Johnston, 2006).

**Summary of findings on English monolinguals with dyslexia**

Chapter 4 examined the phonological and orthographic processing skills of English monolingual children with dyslexia, and compared them to typically developing chronologically age-matched and reading age-matched English-L1, Chinese-L1 and English monolingual children. This allowed for a direct comparison with Chinese-English bilinguals, with whom individuals with dyslexia reportedly share similar cognitive profiles of poorer phonological skills and relatively better orthographic skills, even though the bilinguals do not have literacy difficulties associated with dyslexia.

Our results suggest that the English children with dyslexia were more similar to younger typically developing English monolingual children matched for reading age, than to reading or chronologically age-matched Chinese-English bilingual children. Despite previous research showing that children with dyslexia have poorer phonological skills (Stanovich & Siegel, 1994) and better orthographic skills than reading age-matched English monolingual children (Siegel, Share, & Geva, 1995), we found the children with dyslexia and reading age-matched English monolingual children to have comparable proficiencies in these skills. In addition, the children with dyslexia had poorer orthographic skills, but better phonological skills, than both the younger and same-aged Chinese-L1 children. They also relied more on orthographic skills than phonological skills for both English word reading and spelling, unlike the younger Chinese-L1 children who relied mainly on phonological skills, and the older Chinese-L1 children who used both phonological and orthographic skills. These results contradict proposals that individuals with dyslexia build up orthographic skills to overcome deficient phonological skills (Stanovich & Siegel, 1994), yet rely on less ‘mature’ strategies such as phonological skills for reading and spelling (Bruck, 1990).
There are several possible reasons for why the children with dyslexia were performing at a level that was expected of their reading ability. The developmental lag model suggests that children with dyslexia may progress through the same stages of development but at a slower rate (Stanovich, Nathan, & Zolman, 1988), which would account for their similar performance to the reading age-matched English monolingual children. However, the children with dyslexia did not show deficits across all tasks when compared to the chronologically age-matched children as might be expected if they were indeed developmentally delayed. Hence, it is likely that the children with dyslexia were performing similarly to the reading age-matched English monolingual children due to other reasons. Firstly, children with dyslexia in this study had received literacy support, and hence, this may have translated to gains in phonological skills allowing them to reach the level of reading age-matched English monolingual children and to perform better than the Chinese-English bilinguals. Secondly, less skilled readers require more exposures to a given word to retain an orthographic representation of the word (Ehri & Saltmarsh, 1995; Share & Shalev, 2004). Hence, children with dyslexia may have reached a similar level of proficiency in orthographic skill to the younger typically developing children because they have had more exposure to print (Stanovich & Siegel, 1994; Stanovich, Siegel, Gottardo, 1997). However, this was not enough to overcome the advantage Chinese-L1 bilingual children have gained from learning a L1 in which visual-orthographic skills are vital. It is notable that the children with dyslexia appear to have particular difficulties with the orthographic choice and homophone verification tasks, which tap word-specific/lexical knowledge. This reflects the difficulty individuals with dyslexia have in choosing between similar words (i.e., verification process) because of weaker orthographic-semantic connections (O’Brien, Van Orden, & Pennington, 2003). Finally, the children with dyslexia in this study may have achieved a level of phonological skill that enabled them to acquire and shift to a
more orthographic strategy, since they had a similar level of proficiency in phonological skills to the younger reading age-matched English monolingual children, who were found to utilize their orthographic skills more than their phonological skills.

**Theoretical implications**

According to the dual route cascaded (DRC) model (Coltheart, Rastle, Perry, Langdon & Ziegler, 2001), there are two routes in reading: a lexical route, which requires the application of orthographic processing skills, and a nonlexical route, which makes use of phonological processing skills. Both the Chinese-English bilinguals and children with dyslexia in our studies had access to both routes as seen from their performance on the phonological and orthographic tasks. However, the differences we found in the way these groups of children read and spell English compared to English monolingual children suggest that these children were either more competent in using one route than the other, or were not competent using either route.

