The effects of L1 orthography on processing an artificial logographic script.

by

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A thesis submitted as fulfilment for the degree of
Doctor of Philosophy
School of Psychology and Counselling
Institute of Health and Biomedical Innovation
 Queensland University of Technology
2008
KEYWORDS

Artificial script, bilingual, Chinese reading, inner speech, logography, language transfer, orthographic processing, working memory
STATEMENT OF ORIGINAL AUTHORSHIP

I certify that the work contained in this thesis has not been previously submitted for a degree or diploma at any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

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Signed:

Date:
ACKNOWLEDGMENTS

I dedicate this thesis to my mother Gwen Greasley Ehrich and to the memory of my father, Max Carlton Ehrich (25/12/1927 – 22/02/2008).

I would also like to thank the following people for their help and support. First and foremost, my principal supervisor Dr Renata Meuter for her expertise and endless patience, my associate supervisor Dr Jo Carr for her early encouragement, and my sister Associate Professor Lisa Ehrich for her continuing help.

I would also especially like to single out for thanks Dr Congjun Mu, Dr Jane Crawford, Professor Yan Wu, Dr Doug Mahar, Dr Julie Hansen, Dr Patricia Obst, Chad Brooks, Sue Taylor, the E-Prime Support Staff, and all those who participated in the study.
Abstract

To date, studies have focused on the acquisition of alphabetic second languages (L2s) in alphabetic first language (L1) users, demonstrating significant transfer effects. The present study examined the process from a reverse perspective, comparing logographic (Mandarin-Chinese) and alphabetic (English) L1 users in the acquisition of an artificial logographic script, in order to determine whether similar language-specific advantageous transfer effects occurred. English monolinguals, English-French bilinguals and Chinese-English bilinguals learned a small set of symbols in an artificial logographic script and were subsequently tested on their ability to process this script in regard to three main perspectives: L2 reading, L2 working memory (WM), and inner processing strategies. In terms of L2 reading, a lexical decision task on the artificial symbols revealed markedly faster response times in the Chinese-English bilinguals, indicating a logographic transfer effect suggestive of a visual processing advantage. A syntactic decision task evaluated the degree to which the new language was mastered beyond the single word level. No L1-specific transfer effects were found for artificial language strings. In order to investigate visual processing of the artificial logographs further, a series of WM experiments were conducted. Artificial logographs were recalled under concurrent auditory and visuo-spatial suppression conditions to disrupt phonological and visual processing, respectively. No L1-specific transfer effects were found, indicating no visual processing advantage of the Chinese-English bilinguals. However, a bilingual processing advantage was found indicative of a superior ability to control executive functions. In terms of L1 WM, the Chinese-English bilinguals outperformed the alphabetic L1 users when processing L1 words, indicating a language experience-specific advantage. Questionnaire data on the cognitive strategies that were deployed during the acquisition and processing of the artificial logographic script revealed that the Chinese-English bilinguals rated their inner speech as lower than the alphabetic L1 users, suggesting that they were transferring their phonological processing skill set to the acquisition and use of an artificial script. Overall, evidence was found to indicate that language learners transfer specific L1 orthographic processing skills to L2 logographic processing. Additionally, evidence was also found indicating that a bilingual history enhances cognitive performance in L2.
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<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>ERP</td>
<td>Event-Related Potentials</td>
</tr>
<tr>
<td>ESL</td>
<td>English as a second language</td>
</tr>
<tr>
<td>fMRI</td>
<td>functional magnetic resonance imaging</td>
</tr>
<tr>
<td>L1</td>
<td>First language</td>
</tr>
<tr>
<td>L2</td>
<td>Second language</td>
</tr>
<tr>
<td>L3</td>
<td>Third language</td>
</tr>
<tr>
<td>LTM</td>
<td>Long-term memory</td>
</tr>
<tr>
<td>ms</td>
<td>Millisecond</td>
</tr>
<tr>
<td>RT</td>
<td>Response time</td>
</tr>
<tr>
<td>SLA</td>
<td>Second language acquisition</td>
</tr>
<tr>
<td>SOA</td>
<td>Stimulus onset asynchrony</td>
</tr>
<tr>
<td>STM</td>
<td>Short-term memory</td>
</tr>
<tr>
<td>TLA</td>
<td>Third language acquisition</td>
</tr>
<tr>
<td>VSTM</td>
<td>Visual short-term memory</td>
</tr>
<tr>
<td>VSSP</td>
<td>Visuo-spatial sketchpad</td>
</tr>
<tr>
<td>WM</td>
<td>Working memory</td>
</tr>
</tbody>
</table>
CHAPTER 1

The broad, all encompassing aim of the research described here was to investigate the impact of a language learner’s first language (L1) orthographic background on performance in reading and on reading-related tasks in a second language (L2). The main argument is that the first language orthographic background of language learners can affect the ease with which they acquire and then read L2 text. In essence, the dialectic adopted here is that of linguistic transfer, in this case of L1 reading skills. Odlin (1989) defines transfer as “…the influence resulting from similarities and differences between the target language and any other language that has previously (and perhaps imperfectly) been acquired” (p. 27). In other words, language features acquired through the inculcation of L1 (and possibly other languages) can influence a language learner’s reading of L2 text. The research question central to this thesis is whether language learners transfer specific L1 orthographic processing skills to L2 reading.

Language transfer has been an area of major interest for Second Language Acquisition (SLA) researchers for a number of years (Gass & Selinker, 1992; Odlin, 1989). The field of L2 reading constitutes a point of significant overlap between SLA and language transfer research. Of particular importance to L2 reading, SLA, and language transfer research, is the effect of a language learner’s L1 orthographic background on L2 reading (Grabe, 2002). There is growing evidence that language learners transfer their specific L1 orthographic processing skills to L2 reading (e.g., Akamatsu, 2003; Chikamatsu, 1996; Koda, 1999, 2000; Mori, 1998; Muljani, Koda, & Moates, 1998). This theoretical perspective has been described as “relativist” (e.g., Odlin, 2002).

Koda (1994) categorizes language transfer research into two main perspectives: a universal perspective and a language specific perspective. The universal perspective is based on the assumption that reading skills are the same regardless of the language being processed. In contrast, the language specific perspective views reading as a skill that contains cross-linguistic variation (a relativist position). However, most reading research conducted on language transfer has been conducted from the universal perspective (Koda). These types of investigations have involved either the interrelationship between L1 and L2 reading or the factors that inhibit or facilitate L1
transfer to L2 reading (Koda). For example, the positive and negative effects of transferring L1 syntactic processing strategies to L2 sentence comprehension are a typical focus on language transfer studies (e.g., Bates & Macwhinney, 1989; Nagy, McClure, & Mir, 1997, see Macwhinney, 1997). What distinguishes the studies with a universal perspective from the language specific studies is that they (the universal perspective) do not go into any particular depth to determine the nature of the reading skills which are transferred. That is, when any cross-linguistic variation is found in these studies it tends to be ignored. Language specific studies, on the other hand, seek to determine the nature of any cross-linguistic variation detected during language transfer in reading (Koda). Few language transfer studies have investigated the transfer of specific cognitive skills which were developed in L1 and subsequently applied in L2.

One explanation for the paucity of relativist studies in language transfer research is that any challenge to the notion that cognition is uniform across languages and cultures evokes controversy (Koda). In general, researchers are reluctant to challenge the idea that cognition is the same across languages and cultures because cognitive universalism is a more ethically well-received ideology (Lucy, 1996). Therefore, the present study, which challenges the belief that reading cognition is the same across orthographically different languages, constitutes a controversial theoretical stance.

Karmiloff-Smith (1992) makes some important points about writing systems that undermine the cognitive universalist theoretical stance. For example, writing systems constitute a relatively “new” phenomenon in relation to human psychological behaviour. The very first writing systems developed about 5000 or 6000 years ago. The newness of writing systems to human behaviour makes it highly unlikely that there exists an “…innately specified bias for writing” (Karmiloff-Smith, 1992, p.147). Speech has taken 100, 000s of years to evolve, whereas writing systems are relatively recent. The idea that human beings are genetically predisposed toward writing in a similar way as humans are genetically predisposed toward speech is implausible (Karmilof-Smith). Therefore, it could be said that writing, and hence reading, as psychological human behaviours, are more the product of cultural forces than biological ones. An argument that posits cognitive universalism in relation to reading, ignores the very potent forces of cultural inculcation in regard to this newly acquired skill.
Hence, writing systems have evolved out of a culture and are not universal. As human cultures are highly variant and complex, so too are writing systems. It will be argued in later sections (see for example p. 21) that the linguistic variation arising out of the differences between these highly cultural writing systems results in the development of some specialized L1 reading and processing skills that can be transferred to L2 reading. In summary, the overall aim of the present research study was to investigate the hypothesis that L1 orthographic processing skills can be transferred to L2 reading. This theoretical perspective is relatively under-researched and is contentious among language researchers. Specifically, the question will be examined by contrasting reading and memory performance with an artificial logography in bilingual readers of varied L1 backgrounds (Chinese vs. English) and monolingual readers.