The aetiology of their competency in using either route clearly differs between the individuals with dyslexia and bilinguals as dyslexia is a neurological disorder (Ramus, 2004), and bilingualism occurs due to aural and written exposure to more than one language. Despite, or perhaps because of these differences, their approach to learning English also sheds light on how typically developing English monolingual individuals process the language. Our findings contradict developmental stage theories of reading development (e.g., Gough, Juel, & Griffith, 1992; Chall, 1983) which suggest that mastery of phonological skills is a prerequisite to advance to the next stage. We found that the children with dyslexia and reading age-matched English monolingual children had poorer phonological skills than the older typically developing English monolingual children, yet they relied mainly on orthographic skills for reading and spelling. This suggests that even though children may not be fully competent in terms of their phonological skills, they may still be able to acquire orthographic skills and even
rely on such skills. Hence, these findings are more consistent with Ehri’s (1995; 2005) phase theory, which states that even though children may predominately use a particular skill associated with one phase of development, they can also use the skills acquired from other phases. For example, children in the full alphabetic phase may have complete knowledge of grapheme-phoneme correspondences but may continue to rely on letter names for longer words (characteristic of those in the partial alphabetic phase) or even group letters together as a unit (e.g., -ing, characteristic of those in the consolidated phase) to learn to read. Ehri and Snowling (2004) reiterate that these phases of reading development should not be tied to age or grade, but do highlight that Year 2 readers and beyond tend to be consolidated alphabetic readers, which matches the age of the young English monolingual children in our study. These 8-year old English monolingual children relied mostly on orthographic processing skills, suggesting that they were predominately using whole words or letter units for their reading, which is consistent with the consolidated phase of reading. Another potential explanation as to why these young children depend on orthographic skills when they appear not to have attained full use of their phonological skills is that orthographic skills develop in parallel to phonological skills (see Brown & Deaver, 1999). Hence, children may have access to both phonological and orthographic skills for reading and may use a mixture of skills or the skill that is more efficient for the task. For example, the items in the spelling subtest of the Wechsler Individual Achievement Test-II (Wechsler, 2007) are comprised of mostly irregular words (Kohnen, Nickels & Castles, 2009), which could account for the preference of the English monolingual children for using orthographic skills.

There is less research on whether the development of reading in children with dyslexia is consistent with phase theory. With the consensus that children with dyslexia have a core phonological deficit, it has been proposed that these children may have
difficulty transitioning into the full alphabetic phase and that even if they do, children with dyslexia have such a limited sight word vocabulary that they are not expected to move into the consolidated phase (Ehri & Snowling, 2004). However, the children with dyslexia in our study can be assumed to be in the consolidated phase because of their reliance on orthographic skills for both word reading and spelling, even though it is questionable if these children have acquired complete knowledge and competent use of phonological skills. Snowling, Hulme and Goulandris (1994) described a case study of a child with dyslexia, JM, who had effective word reading skills despite having difficulties with phonological skills (see also Campbell & Butterworth, 1985). It was proposed that JM likely benefitted from the remediation he had for his literacy difficulties. The children with dyslexia that we assessed had also received additional literacy support and this may have enabled the children to move past the alphabetic phase to the consolidated phase. Despite showing skills typical of those in the consolidated phase, the reading age of these children was two years behind their chronological age, suggesting that moving through the four phases of reading development is not sufficient for successful reading acquisition. It could be argued that these children with dyslexia do not have full competency in phonological skills and have bypassed the full alphabetic stage. This means that they do not have the advantage of using a self-teaching device to decode and learn unfamiliar words (Share, 1995), and implies that further improvement in phonological skills may be required for the children with dyslexia to advance their orthographic knowledge.

Even less is known about the application of phase theory to Chinese-English bilingual individuals. Though previous researchers have found ESL learners to acquire English in similar ways to English monolinguals (Chiappe & Siegel, 1999; Chiappe, Siegel & Gottardo, 2002; McBride-Chang & Treiman, 2003), these conclusions were based on associations between phonological processing skills and English literacy
abilities. Few studies have followed ESL learners and examined the developmental sequence in which they acquire English reading and spelling. One exception is Yin, Anderson and Zhu (2007), who provided evidence that Chinese-English bilinguals follow the alphabetic reading sequence described in Ehri’s model. They found that Chinese-L1 children progress through the three alphabetic phases as hypothesized, but that orthographic skills were not confined to a distinct phase and were available to children at all phases. Our results mirror the findings from previous studies showing that phonological processing skills are important for Chinese-English bilinguals. The finding that the Chinese-English bilinguals displayed orthographic skills that were as good as, or better than, the English monolinguals’ also supports Yin et al.’s proposal for an overarching orthographic strategy that is available at any time. However, our finding that the Chinese-English bilinguals predominantly rely on poor phonological processing skills for English word reading and spelling, even in adulthood, suggests that Chinese-English bilinguals may be slow to move between alphabetic phases. It is possible that Chinese-English bilinguals only use orthographic skills in the early stages of learning to read English and that this reliance decreases over time as they recognize the necessity of learning new skills (i.e., phonological skills) in response to the alphabetic structure of English (Koda, 1999; Wang et al., 2003). Additionally, the use of phonology in reading may not be new to Chinese-English bilinguals as fluent Chinese readers do become sensitive to the role of phonology due to the existence of phonetic radicals in compound characters in Chinese and may not rely on the lexical-orthographic approach entirely (Siok & Fletcher, 2001). Nevertheless, the move from a language with a relatively simple phonological structure (i.e., Chinese) to one that has a complex phonological structure and inconsistent grapheme-phoneme correspondences (i.e., English) may account for the over-reliance on phonological processing skills even though such skills are laborious and considered inefficient (Ehri & Snowling, 2004). Yet, the Chinese-
English bilinguals achieved a similar level of English reading and spelling proficiency despite relying on weaker phonological skills. It is possible that the impact of relying on phonological skills may be on efficiency, rather than proficiency, in reading and spelling. Hence, the observed differences in the way Chinese-English bilinguals and English monolinguals approach English literacy highlight that children may use the same skills, but to different extents, to attain similar outcomes.

The differences found between the Chinese-English bilinguals and English monolingual individuals described in both Chapter 2 and Chapter 3 further emphasize that the acquisition process of either one or both of the bilingual’s languages is different from the process in a corresponding monolingual individual. This has been observed in lexical knowledge (e.g., Place & Hoff, 2011), morpho-syntactic knowledge (e.g., Gathercole, 2007), and now, as evident from our findings, in English word reading and spelling. Gathercole (2014) further suggests that the quantity and quality of language exposure affects the course and timing of acquisition of the language. This would partly account for why English-L1 individuals, with English as their dominant language, approach literacy tasks differently from English monolingual individuals as they may not have had the same quantity and quality of language exposure. The other explanation for this finding is that the two language systems in a bilingual are not separate, resulting in some form of interaction between the two languages (e.g., the effect of Chinese on the course of development of English in English-L1 individuals). Although early models of bilingualism proposed separate language systems (e.g., Weinreich, 1953), newer models have tended towards a more integrated language system (e.g., integration continuum, Cook, 2002; integrated neurolinguistic theory of bilingualism, Paradis, 2001). These models propose that different components of the two languages (e.g., syntax, phonology etc.) have different degrees of integration. So, domains of language that share similar processes may interact. Our findings reinforce the notion of
integration between components of the language system. For example, the phonology system may be integrated since both Chinese-L1 and English-L1 bilinguals appear to have poorer phonological skills than the English monolinguals. However, there may be different degrees of integration for different components of the language system (e.g., higher integration for the phonological system than orthographic) and the extent of integration would also depend on the characteristics of the two learned languages.