Bilingualism and SLA

Before embarking on the rationale for the present study, it is important to define briefly what is meant here by bilingualism and SLA. Bilinguals can be considered people who “…use two (or more) languages (or dialects) in their everyday lives” (Grosjean, 2004, p. 34). That is, a bilingual person is someone who can function in a language (other than their native tongue) to meet their daily requirements. The perception of bilinguals as individuals who are equally fluent in two or more languages, also known as the two monolinguals in one person perspective (see Grosejean, 1989), is not adopted here. Bilinguals who are equally fluent in both their languages are also known as balanced bilinguals (Toribio, 2001), whereas bilinguals who have greater proficiency in one language than the other are known as nonbalanced bilinguals. Because balanced bilinguals do not represent the majority of bilingual speakers in the world (Cook, 2003), here, the term bilingual will refer to nonbalanced bilinguals (unless otherwise stated). The main point here is that bilinguals are language users at different points on a continuum in terms of proficiency in different L1 and L2 skills.

SLA is defined as

…the learning of language, to any level, provided only that the learning of the ‘second’ language takes place some time later than the acquisition of the first language.” (Mitchell & Miles, 2004, p. 5)
Under this definition, SLA covers the learning of any language which is not the native language of the language learner. Also, the terms ‘learning’ and ‘acquisition’ will be used interchangeably in the thesis, unless otherwise specified.

The present study required both monolingual and bilingual participants to acquire an artificial orthography. For the monolinguals this effectively involved the acquisition of an L2, for the bilinguals, the artificial orthography constituted an L3. The acquisition of an L3 by bilinguals is a relatively new research field (Cenoz, Hufeisen, & Jessner, 2001). Of the studies conducted thus far, most have found that bilinguals demonstrate greater proficiency than monolinguals when acquiring a third language (e.g., Cenoz & Valencia, 1994; Jessner, 1999; Klein, 1995; Thomas, 1988; see Cenoz, 2000). For example, Cenoz and Valencia demonstrated that, in an immersion programme in Basque country (Spain), the bilingual groups outperformed the Spanish monolinguals in the acquisition of English. Young adult monolingual Spanish, Spanish-Basque\(^1\) and Basque-Spanish bilinguals, who were either L2 or L3 learners of English, were questioned on a number of educational, cognitive, and social psychological factors related to language learning and underwent a series of English language tests including speaking, listening, reading, writing, grammar and vocabulary. Bilingualism was found to be a strong predictor of English language proficiency.

Cenoz and Valencia (1994) gave several possible reasons for this bilingual performance advantage. One was that the knowledge of how two languages work (Basque and Spanish) increases the levels of metalinguistic awareness of bilingual language learners when acquiring an L3. When bilinguals learn an L3, they have the advantage of being able to compare their knowledge of two other linguistic systems with the one they are learning. This might account for their superior performance. Alternatively, bilinguals may have been more sensitive to the needs of other speakers. For example, in the Basque region of Spain, it is necessary for Basque-Spanish bilinguals to continually switch languages to accommodate the Basque proficiency of the interlocutor. This heightened sensitivity to the needs of other speakers may have increased the bilinguals’ levels of communicative competence in an L3. Thus, either the bilinguals’ increased metalinguistic awareness and or their superior communicative

\(^1\) By convention, the first, dominant language is given first.
competence may explain why they outperformed monolinguals on language learning tasks.

However, bilinguality may not provide similar benefits in the acquisition of an artificial third language. For example, Nayak, Hansen, Krueger, and Mclaughlin (1990) investigated the effect of multilinguality (defined as fluent in three or more languages) on the acquisition of a miniature artificial linguistic system. Multilinguals and monolinguals learnt non-words consisting of trigrams (e.g., NEB, JAX), which were associated with categories of geometric shapes. These trigrams were arranged into a series of single sentences that obeyed a set of syntactic rules. Participants were tested on their memory skills and their ability to discover the syntactic rules. Overall, the multilinguals did not outperform the monolinguals in their ability to learn this artificial language. However, they were more flexible in their range of processing strategies. In summary, the superiority of bilinguals over monolinguals when acquiring a third language may not extend to the acquisition of an artificial language but it may extend to a greater flexibility in language processing strategies. This finding has three important implications for the present study. First, using an artificial linguistic system as an instrument to investigate cognitive processing may not provide any between-group differences based on cognitive performance. Second, the use of an artificial linguistic system may, however, provide a useful instrument for the investigation of participants’ cognitive strategies. Third, bilinguality per se may affect participants’ use of cognitive strategies when processing an artificial linguistic system. Because a participants’ L2 background can impact on the cognitive strategies used to process an artificial linguistic system (and possibly their performance as well), the present study incorporated both bilingual and monolingual groups of language learners. In this way the potential effects of bilinguality on the processing of an artificial script could be explored.

Understanding the Reading Process

Having defined bilingualism and SLA, the concept of reading as a cognitive process will now be investigated. It is generally accepted that the reading process, whether it be in L1 or L2, is interactive. In its simplest form, the interactive nature of the reading process can be depicted as an equation: “R = D x C” (Gough & Wren, 1999, p. 70), which translates as reading (R) is equivalent to decoding (D) times comprehension
(C). In other words, the written text must be analyzed from the interaction of two contrasting processes, i.e., the analytical particularistic evaluation (the decoding of individual units), in conjunction with broader, more global concerns (the use of context and inference to establish meaning). The degree to which each of these two contrasting perspectives (D or C) in the processing of written text is emphasized is a matter of contention amongst reading researchers. Some argue for a major role for comprehension/meaning (e.g., Goodman, 1989 (L1); Carrell, 1989 (L2); Carrell & Eisterhold, 1989 (L2)), while others are in favour of a stronger role for decoding (e.g., Eskey, 1989 (L2); Gough & Wren, 1999 (L1)).

The present research mostly concentrates on the role of decoding in the reading process. There are two main reasons for this. First, studies have shown the graphophonic system to be primary in the reading process. For example, in a text predictability study, Gough and Wren (1999) found that readers rely more on the printed word than they do on other contextual factors. This implies a heavy role of decoding in the reading process. Second, a focus on graphophonic processes, which involve the retrieval of a speech code from an orthographic structure, is a largely unresolved area of research. There are a number of researchers who have diametrically opposed views on this issue (Rayner & Clifton, 2002). Hence, more research that investigates the role that graphophonic processes play in reading is needed. The present study is an attempt to address this need. Here, an artificial script was controlled for a number of graphophonic processes in order to investigate their effect on silent reading and whether or not these processes can be transferred from L1 to L2.

As a psychological act, reading is a covert process (Urquhart & Weir, 1998). The nature of this covert process is a complex one. In order to read, the eye must first fixate on written text. However, what comes next in terms of decoding the letter, syllable or character to retrieve meaning is subject to much controversy and division amongst researchers. In terms of recent research involving the decoding aspects of reading (e.g., orthographic, phonological and semantic processing), there is much debate over the role of the graphophonic system. This debate can be broken down into two main areas that involve the role of phonological processes in regard to word identification, focusing on whether phonological information helps access a word’s meaning (pre-lexical), or
whether its role is one of identification (post-lexical) (Perfetti, 1999). In other words, is written text translated into a speech code before a meaning is ascertained or is the meaning retrieved directly from the graphemic properties of the text? Put simply, how important is the sound of the word when reading? In the reading of English, this debate has lasted a century (Jared, Levy, & Rayner, 1999). Even though most research investigating the role of the graphophonic system in reading has been conducted on alphabetic languages such as English (Koda, 1994), this debate is present also in cross-linguistic studies which investigate non-alphabetic scripts (e.g., Chinese and Japanese Kanji) as well. For example, in relation to reading English, the pre-lexical route is present in most current models of lexical access (Feng, Miller, Shu, & Zhang, 2001) (see Figure 1.1). This route follows the course of orthography-to-phonology-to-semantics (Feng et al., 2001). The existence of this particular route has been supported in the many studies which have shown that phonological processes are activated early when reading English (e.g., Folk, 1999; Gottlob, Goldinger, Stone, & Van Orden, 1999; Henderson, Dixon, Petersen, Twilley, & Ferreira, 1995; Lesch & Pollatsek, 1993; Lukatela & Turvey, 1991, 1994; Pollatsek, Lesch, Morris, & Rayner, 1992; Van Orden, Johnstone, & Hale, 1988). Stanovich (2000), in a detailed review of the role of phonology in reading English, argues that there is increasing awareness of the crucial role that phonological processes play. However, the view that the pre-lexical route in reading English is the primary one has been challenged (e.g., Davelaar, Coltheart, Besner, & Jonasson, 1978; Martin, 1982; McQuade, 1981; Van Orden, Pennington, & Stone, 1990) and it has been argued that the role of phonological processes in reading English has been greatly exaggerated (e.g., Coltheart, 1999; Damian & Martin, 1998). In between these two theoretical stances, Dual Route reading models (e.g., Coltheart, 1980; Coltheart & Rastle, 1994; Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001) suggest that both pre-lexical and post-lexical routes can be used in combination to retrieve meanings from orthographic structures.