**Practical implications**

Understanding what ESL children and children with dyslexia know and can do and how they approach literacy tasks is essential to helping them successfully attain literacy skills. With remediation, the children with dyslexia in our study were able to achieve phonological and orthographic skills commensurate with their reading level. They were able to move past using phonological skills to adopt a more orthographic strategy. However, perhaps because they were relying on a skill in which they were not fully competent, they were still unable to achieve reading levels similar to that of their same-aged peers. Compared to the children with dyslexia, Chinese-English bilinguals do not have the literacy difficulties associated with poor phonological skills. In contrast, they were equally proficient in English word reading and spelling abilities as the English monolinguals. However, differences in the proficiency of phonological and orthographic processing skills may have a greater impact on more complicated literacy tasks such as reading comprehension (e.g., Bell & Perfetti, 1994; Nassaji, 2003; Stanovich, 2000) and reading fluency (e.g., Georgiou, Parrila, & Papadopoulas, 2008). Thus, it is important that instructional approaches address the group differences in underlying skill proficiencies. Yin et al. (2007) suggested that since Chinese-English bilinguals follow a similar alphabetic developmental sequence as English monolinguals, pedagogical methods suitable for English monolinguals and children with dyslexia would also be suitable for these bilinguals.
The most important skill to focus on initially would be to establish children’s phonological skills. It is now known that phoneme awareness should not only be taught explicitly (Stuart, 1999) but should be combined with the teaching of links between sounds and print (Blachman, Tangel, Ball, Black & McGraw, 1999; Ehri, Nunes, Willows, Schuster, Yaghoub-Zadeh & Shanahan, 2001; Hatcher, Hulme & Ellis, 1994). This may encourage the Chinese-English bilingual children to move through the alphabetic phases more quickly. In addition, improvements to phonological skills will promote decoding and enable both bilinguals and children with dyslexia to ‘self-teach’ unfamiliar words (Share, 1995) and allow greater access and exposure to varied texts. This will, in turn, enhance children’s sight word vocabulary.

However, emphasizing phonological skills is not sufficient given that English has an inconsistent orthography. Ziegler and Goswami (2006) suggest a variety of strategies are needed for successful English acquisition: grapheme-phoneme conversion, recognizing letter patterns, and whole word recognition (see also Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001). In a training study by Walton and Walton (2002), beginning readers were trained to use either rhyme analogies (e.g., light-right, see Goswami, 1986) or phoneme-grapheme correspondences to learn to read. They found that both groups performed significantly better in reading than a control group, especially the rhyme analogy group who could read using both analogies and letter-recoding strategies. Hence, having a repertoire of strategies resulted in better reading acquisition gains for children. Since our results showed that children with dyslexia do not have competent orthographic skills, and yet rely on them for reading and spelling, and Chinese-English bilingual children have proficient orthographic skills but are not applying them, it is essential that instructional practices include explicit orthographic training to boost orthographic skills in children with dyslexia and encourage the use of such skills in bilingual children. Ehri and Snowling (2004) suggest an explicit teaching
of larger blends of grapheme-phoneme units and systematic spelling instruction (e.g., letter clusters that map spelling rules/patterns) to improve children’s knowledge of rime units and orthographic conventions. Indeed, studies conducted in transparent orthographies (German: Ise & Schulte-Korne, 2010; Dutch: Timjs & Hoeks, 2005) have shown that orthographic spelling training (e.g., the teaching of orthographic spelling rules) improves spelling deficits in children with dyslexia. Coupled with orthographic training, repeated orthographic print exposure to a variety of words is vital as poor readers often require more exposures to learn unfamiliar words than skilled readers.

Therefore, pedagogical approaches to English for bilingual children and remediation programs for children with dyslexia should include the teaching of both phonological and orthographic strategies. It is clear that both groups of children would benefit from explicit phonemic training that links phonemes to print not only to enable smooth transition through the alphabetic phases of development, but also to initiate self-teaching of sight words. Orthographic training comprising rimes/letter patterns as well as whole word recognition would be useful for children with dyslexia, especially since it has been shown to improve spelling, and spelling difficulties appear to be more severe than reading difficulties in these children (e.g., Pennington, et al., 1986). The teaching of orthographic strategies to Chinese-English bilinguals is less clear given their proficiency in orthographic skills, but perhaps highlighting these strategies with examples of when to use them (e.g., rime analogy can be used for words such as light containing the common rime –ight) would encourage reliance on orthographic skills and a shift away from phonological skills. Emphasis should also be on general orthographic knowledge (i.e., permissible letter patterns and rimes), rather than word-specific knowledge, as Chinese-English bilinguals appear to be less proficient in this component of orthographic skill.
Limitations and Future Directions