The importance of phonological processes in the decoding of Chinese characters is equally unclear. On one hand, orthographic features of Chinese characters have been found to be crucial to word identification and lexical access, with a lesser role for phonological processes (e.g., Chen, Flores d’Arcais, & Cheung, 1995; Ju & Jackson,
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1995; Shen & Forster, 1999; Tan, Hoosain, & Peng, 1995; Wong & Chen, 1999; Zhou & Marslen-Wilson, 2000, Zhou, Marslen-Wilson, Taft, & Shu, 1999). On the other, phonological processes have been found to be important in the mediation of lexical information from Chinese orthography (e.g., Flores d’Arcais, Saito, & Kawakami, 1995; Hung, Tzeng, & Tzeng, 1992; Perfetti & Zhang, 1995; see Leong, 1997 for a review of these studies). For example, Perfetti and Zhang argue that all writing systems, including logographic Chinese, trigger a “word identification reflex” (p.160). As part of this “reflex”, described as the Universal Phonological Principle, a phonological object is automatically triggered upon word identification. Hence, the pre-lexical/post-lexical debate is prevalent within and across language systems, such as Chinese and English.

Figure 1.1. Routes to the semantic associations of the character/word for “cat” in Chinese (a) and English (b). The pronunciation for Chinese morphemes, such as the above character pronounced as /mao(1)/, can only be attained via memory, whereas the pronunciation for the English word equivalent /kæt/ can be retrieved either by phonemic assembly or memory. This illustration was created from a description of the reading process from “Alphabetic and nonalphabetic L1 effects in English word identification: A comparison of Korean and Chinese English L2 learners” by M. Wang, K. Koda, & C. Perfetti, 2002, Cognition, 87, p. 130.
Therefore, what is known about the reading process is equally unclear in both the English and Chinese languages. It appears that similar processes, such as phonological and orthographic processing, are involved and disagreed on. However, in reading words of any kind of script, whether in English or in Chinese, there are some fundamental cognitive skills that are required in order to recognize an orthographic structure and to access meaning and associated phonology. All readers utilize these universal cognitive skills at some point during the act of processing a script. However, the degree of dependence on these universal cognitive processes may vary according to the type of script being read. For example, reading studies that have investigated the transfer of L1 orthographic processing skills to L2 have found that alphabetic or syllabic orthographic background readers derive more of a benefit reading an alphabetic or syllabic L2 than L1 logographic readers (e.g., Akamatsu, 2003; Chikamatsu, 1996; Koda, 1999, 2000; Mori, 1998; Muljani, Koda, & Moates, 1998; Wang, Koda, & Perfetti, 2002). This indicates that a reader’s L1 orthographic processing experience may result in the development of specific skills that can be transferred to facilitate the processing of an orthographically congruent L2. This situation would be implausible given orthographic processing skills were uniform across variant orthographic types. An important goal of the research presented here was to shed new light on the cognitive processes involved in reading through an approach that investigates L2 orthographic processing from the theoretical perspective of language transfer. However, for a reader to be able to transfer specific L1 orthographic processing skills to facilitate the ease of processing orthographically congruent L2 script, several key criteria must be met. These criteria are listed below:

1. Orthographies are different
2. Different orthographies are associated with different processing procedures
3. Different orthographic processing procedures can be transferred to L2 reading

In order to further understand the complexities of orthographic processing within a language transfer theoretical framework, these key criteria will be discussed in turn.

Orthographies are Different

Mattingly (1992) lists six major orthographic traditions: (1) Mesopotamian cuneiform, (2) Cretan, (3) Chinese (including Korean and Japanese), (4) Mayan, (5)
Egyptian, and (6) West Semitic (including Phoenician (c. 1600 B.C.) and Ras Shamrah cuneiform, Old Hebrew, South Arabic, Aramaic, and Greek alphabetic writing). Today, the major orthographic systems can be broken down into three main types: logography (e.g., Chinese), alphabets (e.g., English), and syllabaries (e.g., Korean Hangul). There are significant structural differences between these three orthographic types. The major difference lies in the nature of the graphemic units associated with each orthography. In logography, such as Chinese characters, a single graphemic unit constitutes a meaning and has an associated pronunciation. This is known as addressed phonology. Therefore, the pronunciation of a Chinese word is recalled from memory and is not constructed through the assemblage of individual sound units (Patterson & Coltheart, 1987). Of course, there are phonetic radicals within these characters that can enable the access of pronunciation via internal structure. However, these radicals are not reliable. For example, from a list of 1522 phonetic radicals, only 18 provide consistent pronunciation for more than three compound characters totaling 98 characters in all (Gao, 1983). Therefore, generally speaking, logographic readers must recall a Chinese character’s pronunciation without the aid of phonemic or syllabic clues (see Shen & Forster, 1999, for a more complete discussion).

In alphabets and syllabaries, the smallest graphemic units represent a sound code, such as the phonemes of alphabets and the syllables of syllabaries. These sound codes are assembled together to form a word’s phonology (Patterson & Coltheart, 1987). This is a major point of contrast with logography, where the word’s pronunciation is not apparent through a graphemic configuration. Alphabetic and syllabic readers can access a word’s phonology through the assemblage of graphemic units and, in some cases, can even access a word’s phonology before all of these units of a word have been displayed (e.g., Pollatsek et al., 1992), whereas logographic readers must largely recall a word’s phonology from memory.

The degree to which an orthography conforms to grapheme-to-phoneme correspondence (GPC) rules determines whether it is “deep” or “shallow” (Katz & Frost, 1992). For example, Chinese has no GPC rules and can therefore be considered a “deep” orthography (Hoosain, 1991). In contrast, the letters of Serbo-Croatian directly correspond to the phonemes of the spoken language and therefore Serbo-Croatian can be
considered a “shallow” orthography (Katz & Frost). The Orthographic Depth Hypothesis proposes that the shallower the orthography, the greater the amount of phonological recoding is carried out in order to attain lexical access (Katz & Frost). That is, a reader of a Serbo-Croatian text would systematically analyse the internal components (letters) of words in order to retrieve a phonological code, which would then trigger a lexical association. Therefore, a particularly shallow orthography, such as Serbo-Croatian, would involve more phonological recoding than logographic Chinese in the attainment of lexical access from printed words. There is growing evidence that the Orthographic Depth Hypothesis is an accurate reflection of early L2 reading behaviour (Grabe, 2002).

In the next section it is argued that the orthographic structural variations between phonographic (English) and logographic (Chinese) systems result in the development of some alternate cognitive processing orientations during reading, particularly at the graphophonic level. That is, the inculcation of alphabetic script results in reading cognition that is orientated toward phonological processing, whereas the inculcation of logographic script results in more visually orientated reading cognition.

**Different Orthographies Require Different Processing Procedures**

Much research into the reading of English has focused on the role of phonological processing of text (Stanovich, 2000). Even though the case has been argued against a strong role of phonology in reading English (e.g., Coltheart, 1999; Damian & Martin, 1998), and Dual Route models include a combination of phonological, orthographic and semantic processing (e.g., Coltheart, 1980; Coltheart & Rastle, 1994; Coltheart et al., 2001), the general consensus is that phonological processing is primary (Perfetti, 1999; Stanovich, 2000). There are a number of studies that have demonstrated that the orthography-to-phonology-to-semantics route is the primary one in English word identification.

**English Language Graphophonic Processing**

Evidence that the orthography-to-phonology-to-semantics route is the primary one in English word identification can be found in a study by Lukatela and Turvey (1991) who investigated the effect of briefly presented word primes on the naming of pseudohomophone targets presented subsequently. The technique of priming is used to
investigate the facilitatory and inhibitory effects of phonology, orthography and semantic/lexical processing during reading. The information contained in the primes can either facilitate response or interfere with target identification depending on the nature of their relationship. A series of semantically related primes and targets (e.g., table – chair), pseudohomophones (e.g., table - char) and unassociated pairs (e.g., novel - chair) were presented for naming. Pseudohomophones were named faster when primed semantically. Facilitation was also found when the targets shared phonological characteristics with associates of the primed words. For example, targets like char (a pseudohomophone of chair) were named faster when primed with table than when they were primed with unrelated words (e.g., novel) or non-words (e.g., thar). The findings were not a result of orthographic processing: when both pseudohomophones (e.g., char) and non-words (e.g., chark) shared the same letter overlap with the target words (e.g., chair) the same pattern of results was found. This type of priming (known as associative priming) is believed to be primarily a lexical process. Word meaning is retrieved through the activation of a word’s lexical representation. That is, facilitation of the processing of a pseudohomophone (like char) occurs via the activation of its phonological representation. Importantly, if lexical access was graphemic only, table would not have facilitated the naming latency for char. Therefore Lukatela and Turvey argued that phonology plays a decisive role in lexical access of visually presented words.

In a later study, Lukatela and Turvey (1994) investigated the relative contribution of phonological and orthographic components in priming. Primes and targets were controlled for phonological and orthographic overlap through the use of homophones (e.g., tower – toad), semi-homophones (e.g., tode – toad), and orthographic neighbours (e.g., told – toad). Overall, strong effects were found for the homophone and semi-homophone primes in the identification of associated target words. However, primes that were orthographically similar to the target words (e.g., told – toad) did not result in strong priming effects. These results support the notion that assembled phonology is the dominant route in English word identification.