This thesis makes a significant contribution to the research on bilinguals and atypical learners, however, there are certain concerns that should be addressed in future studies. These include the relatively small sample-to-variable ratios for the regression analyses and the use of a cross-sectional method in comparing age groups. The small sample sizes in the studies described in this thesis were partly because of difficulties recruiting bilingual individuals who were exposed to both Chinese and English from a young age, especially bilingual adults in a monolingual setting, and also because of the necessary exclusion of participants due to below average performance on the literacy and/or non-verbal IQ tasks. Clearly, the small sample sizes in each language background and age group may, potentially, have restricted the variability in scores within each group and limited the power to find significant effects. Hence, strong conclusions of group differences found in the types of skills that contributed to reading and spelling should be cautioned especially since most of the patterns of simple correlations did not differ significantly among the three groups in the studies. However, some of our results support findings from previous studies, such as the poorer phonological skills in Chinese-English bilinguals relative to English monolinguals (e.g., Cheung, Chen, Lai, Wong, & Hills, 2001), and the reliance on phonological skills in Chinese-English bilingual children (e.g., McBride-Chang & Kail, 2002), suggesting that these findings may be robust even in small samples. In addition, based on power analyses, only four non-significant findings were considered underpowered: the contribution of orthographic skills for spelling in the older English-L1 children, the contribution of orthographic skills for reading in English-L1 adults, the contribution of phonological skills for spelling in English monolingual adults, and the contribution of phonological skills for reading in children with dyslexia. If orthographic skills were found to contribute to English word reading and spelling for older English-L1 children
and adults, this would strengthen the proposition that Chinese-English individuals may be slow to move on from the alphabetic phase, as the English monolingual children were shown to rely on orthographic skills from a young age. The possibility of phonological skills contributing to reading in children with dyslexia would not be surprising as this has been found in previous studies (e.g., Manis et al., 1993). However, the possible contribution of phonological skills for spelling in English monolingual adults is unexpected and future studies should further explore these skills in proficient adults.

Future studies utilizing longitudinal methods to track the growth and development of phonological and orthographic skills as well as the reliance on these skills for English word reading and spelling would be useful to corroborate our findings of Chinese-English bilinguals’ over-reliance on alphabetic strategies. If replicated, this would raise questions as to how efficient these bilinguals are at reading, as sounding-out strategies are known to be laborious. Longitudinal studies investigating the associations of phonological and orthographic skills, to word reading and spelling can also help disambiguate the bidirectional effects between such cognitive-linguistic skills and literacy skills. As this thesis examined such skills in children and adults at a single point in time, we cannot conclude that phonological and orthographic skills influenced their literacy abilities, or vice versa. Such studies can also examine how phonological and orthographic processing skills interact over the course of development and provide further insight into the relationship between these two cognitive-linguistic skills. In addition, further investigations on the speed and accuracy of word reading (i.e., reading efficiency or fluency) in Chinese-English bilinguals are warranted as research in this area is scarce.

Furthermore, as this thesis aimed to examine the use of phonological and orthographic skills for word reading and spelling across different age groups, similar
literacy tasks and measures of phonological and orthographic skills were used for both children and adults. However, since the adults were proficient readers and spellers of English, single word reading and spelling accuracy may not have been the most sensitive measures. There is a need to examine more complicated reading processes such as reading comprehension and word and text reading fluency, as phonological and orthographic processing are also implicated in these tasks (e.g., Bell & Perfetti, 1994; Georgiou et al., 2008). In addition, the measures of orthographic processing need to be refined when used in adults. The adults from this study obtained high levels of accuracy on the orthographic tasks, and so, error scores and reaction times had to be combined for use in later analyses. Though this increased the variability of the scores, accuracy and speed measures may not be equivalent (Hagiliassis et al., 2006), making comparisons across age groups difficult. This highlights the need for more complex measures of orthographic skills (e.g., masked form priming lexical decision tasks, Castles, Davis, & Letcher, 1999; rapid lexical decision tasks, Leinonen et al., 2001) that can be used with proficient participants.