Consistent with this idea, studies investigating the time course of phonological activation in English word identification have found that phonological activations
precede lexical access. For example, using a masked priming paradigm in which the primes were either homophones of semantic associates of target words (e.g., *beech* – *sand*) or visually similar (e.g., *bench* – *sand*), Lesch and Pollatsek (1993) found that at short Stimulus Onset Asynchrony (SOA; 50 ms), homophone primes (e.g., *beech*) significantly facilitated the naming times of target words (e.g., *sand*) when compared to visually similar primes (e.g., *bench*). However, at longer SOAs (250ms), homophones did not facilitate naming latencies more than visually similar primes. Lesch and Pollatsek argued that this differential effect, revealed through a time-course manipulation, constituted powerful evidence for the orthography-to-phonology-to-semantics route in English reading. At 50 ms, the phonology of the word is activated first, followed only later by its semantic meaning. Thus *beech* indirectly activates the meaning of *beach* through shared or closely linked phonological representations, thus priming the target (*sand*). However, at longer prime SOAs the extra processing time would allow for the orthographic discrepancy (*beech* not *beach*) to be computed and resolved, restricting semantic activation to *beech*. *Beech* is unrelated to the target *sand* and hence no facilitation is observed.

Not only have studies found that phonological codes are activated early in English word identification but Pollatsek et al. (1992) found that phonology may be triggered even before all the graphemic elements of a word are fully revealed. In Experiment 1, primes consisted of words which were visually similar (e.g., *cake* – *sake*) or homophonic to the target (e.g., *brake* – *break*). Primed words were presented as a preview, as follows. As soon as a participant’s right eye moved by a third of a degree to read the prime a boundary mechanism was triggered which resulted in the display of a target word. Homophones gave a significantly better preview benefit than visually similar words in terms of naming latencies (approximately 11 ms). Similar findings were obtained for the priming of targets embedded within a short sentence (Experiment 2). Fixation times on target words were significantly shorter with a preview of homophones than with visually similar words. The results support the contention that phonology, not orthography, is crucial in English word identification.

The studies reviewed so far have investigated the role of phonology in English word identification through the use of naming tasks. These studies have indicated that
phonological processing is crucial to English word identification. However, the use of naming tasks to investigate phonological processes in word identification research has come under criticism (e.g., Shen & Forster, 1999). The problem is that when a word is named, its phonology is automatically activated. Therefore, the phonological effects attained in naming tasks may be more a reflection of the task than the processes involved in English word identification.

However, studies have shown that phonology plays an important role in English word identification even when tasks were used that did not involve naming (e.g., Gottlob, Goldinger, Stone, & Van Orden, 1999; Van Orden, Johnstone, & Hale, 1988). Van Orden et al. examined the false positive error rates associated with homophones and non-words during a categorical decision task. Participants were presented with a categorical statement, (e.g., An article of clothing) followed by a target that either did or did not belong to the previously displayed category. Target words were controlled for real-word homophony (e.g., hare - hair), non-word homophony (e.g., sute – suit), and spelling controls in two conditions, real words (e.g., harp) and non-words (e.g., surt). Significantly more errors were made when presented with a category decision (e.g., An article of clothing) followed by a non-word homophone target (e.g., sute) than with an orthographically similar word target (e.g., surt). Because non-words, such as sute, have no lexical entries, it was argued that phonological processes were crucial to word identification, positing a lesser role for orthographic factors.

Similarly, Gottlob, Goldinger, Stone, and Van Orden (1999) used an association judgement task to investigate the role of phonology in English word identification. Three categories of words (homographs, which had separate meanings and pronunciations (e.g., wind); homonyms, which had the same pronunciation but different meanings (e.g, hide), and control words (e.g., clock), were presented as primes and targets in varying orders. Participants were required to determine if the target was categorically related to the prime (e.g., breeze – wind). Targets (e.g., wind) were classified according to dominant and subordinate meanings (e.g., breeze and turn respectively). For homographs (e.g., wind), response times (RTs) were slowed when subordinate meanings were primed (e.g., turn – wind). However, no performance decrements were seen for subordinate vs. dominant primes displayed before homonym
targets (e.g., vampire – bat vs. baseball – bat). This pattern of results again reveals a strong relationship between phonology and meaning.

In summary, the evidence presented here supports the notion that the orthography-to-phonology-to-semantics route is dominant in English word identification. That is, the role of phonology plays a crucial part in the access of meaning from written alphabetic script. To what extent this may or may not be the case also for other, non-alphabetic languages, in particular Chinese, is the focus of the next section.

**Chinese Language Graphophonic Processing**

While there is general agreement on the importance of phonology in reading English (Stanovich, 2000), there is less agreement on its role in Chinese character reading. Several studies have indicated that phonological processes are important in the mediation of lexical information from Chinese orthography (e.g., Flores d’Arcais, Saito, & Kawakami, 1995; Hung, Tzeng, & Tzeng, 1992; Zhou & Marslen-Wilson, 1999; see Perfetti & Zhang, 1995 for review). However, many other studies suggest that phonological processes play a reduced role (or in some cases no role) in Chinese word identification (e.g., Chen, Flores d’Arcais, & Cheung, 1995; Ju & Jackson, 1995; Shen & Forster, 1999; Tan, Hoosain, & Peng, 1995; Wong & Chen, 1999; Zhou & Marslen-Wilson, 2000; Zhou & Marslen-Wilson, Taft, & Shu, 1999). Both bodies of evidence will be discussed in turn.

As with alphabetic reading, there is evidence indicating that phonological processes are important in Chinese reading. Flores d’Arcais et al. (1995) examined Kanji characters in terms of phonological and semantic activation. Each target character contained a semantic radical located on the left and a phonetic radical located on the right. The semantic radical was either meaningfully related or unrelated to the target character, while the phonetic radical was either homophonic with or had a different pronunciation to the target character. In a naming task, target characters were displayed with either the left or right radical appearing at various time intervals (e.g., SOAs of 60 ms and 180 ms) before the whole target character was revealed. The results indicated that, in contrast to English naming, both semantic and phonological activation are present early (e.g., 60 ms) in Kanji character naming. The early triggering of both
phonological and semantic information from phonetic radicals suggests that the lexical access of Kanji characters is attained simultaneously with the activation of phonological information. Hence, this finding conflicts with the orthography-to-meaning route in Chinese word identification which specifies that lexical information is retrieved directly from the orthographic structure of the character (bypassing the need for activation of phonological information).

Similar observations were made by Zhou and Marslen-Wilson (1999) who investigated the effect of priming by phonetic and semantic radicals on the naming of compound Chinese characters. A semantic or phonetic radical was presented briefly, immediately followed by a target Chinese compound character. Phonetic radicals were found to facilitate the access of semantic information of Chinese compound targets. Therefore, Zhou and Marslen-Wilson argued that phonological and semantic information are activated simultaneously upon the identification of Chinese characters. Therefore, Zhou and Marslen-Wilson’s findings are also not consistent with the idea that lexical information is attained from Chinese characters directly from their orthographic structures (orthography-to-meaning route). The finding of the simultaneous activation of phonology with semantic information when reading Chinese characters conflicts with this idea.

Hung, Tzeng, and Tzeng (1992) used the picture word adaptation of the Stroop paradigm² that incorporated a naming task as the response measure to investigate orthographic and phonological processes in Chinese reading. Chinese characters, orthographically, phonologically, or semantically related to the picture name were superimposed on simple line drawings. Both phonological and graphemic information were found to facilitate the naming of a corresponding picture, indicating that Chinese readers can access word meaning either via the grapheme or via the phoneme.

² In a typical Stroop paradigm (Stroop, 1925) the names of colours are presented in black or in incongruent colours (e.g., the word red printed in blue). The task is to name the colour of the word while ignoring the word itself. The delay experienced in the incongruent condition constitutes the Stroop effect and reflects the interference experienced when having to overcome the automatic tendency to read the word (instead of naming its colour).
In summary, studies reviewed here contest the orthography-to-meaning route in Chinese word identification through providing evidence that phonological processes are activated early in Chinese reading. However, in all of these studies responses involved the participants having to name targets. As previously mentioned, the naming of targets automatically activates phonological information. Therefore, these studies may have been biased towards phonological processing. In the next section, studies that demonstrate the primary role of visual, orthographic structures in Chinese word identification are discussed. In these studies, phonological activations were not found to play a crucial role in the attainment of lexical information from Chinese characters.

For example, in Chen et al.’s (1995) study, semantic processing was measured through homophonic and graphemic distractors in a categorization task. Participants were given a category (e.g., bird) followed by the target (e.g., magpie or sir) and had to decide whether the target was of the same category as the previous target (e.g., bird–magpie vs. bird-sir). The homophonic distractors differed in orthographic structure and meaning to the categories but shared a pronunciation (e.g., both bird and sir are pronounced as /jeuk(3)/ in Chinese). The graphemic distractors differed in meaning and pronunciation to the categories but had similar orthographic structures. Contrary to what would be expected if phonology were the deciding factor, homophonic distractors failed to significantly impair the readers. However, graphemic similarity distractors did impair performance suggesting an important role for the orthography-to-meaning route and casting doubt on a universal phonological activation principle (as advocated by Perfetti & Zhang, 1995). Indeed, Chen et al. (1999) found that phonology played no role in a semantic categorization experiment involving Chinese characters.