To better understand the transfer of L1 skills to L2 literacy, Chinese phonological and orthographic measures should be included in future studies. This may disambiguate the direction of transfer between L1 and L2 skills. It would also be interesting to investigate the relationships among phonological and orthographic skills, and reading and spelling in bilinguals who acquire the L2 later, after the L1 is well established. Perhaps due to differences in language exposure, the acquisition of English in English-L1 individuals appears to be influenced by the acquisition of Chinese, their L2. Thus, including a bilingual group that acquired the L2 much later may help to determine if external factors (e.g., amount of exposure, Gathercole, 2007) or other individual cognitive variables affect the acquisition of skills required for the L2 and the trajectory of L2 literacy development.
More research also needs to be done to examine the other processes that may be involved in English reading and spelling for bilingual individuals. Nation and Snowling (2004) found that oral language proficiency, such as vocabulary knowledge and listening comprehension, predicted reading comprehension and word recognition in English monolingual children concurrently as well as longitudinally (4.5 years later). However, later studies suggest that vocabulary may only be associated with certain aspects of reading (e.g., exception word reading, Ricketts, Nation & Bishop, 2007). The influence of vocabulary for bilinguals’ literacy is less explored but our findings suggest that receptive vocabulary may be just as important for Chinese-English bilinguals as for English monolinguals. Indeed, research from Spanish-English bilingual children suggests that English vocabulary proficiency may be associated with better English nonword spelling performance and more orthographically plausible English spellings (San Francisco, Mo, Carlo, August, & Snow, 2006). This relationship between oral language skills and word reading and spelling in bilinguals deserves further attention.

Though the use of a sample of children with dyslexia who had received additional literacy support (i.e., Chapter 4) suggests that it is possible for these children to attain underlying skills equivalent to their reading level, having received remediation may have obscured other potential differences between these atypical learners and typically developing monolingual children. Hence, future studies should use a sample of children with dyslexia who have not had any form of remediation, or take into account the specific intervention children had received, to ascertain if the similarities and differences from the cognitive profile of younger children hold true. Furthermore, while we have attempted to control for one of the more important learning differences among the language background groups (i.e., exposure to alphabetic coding system), there may be other differences in ways of teaching and learning among the groups that may have affected our findings (e.g., home literacy experiences). Future studies should account
for more of these differences so as to make the groups more comparable. In addition, assessing English monolingual children younger than those we have assessed in Chapter 3 may help to refine the phase model of development and determine when children move from using predominately alphabetic to orthographic strategies, or if, orthographic strategies are available from a young age.

**Concluding remarks**

There is a need for more research on English literacy in populations other than English monolinguals, such as ESL learners and atypical readers. This thesis addressed this need by investigating phonological skills and the lesser known orthographic skills in Chinese-English bilingual children and adults, and in English monolingual children with dyslexia. We also added to knowledge pertaining to the developmental trajectory of English literacy in Chinese-English bilingual individuals by examining their reliance on phonological and orthographic skills across age groups.

Our results suggest that there are some similarities in the way Chinese-English bilingual, dyslexic and typically developing English monolingual individuals approach English word reading and spelling. The findings are consistent with the existing literature showing that both phonological and orthographic skills are important for English word reading and spelling regardless of the background of learners, and that models of reading development proposed for English monolinguals can also be used as a model for other populations. However, there remain group differences, such as disparities in skill proficiencies and the persistent use of phonological skills in bilingual individuals, suggesting a much-longer influence of early language exposure than we expected. Individuals with dyslexia were also found to be more similar to younger typically developing children than presumed. These unexpected results deserve further investigation as group differences may become more pronounced on more complicated literacy tasks.
Our understanding of how bilingual and atypical learners approach English reading and spelling has increased rapidly in recent years. By comparing bilingual (e.g., Chinese-English bilingual children and adults) and atypical learners (e.g., children with dyslexia), we have contributed to the understanding of the skills that individuals bring to the learning of a language, and how individuals from varied backgrounds may approach the learning of English. It is hoped that this knowledge will aid in pedagogical and remediation efforts for all English learners.
References