Similar observations were made by Ju and Jackson (1995). Using backward masking, they found that graphic information was processed very early in Chinese reading. Brief (30 ms) presentations of a target word were followed by a mask (a pseudo-word also presented for 30 ms) which was graphemically and or phonemically

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3 The backward masking paradigm involves the identification of a briefly presented target followed immediately by a briefly presented item known as the “mask”. Masks are visually or phonetically related to the target and are designed to either facilitate or interfere with how the target is processed. Backward masking is often used to determine the time course of orthographic, semantic or phonological activation in reading studies.
related to the target. Written responses were collected. Graphemic information facilitated the identification of target characters at 30 ms whereas phonological information did not. Therefore, this study supports the argument that phonology does not play a role in early word identification in Chinese reading. However, because the participants were required to respond in writing it is possible that this task was biased towards graphemic processing. Just as phonological processing is activated automatically in naming tasks, then, so too would graphemic processing be activated automatically when writing. Therefore, this result may simply be a task effect.

In a masked priming paradigm used in a lexical decision context, Tan, Hoosain, and Peng (1995) demonstrated that the graphic structures of Chinese characters played an important role in Chinese word identification. Masks consisted of graphic characters which were visually similar to the target, phonological characters which were homophonic but orthographically dissimilar to the target, semantic characters which were synonymous but orthographically and phonologically unrelated to the target and unrelated control characters. Target characters and masks were exposed for 50 ms and 30 ms respectively. Written responses were collected. Graphically similar masks facilitated the target character’s identification. However, this was not the case for phonetic and semantic masks. This highlighted the importance of the graphical structure of characters, which were activated as whole units before phonological codes could be accessed. However, as with Ju and Jackson’s (1995) study, having the participants respond in writing may have biased the task towards graphemic processing.

In another masked priming paradigm, Shen and Forster (1999) found that, in terms of Chinese word identification, lexical access was directly attained through the orthographic structure of the character and phonology was accessed only after this process. In a naming task, both phonological and orthographic primes facilitated identification. In a lexical decision task, phonological primes did not facilitate response but orthographic primes did. It would appear, therefore, that different results are obtained as a function of varied task demands. Chinese readers appear to rely solely on orthographic character features in the word identification process. Unlike the previous two studies, the participants of Shen and Forster’s study did not respond in writing. Therefore, it was unlikely that the task was biased towards graphemic processing.
Hence, this study provides strong evidence that the meaning of a word is retrieved directly from the orthographic structure without the facilitatory effects of phonology in Chinese reading (i.e., the orthography-to-meaning route). However, Shen and Forster further suggested that, after this initial identification, phonology may play a role in post-access comprehension of Chinese reading.

Similar observations were made by Wong and Chen (1999) using eye tracking. They found direct evidence that the visual/orthographic features of Chinese characters are used to access meaning during the early or initial stages in reading. Only during later processing did phonology play a more active role. In this study, target characters were removed from short passages and contextually inappropriate ones were presented. The inappropriate characters were selected to be either orthographically or phonologically similar or dissimilar to the targets. A series of measures were recorded, including the time of first fixation, gaze duration and total reading time. In the passages a target character was placed mid-sentence to serve as a disruptor. The length of time spent on reading the target characters was used to measure the level of disruption. At first fixation (the time spent fixated on the target word when initially encountered), there were robust orthographic effects but extremely weak and unreliable phonological effects. More reliable phonological effects were detected when the total reading time of each passage was taken into account. Wong and Chen argued that orthographic processing played an important role in the early stages of Chinese reading whereas phonological processing became more prominent later on. Recall that Shen and Forster (1999) also observed that visual/orthographic effects were found early in Chinese reading while phonological processing became more prominent in the later stages. It appears that the visual/orthographic structure of Chinese characters is crucial to their identification with phonological processing playing a secondary role. This is in direct contrast to the findings of the English reading studies which suggest that phonological processing has a primary role in the identification of English words (e.g., Gottlob et al., 1999; Lesch & Pollatsek, 1993; Lukatela & Turvey, 1991, 1994; Pollatsek et al., 1992; Van Orden et al., 1988).

In summary, from the studies reviewed here, a general pattern has emerged. In terms of English reading, phonological processes appear to play a dominant role in word
identification while in Chinese reading the visual/graphic structure of the character is crucial to its identification. This difference in processing is significant because it indicates that specific orthographies may require specific types of processing. This is a fundamental assumption of this study and a necessary prerequisite for an investigation into L1 orthographic transfer effects in L2 reading.

Cross-Linguistic Graphophonic Processing

The studies reviewed thus far investigated reading in the English or Chinese language exclusively. Some studies have investigated both English and Chinese reading together and have found significant orthographic processing differences. Notable among these are the studies by Hanley and Huang (1997) and Feng et al. (2001). These studies contrast the difference in the cognitive processes utilized in Chinese and English reading.

Hanley and Huang (1997) investigated the relationship between phonological awareness and reading ability in Chinese, Taiwanese, and British school children, who were tested on phonological awareness tasks such as rhyme ability and phoneme deletion. Visual skills were tested also using the Visual Paired Associates (VPA) test. This test required children to learn the colours associated with six abstract line drawings for later recall. This task was selected because of its perceived similarity to the learning of Chinese characters. For the Chinese and Taiwanese children, phonological awareness was not significantly correlated with reading ability. By contrast, the British children demonstrated a strong correlation between their level of phonological awareness and their reading ability. For the Taiwanese and Chinese children, only visual skill was the most powerful predictor of their reading ability, suggesting that this would provide a significant advantage in the acquisition of Chinese characters. These findings have some significant implications for the present study. First, they provide converging evidence with the English and Chinese word identification studies, which also showed that phonology plays a crucial role in English word identification whereas in Chinese word identification visual/orthographic processes are predominant. Second, it is possible that specific visually-related processing may be exclusively associated with Chinese reading. This idea will be discussed later in this chapter.
Cross-linguistic differences have been shown also when adult readers of English and Chinese were compared. For example, in a recent cross-linguistic study, Feng et al. (2001) investigated the role of phonological processes in Chinese and English word identification. Both the time course of phonological activation in reading Chinese (Experiment 1) and English (Experiment 2) were explored. In an adaptation of Wong and Chen’s (1999) paradigm target words and target characters were embedded in English and Chinese passages, respectively. These target words/characters were contextually inappropriate and consisted of orthographically similar and dissimilar homophones (e.g., creek – creak), orthographically similar control words (e.g., creed), and dissimilar control words (e.g., gland). Eye tracking data associated with the embedded targets revealed early phonological activation when reading in English but not Chinese. For example, dissimilar homophones provided early benefits for English readers but not for Chinese readers. At first glance, this suggests that, when reading in Chinese, phonology is not activated, in direct contrast to the observed pattern for English. Consistent with Hanley and Huang (1997) visual processing was shown to be more important in Chinese reading while phonological processing may have a greater role in English alphabetic reading. The idea that visual processing may be more crucial to Chinese logographic reading than English alphabetic reading will be tested empirically in Chapter 2 of this study.

The Close Relationship Between Chinese Orthography and Visual Processing

In Chinese character identification, the orthographic structure is crucial to lexical access, whereas phonology may play a reduced role (e.g., Chen et al., 1995; Ju & Jackson, 1995; Shen & Forster, 1999; Tan et al., 1995; Wong & Chen, 1999; Zhou & Marslen-Wilson, 2000). Therefore, for logographic readers, the orthographic (visual) structure of the character plays a crucial role in word identification. Thus it seems reasonable to posit that logographic readers are potentially more reliant on visual information as a means of processing written text than their alphabetic counterparts.

The visual complexity of the Chinese writing system would appear to require such reliance. In mainland China, school children (grades 1 to 6) internalize approximately 2,570 distinct Chinese characters as part of their general literacy. The Chinese characters that are taught increase in visual complexity as the primary school
children progress each year, with 95% of the characters averaging between 7 to 12 strokes (with 1 stroke the least and 24 strokes the most complicated) (Shu, Chen, Anderson, Wu, & Xuan, 2003). In addition to the visual complexity of Chinese orthography, the pronunciations of each character are far less systematic and regular than those of alphabetic languages (see Hoosain, 1991). As Chinese school children learn progressively more and more structurally complex characters, these characters become less and less reliable in terms of their pronunciation cues. For example, of the 2,570 distinct Chinese characters that school children must acquire, there are 650 phonetic compounds that contain regular phonetic cues, 370 with ambiguous phonetic cues, and 720 non-phonetic cues. In all, only 23% of Chinese character compounds with phonetic radicals are perfectly regular (Shu et al.). Given the low incidence of phonetic regularity it would appear that the memorization of complex visual orthographic structures occurs largely without the facilitating effects of phonology. Therefore, during the critical period of language internalization, Chinese children are inculcated with an incredibly complex visual writing system that has a limited reliance on pronunciation cues.

Hence, the transformative power of the internalization of a highly visual/graphic writing system may have led to a heightening of visual processing skills and strategies for logographic readers (see also Hanley & Huang, 1997). These skills may be less developed in phonographic readers who have not internalized a visually complex orthographic system. Instead, phonographic background readers, through the inculcation of their alphabetic or syllabic orthographic system, may have developed literacy skills which are particularly suited to processing alphabetic or syllabic script (e.g., phonological skills). Recall that Hanley and Huang (1997) found that visual skills were the reliable predictor of Chinese (logographic) children’s reading skill, whereas phonological skills were the reliable predictor of British (phonographic) children’s reading skill.

It is possible that the learning of thousands of complex Chinese characters, which resemble pictures, may lead to a particularly efficient visual processing system, especially in terms of memory for complex visual shapes. Indeed, a number of studies have shown that L1 logographic participants outperform L1 alphabetic participants on a
variety of memory tasks, such as visuo-spatial WM tasks (e.g., Demetriou, Kui, Spandoudis, Christou, Kyriakides, & Platsidou, 2005), memory for abstract visual shapes (e.g., Flaherty, 2000; Mann, 1985), spatial memory (e.g., Tavasolli, 2002) and on tests requiring spatial processing (e.g., Stevenson, Stigler, Lee, Lucker, Kitamura, & Hsu, 1985; Stevenson & Yíng-Lee, 1990; Tamaoka, Saklofske, & Ide, 1993). Working memory will be discussed in detail in Chapter 3.

Furthermore, studies have shown that basic cognitive processes can be developed into highly sophisticated cognitive behaviour under certain learning conditions. For example, Stigler, Chalip, and Miller (1986) found that, as a result of abacus training, children had a different representation of numerical calculations based on a 'mental abacus’ that enabled them to manipulate numbers with remarkable speed. These children portrayed no other such amazing abilities. In a similar, developmental fashion, logographic background literates, such as Japanese and Chinese readers, may have a particularly well-developed visual system that allows them to process text without a strong reliance on phonological access, as has been demonstrated by the Chinese word identification studies (e.g., Chen et al., 1995; Ju & Jackson, 1995; Tan et al., 1995).

Evidence that logographic orthographies may require cognitive processing that is closer related to pictures and visual phenomena than alphabetic and syllabic writing systems come from studies of general cognition and neuroimaging. The evidence is both behavioural and physiological, as discussed below.

**Processing of Logographic Orthographies: Evidence from Cognition and Neuroimaging**

Rusted (1988) investigated the relationship between picture processing and reading in Chinese-English bilinguals and monolingual English speakers using a picture-word interference paradigm. Pictures and superimposed words were either semantically related (closely or distantly) or semantically unrelated. The interference levels were comparable overall between the Chinese-English bilinguals and English monolinguals, however bilinguals responded more slowly to pictures and Chinese text. These results support the notion that visual/pictures correspond more closely with logographic script than pictures/imagery with alphabetic script.
Similar observations were made by Chen and Tsoi (1990) who investigated whether logographic background language users and alphabetic background language users process words and symbols differently. Chinese-English bilinguals and American monolinguals were asked to read words and name symbols (calculation symbols such as \textit{plus}, \textit{minus}, \textit{divide}, and \textit{times}) in their native tongue. English and Chinese words were superimposed over pictures of the calculation symbols (e.g., a \textit{plus} sign with the Chinese character representing \textit{minus} or the English word for \textit{minus}) to provide Stroop style interference effects. The pattern of results was different for the Chinese-English bilinguals and English monolinguals. The Chinese-English bilinguals were equally fast in naming calculation symbols and Chinese logographs. The monolinguals, however, took longer to name calculation symbols than to read English words. Also, for the bilinguals Chinese logograph distractors generated more interference in word naming while symbol distractors generated more interference for symbol naming. For the monolinguals, English distractors were associated with larger interference effects when naming symbols. The results suggest that Chinese-English bilinguals process symbols similarly to the Chinese writing system whereas English monolinguals process symbols and the English writing system differently.

One problem with interpreting the findings of Rusted (1988) and Chen and Tsoi (1990) is that bilingual and monolingual groups were compared. Because studies have found that a bilingual background can facilitate performance on cognitive tasks involving language (see Cenoz, 2000) it is not known whether the differences that were attained in these studies were due simply to a difference in bilingual versus monolingual background. However, these studies do provide some evidence that the Chinese writing system may be closer to picture processing than English. This suggests that Chinese orthography may require more visually orientated processing than alphabetic English, consistent also with Hanley and Huang’s (1997) study which found a correlation between visual processing skills and reading in Chinese school children.

Furthermore, a number of studies have found that a L1 logographic background may enhance visual and spatial memory performance. For example, Mann (1985) investigated the phonological and visual memory skills of Japanese children in regard to their reading ability. Primary school aged Japanese children were tested on their ability
to remember abstract visual designs, having to indicate any design that occurred more
than once in a set. Their recognition of Kanji and Kana words was similarly tested.
Reading ability and memory for visual abstract shapes were significantly correlated.
Mann compared these data with an earlier study by Liberman, Mann, Shankweiler and
Werfelman (1982) on American school children in which a similar correlation was not
found. A comparison of the data showed that Japanese school children had better
memory for abstract visual designs. Mann also found a correlation between memory for
Kanji and abstract visual designs but no correlation for abstract visual designs and Kana.
This study clearly demonstrates that (1) logographic background readers are better at
tasks that involve visual memory for abstract designs than phonographic background
readers, and (2) Kanji or logographic script is closer associated with abstract visual
designs than phonographic (syllabic) script (Kana). Mann’s findings are highly
significant to the present study. This thesis is primarily concerned with an investigation
into the transfer of specific L1 orthographic processing skills to L2 reading. If an L1
logographic background can enhance a language learner’s visual processing capability,
then it is likely that such a background would benefit the processing of a highly visual
logographic L2. This idea is empirically investigated in Chapter 2.

Mann’s (1985) study focused on visual memory for abstract designs and found
that a L1 logographic background benefits this type of processing. Additionally, there is
evidence that an L1 logographic background may benefit spatial memory. For example,
Tavasolli (2002) compared a group of Chinese-English bilinguals and English
monolinguals and tested them on their spatial memory for animals, which were visually
presented on cards as written words (in English and Chinese) and as pictures.
Participants were told to study the cards for a short period of time. After a short math
filler task, they were given new cards which had the same items but in different
locations on the cards. In the Chinese-English bilinguals, spatial memory for Chinese
characters was better than for alphabetic words. Monolinguals recalled the spatial
location of animal pictures better than animal words, whereas there was no difference
for the Chinese group’s recall of the positions of animal pictures and Chinese characters.
These findings support studies, such as those of Rusted (1988) and Chen and Tsoi
(1990), which have shown that Chinese characters bear a closer relationship to picture
processing than English words. In addition, it appears that the processing of logographic script is more closely associated to spatial processing than alphabetic script. However, here too differences in language background were not controlled for.

More convincing evidence that the Chinese writing system requires more visual processing than alphabetic writing systems such as English can be found in the studies of Nakagawa (1994) and Hatta (1992). In these studies, the hemispheric processing of Chinese characters was examined, revealing a right hemisphere bias for Chinese characters. This is significant because the right hemisphere has been associated with visual processing (e.g., Chiarello, Burgess, Gage, & Pollock, 1990; Jonides, 2000). For example, Nakagawa (1994) investigated left and right hemisphere processing during visual Kanji character word recognition tasks. Real and unreal Kanji characters were displayed briefly either to the left or right of a centred position. Primes (antonyms, remote associates, unrelated, or neutral) were displayed briefly before target characters. For single Kanji characters there was a decided right hemisphere advantage. This contrasts with a similar study with English speakers involving English words, in which a left-hemisphere advantage was found (Nakagawa, 1991). The right hemisphere preference for Kanji is evidence that a fundamental difference exists between reading in orthographically divergent scripts and that different parts of the brain are utilized depending on whether the character is Kanji or a structure from an alphabetic script. The highly visual nature of Kanji determines a right-hemisphere preference. This study is consistent with Rusted’s (1988) and Chen and Tsoi’s (1990) findings that Chinese characters are closer aligned to visual processing than alphabetic script, such as English.

In a study similar to Nakagawa’s (1994), Yamaguchi, Toyoda, Xu, Kobayashi, & Henik (2002) investigated the differences in hemispheric processing of Japanese Kanji and Kana. The Stroop paradigm was combined with Event-Related Potentials (ERPs). Square patches of colour were presented with congruent or incongruent Kanji or Kana colour words superimposed on them, and the colour of the patch had to be named. Larger interference effects were found for stimuli presented in the left visual field (indicating processing in right hemisphere) for Kanji words, and in the right visual field (processing in the left hemisphere) for Kana words. ERP data supported this finding. Consistent with other studies (e.g., Nakagawa, 1991) it appears that Chinese characters
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are more closely associated with visual processing, as revealed in a right hemisphere advantage.

In a similar experiment, Hatta (1992) investigated the effect of Kanji attributes on visual field differences during three tasks, lexical decision and naming (both involving word/non-word decisions) and semantic classification (involving concrete/abstract decisions). Japanese monolinguals were presented with real and not-real Kanji characters, which were controlled for familiarity, concreteness, hieroglyphicity, stroke number and regularity, in either the left or right visual field. Hieroglyphicity was defined as a subjective impression about the similarity of a Kanji character and its representative real world object. Regularity was defined as the subjective interpretation of the level of geometric symmetry of Kanji characters. In naming and semantic classification, a significant left visual field advantage was found, indicating a right hemisphere processing bias for Kanji characters during these tasks. Kanji concreteness and hieroglyphicity also were highly correlated with each other. Therefore, the right hemisphere preference of processing Kanji demonstrated could be attributed to imagery-related factors. This study is consistent with Nakagawa’s (1991, 1994) findings that Kanji characters are processed in the right hemisphere.

There is much evidence to support the idea that words and pictures are processed in different parts of the brain (even though a large degree of topographic overlap has been detected) (e.g., Federmeier & Kutas, 2001). Topographic differences in brain activity in relation to processing different types of orthographies have also been found (e.g., Chen, Fu, Iversen, Smith, & Mathews, 2002; Tan, Liu, Perfetti, Spinks, Fox, & Gao, 2001; Yamaguchi, Toyoda, Xu, Kobayashi, & Henik, 2002). For example, Tan et al. (2001) investigated the neural system associated with logographic reading using functional magnetic resonance imaging (fMRI). In two tasks, participants from Mainland China were required to judge a pair of Chinese characters on their semantic and homophonic relatedness. Even though there was considerable topographic overlap with areas strongly associated with alphabetic reading, logographic reading peak activations were found in the middorsal prefrontal region, an area associated with the mediation of spatial and verbal working memory but one that few alphabetic reading
fMRI studies highlighted. These distinct topographic regions activated by logographic reading may occur as a result of the visual-spatial complexity of logographic script.

In another fMRI study, Chen et al. (2002) investigated phonological and semantic aspects of pinyin and Chinese character processing. Pinyin is the representation of the Chinese language in English syllables (e.g., *ch, zh, ang* etc). Mandarin native speakers had to identify written pairs of pinyin or Chinese characters as real words (depending on their sound). This task is possible because in Chinese there are many homophones, such that many Chinese character combinations can be formed which are nonsensical but have real word pronunciations. The assumption here was that, in order to determine whether the pinyin targets were real or not, the English letters would have to be assembled for the attainment of a pronunciation code. With the Chinese character combinations, the pronunciation code would be extracted without any assemblage of intraword particles. No significant hemispheric preference for either pinyin or Chinese characters was found but distinct activations in various brain sub-regions were detected that were different for pinyin and characters. This study provides further evidence that the orthographic and phonological aspects of the written word are subserved by anatomically different brain areas.

*Interim Summary*

A range of evidence from both cognitive psychology and neuroscience supports claims that (1) logographic script is processed in different parts of the brain to alphabetic and syllabic scripts, (2) logographic script is more strongly associated with visual processing than alphabetic or syllabic script and (3) a logographic background may enhance visuo-spatial processing skills. These main findings support the argument that the inculcation of a particular orthography can directly impact on cognitive processing.

It was established that there are important structural differences between logographic Chinese and alphabetic English orthographies. Evidence was presented that these orthographic differences may impact on the degree to which readers utilize orthographic or phonological processing skills. A general pattern was identified, with logographic Chinese readers utilizing more visually-orientated processing strategies and alphabetic English readers utilizing more phonologically-orientated processing strategies. It would stand to reason that such fundamental differences in the processing
of language might impact on one’s ability to acquire an L2. In the next section, studies that investigate the transfer of specialized L1 reading skills and strategies to L2 processing contexts will be discussed. These studies will encompass those that focus on language transfer in terms of L1 graphophonic processing skills, and kusho.

L1 Graphophonic Processing to L2 Reading

Logographic Chinese readers seem to rely more on orthographic (visual structural) factors than alphabetic or syllabic readers when identifying words. Conversely, the alphabetic or syllabic readers rely more on phonological processing systems to identify words, with orthographic factors appearing to play a less important role. A number of cross-linguistic studies have shown that this general pattern is repeated when language learners read in an L2. That is, language learners transfer the processing skills specific to their L1 and utilize these when processing L2 script. As mentioned before, cross-linguistic studies investigating the transfer of L1 orthographic processing skills to L2 reading are the exception not the norm. Most language transfer research investigates L1 and L2 reading from the perspective that all orthographies are processed in the same way (see Koda, 1994) whereas the studies reviewed here have been conducted from a relativist theoretical framework.

In several studies, Koda (1989, 1990) found that logographic background language users were less impeded than alphabetic background language users when they were deprived of phonological processing during L2 reading tasks. In Koda’s (1989) study, adult groups with L1 alphabetic backgrounds (Spanish, Arabic, and English) were compared with L1 logographic Japanese readers. English and Japanese non-words (phonologically similar, phonologically dissimilar but graphically similar, and unprounceable) and Sanskrit symbols were displayed in small sets. The task was to identify a probe from these sets. Japanese participants did better in identification of the unprounceable sets of cards than in the phonologically similar set while the reverse was true for the L1 alphabetic background participants. It appears that, when deprived of phonological processes, the logographic Japanese readers were able to rely on visual processing to correctly identify the unprounceable items. This study supports the argument that a logographic background may facilitate the ease of visual processing in L2 reading.
Similar observations were made by Mori (1998). First language logographic (Chinese and Korean\(^4\)) and phonographic (English) background speakers learning Japanese were compared on a short-term memory (STM) test involving pseudo-characters, which were controlled for phonological accessibility. The pseudo-characters consisted of pronounceable Katakana and non-pronounceable Kanji radicals. Only the participants with a phonographic L1 background suffered a performance decrement when they had to remember non-pronounceable pseudo-characters. These findings again illustrate that L1 logographic and L1 alphabetic readers may have developed processing skills specific to their orthographic background. Specifically, an L1 logographic background facilitates the STM recall of visual orthographic structures.

The studies of Koda (1989) and Mori highlight the important relationship between reading and memory processes. For example, it is likely that, as a result of their L1 orthographic background, Chinese and Japanese readers were able to rely on their visual skills to retain unpronounceable items in STM. Lacking an L1 logographic background, the phonographic readers performed poorly on this task. Therefore, these studies illustrate a connection between reading (e.g., the effect of L1 orthography on cognitive processing) and memory processes. The relationship between L1 orthographic background and memory will be discussed at length in Chapter 3.

Koda (1990) examined divergent phonological coding strategies in reading with L1 logographic (Japanese) and L1 phonographic (Spanish, Arabic and English – for native control) learners of English. Target Sanskrit symbols (unpronounceable) and English (pronounceable) nonsense words were embedded in short passages. The meanings of the targets were derived from context clues in the passages. Participants were required to recall the targets’ meanings from memory. While the phonographic background readers were significantly impeded when recalling the Sanskrit symbols, the logographic background Japanese were almost unaffected. This finding suggests that the logographic Japanese readers were relying on their L1 orthographic (visual) processing skills to facilitate the retention of the Sanskrit orthographic structures.

\(^4\) The Korean language (Hangul) consists of a syllabic script. However, the Korean participants in this study had a history of Chinese character learning and were categorized as logographic background readers.
In a more recent study, Koda (1999) examined intraword sensitivity in logographic (Chinese) and phonographic (Korean) readers who had knowledge of English. Korean, or Hangul, as a syllabary, qualifies as a phonographic language. It was assumed that phonographic readers should display more intraword sensitivity than their logographic counterparts. Orthographic sensitivity was defined as “…the learners’ understanding of the internal orthographic structure of words” (p. 52). Because Koreans utilize a syllabary as their writing system, they may be more sensitive to the internal structure of words than Chinese readers. Therefore, it was predicted that Koreans may display superior performance at a task that tested intraword analysis in a foreign language compared to the Chinese readers. Korean and Chinese readers were required to identify words on the basis of their potential as real English words. The Korean readers were significantly better than the Chinese readers at rejecting low–frequency illegal strings. Clearly, the Koreans transferred their L1 syllabic processing skills to L2 alphabetic reading. Koda’s (1999) study provides further evidence that phonological processing is more crucial to phonographic readers than logographic readers and that L1 reading skills can be transferred to L2 reading.

Similar differences were found in Korean and Chinese learners of English using an extension of the intra-word sensitivity paradigm (Koda, 2000). Chinese and Korean adults learning English as a Second Language (ESL) were presented with an intraword structural sensitivity and analysis efficiency task. English words and pseudo-words were presented in three conditions, controlled for morphological factors through the manipulation of prefixes and suffixes to target words. In Condition 1, word stimuli contained two meaningful units (e.g., in + visible). In Condition 2, the stimuli consisted of words that could not be broken down into two meaningful units (e.g., re + volve), while in Condition 3, words shared the same prefixes (e.g., re + gime, in + fant). Three parallel, matching pseudo-word conditions were created. The task was to determine whether or not the words could be broken down into meaningful units. Consistent with previous research, Korean readers were more efficient at performing the intraword structural analysis task than their Chinese counterparts.

In another intra-word sensitivity study, Muljani et al. (1998) investigated L1 orthographic effects on L2 word processing in Indonesian (alphabetic L1), Chinese
(logographic L1), and English (alphabetic L1) readers who performed a lexical decision task on English words and non-words. The English words used differed in frequency (high or low) and the congruency of their consonant-vowel pattern with Indonesian words (congruent vs. incongruent). It was predicted that Indonesian readers of English would process English words congruent with L1 consonant and vowel patterns faster than incongruent words. Chinese readers, by contrast, should be unaffected by this manipulation, given that these patterns are not represented by Chinese orthographic structures (characters). The results largely confirmed this. The Indonesian readers performed significantly better than the Chinese readers when processing congruent English words. Not surprisingly, the English monolinguals (as native speakers) outperformed the Indonesians and Chinese on all tasks. Consistent with Koda’s (1999, 2000) studies, the findings of Muljani et al. clearly demonstrate the transfer of L1 orthographic processing skills to L2 reading.

Intraword sensitivity studies have not been limited to word level investigations. For example, Akamatsu (2003) extended the intraword sensitivity paradigm from individual words to whole passages of text. L1 logographic readers (Chinese and Japanese) and L1 alphabetic readers (Iranians) silently read short English passages of three levels of difficulty (easy, moderate, and hard). Half were presented in normal print and half were case altered (e.g., CaSe AlTeReD). The assumption here was that non-alphabetic ESL learners, who rely more on orthographic factors in text processing (e.g., Chinese logographic readers), would perform worse on this task than their Iranian alphabetic reader counterparts. Results confirmed that logographic readers’ reading times were significantly slower than those of alphabetic readers, supporting the notion that L1 orthographic background impacts on L2 reading. These results were consistent also with Koda’s (1999, 2000) findings.

Using a lexical decision task instead of an intraword sensitivity task, Chikamatsu (1996) investigated the effects of L1 orthography on L2 reading in Chinese and English monolingual learners of Japanese. Kana (Hiragana and Katakana) words and non-words, controlled for visual familiarity (as an orthographic control) and word length (as a phonological control) were used. Chinese readers were significantly slower in the visually unfamiliar condition than the English readers. This effect indicated that the
Chinese readers relied more on visual factors during the processing of L2 Kana words than did the English readers. Furthermore, the English readers were significantly slower in the word length condition than the Chinese readers. Specifically, the English readers’ RTs to longer Kana words were significantly longer than those of the Chinese readers, indicating increased reliance on phonological processing in kana word recognition compared to Chinese readers. Thus it appears, consistent with studies in different domains (e.g., Akamatsu, 2003; Chikamatsu, 1996; Koda, 1989, 1990, 1999, 2000; Mori, 1998; Muljani et al., 1998), that Chinese readers tend to be more orientated toward visual processing during L2 word recognition than English (i.e., alphabetic orthography) readers who rely more heavily on phonological processes during L2 word recognition. The finding further suggests that both Chinese and English readers transferred their L1 specific processing skills to an L2 reading task, with outcomes specific to the transferred skills. Furthermore, it is important to note that all the research thus far, investigating the transfer of L1 orthographic processing skills to L2 reading (e.g., intraword sensitivity studies), has been conducted from the perspective of either L1 logographic or L1 phonographic language learners undertaking L2 phonographic reading. There is a paucity of L2 language transfer reading research undertaken from an L2 logographic perspective, one which the present study aims to address.

Further evidence to support the position that specific L1 orthographic processing skills can be transferred to L2 reading can be found in the cross-cultural kusho studies of Endo (1988) and Sasaki (1987). Kusho is the spontaneous act of writing a Chinese character with the finger, in either space or on a part of the body. Kusho seems to be prevalent only in Chinese character learning cultures (e.g., Chinese, Taiwanese & Japanese), particularly Taiwanese. In Endo’s study, kusho was investigated in various conditions during a spelling task involving long and short words. Japanese students were told words in Japanese and then had to spell them in English only. This task was undertaken in three conditions, (1) using kusho, (2) with an experimenter guiding the participant’s writing hand, and (3) with the participant moving her index finger in a straight line. Only the use of kusho was found to have a facilitatory effect. Endo argued that Japanese writing is fundamentally different from English writing because of the way it is learnt. Japanese writing is learnt as a type of motoric/visual process, whereas
English is learnt with an emphasis on phonemes. Accordingly, if motoric processes are involved in the learning of language, motoric processes must play a part in the recall of language, hence the phenomenon of kusho and the use of motoric processes in linguistic recall.

In a much larger kusho study, Sasaki (1987) conducted six experiments on various cultural groups of adults and children. A series of experiments demonstrated that finger writing was an important aid in anagram tasks (created from Kanji characters) as well as in English spelling tasks. A strong correlation was found between the number of Chinese characters previously learnt and reliance on the use of kusho. For example, it was found that the Taiwanese participants (who learn many more Chinese characters than other Chinese character cultural groups) relied on kusho the most. At the other end of the spectrum, non-Chinese character cultural members (e.g., Americans, Greeks) found finger writing more a hindrance than a help in these anagrammatic tasks. Of course, the alphabetic background participants were asked to engage in a technique they had not used before. Therefore, the finding that the use of kusho hindered the L1 alphabetic language users may simply have been a reflection of their inexperience with a new technique. However, even if this is so, the critical point here is that kusho is specific to logographic background language users. Because kusho is not used by alphabetic background language users is proof that it is not a universal cognitive technique, as is, say finger counting by young children. Arguably, kusho reflects the nature of L1 orthographic processing of logographic language. That is, in order to facilitate the recall of a logograph kusho is a way of reconstructing its visual image. Recall that studies have found that visual processing is more important to logographic reading (e.g., Chen et al., 1995; Ju & Jackson, 1995; Shen & Forster, 1999; Tan et al., 1995; Wong & Chen, 1999; Zhou & Marslen-Wilson, 2000) than to alphabetic reading (e.g., Gottlob et al., 1999; Lesch & Pollatsek, 1993; Lukatela & Turvey, 1991, 1994; Pollatsek et al., 1992; Van Orden et al., 1988). Therefore, it seems reasonable to posit that alphabetic language users have not evolved the technique of kusho (and conceivably find it a hindrance) because the L1 orthographic processing of alphabetic language does not require intense visuo-spatial analysis.
It was also found that Japanese participants transfer finger writing when word tasks are conducted in English. Sasaki interpreted the results of this study as direct evidence of the notion that culture can directly impact on cognitive processing. These kusho studies have important implications for the present study because they demonstrate (1) that specific cognitive behaviour can arise to accommodate the recall of the structural attributes of an orthography and (2) this specific cognitive behaviour can be transferred to L2 processing. In summary, these kusho studies demonstrate quite clearly how a language learner’s L1 orthographic background can impact on their cognitive processing. It would appear that cultural members who have acquired Chinese characters tend to rely on visual/motoric processes when confronted with Chinese character anagram tasks and transfer these visual/motoric processes to solve L2 English spelling tasks.

Recent fMRI evidence has confirmed behavioural data indicating that orthographically variant language learners process their respective L1 scripts differently and transfer their L1 processing skills to L2 reading. For example, Nakada, Fuji, and Kwee (2001) asked English-Japanese bilinguals and Japanese-English bilinguals to read paragraphs of written text in English and in Japanese (logographic Kanji). Even though the findings revealed a degree of topographic overlap in the activation of some regions for both Japanese and English language reading (e.g., in the left fusiform gyrus), distinct topographic brain regions were identified also. For L1 English reading, significantly greater levels of activation were found in the lingual gyri (LG) bilaterally for English-Japanese bilinguals, while activations flanking the left inferior temporal sulcus (ITS) occurred for Japanese-English readers reading Japanese. In terms of L2 reading, this pattern of activation was repeated. That is, the LG bilaterally was activated when the English-Japanese bilinguals read L2 Japanese and the area flanking the left ITS was activated when the Japanese-English bilinguals read L2 English. This finding provides convincing evidence that not only were Japanese and English readers processing their respective scripts in different topographic regions of the brain, they also were utilizing these same regions when processing a highly variant L2 script. This is strong evidence in favour of the language transfer hypothesis.
Interim Summary

The studies reviewed here are consistent with alphabetic language graphophonic studies which support the importance of phonological processes in word identification (e.g., Gottlob et al., 1999; Lesch & Pollatsek, 1993; Lukatela & Turvey, 1991, 1994; Pollatsek et al., 1992; Van Orden et al., 1988) and Chinese language graphophonic studies which support the importance of orthography to Chinese word identification (e.g., Chen et al., 1995; Ju & Jackson, 1995; Shen & Forster, 1999; Tan et al., 1995; Wong & Chen, 1999; Zhou & Marslen-Wilson, 1999). These studies reviewed here (e.g., Akamatsu, 2003; Chikamatsu, 1996; Koda, 1999, 2000; Muljani, Koda, & Moates, 1998) have demonstrated that specific L1 orthographic processing skills can be transferred to L2 reading contexts. Recently, this argument has gained support from converging neurophysiological evidence from fMRI investigations.

However, language transfer research has only investigated the transfer of L1 alphabetic or syllabic skills to L2 alphabetic reading. As yet, no research has investigated (in any depth) the possibility that L1 logographic readers may be able to transfer their specific L1 orthographic processing skills to L2 logographic reading. One of the main aims of the present study was to address this issue.

The Present Research Study

Thus far it was argued that the inculcation of an L1 orthography can result in the development of specific cognitive skills which are transferred to L2 reading. In particular, that the inculcation of logographic Chinese as a first language may orient readers to rely more on orthographic (visual) factors when reading Chinese words, a tendency that is transferred to the reading of other languages. In contrast, the inculcation of an alphabetic English orthographic system may result in an orientation toward a greater dependency on phonological processing when reading both English words and other languages, whether or not these be orthographic. This argument is, in effect, an interpretation of the Orthographic Depth Hypothesis which stipulates that, in order to attain the lexical access of words, the shallower the orthography, the stronger the reliance on phonological processing. English, being an alphabetic language, has a higher degree of regularity in terms of GPC rules than logographic Chinese. Therefore, English is considered a shallower orthography than Chinese.
If logographic background readers rely more on visually-related cognitive processes than alphabetic readers during their respective L1 reading tasks, then, one would predict that logographic readers would outperform alphabetic readers during a highly visual, L2 logographic reading task. That is, L1 logographic readers would transfer and apply their specialist L1 cognitive skills to a congruent L2 logographic reading context. The L1 alphabetic readers would also transfer their specific L1 cognitive skills (phonologically-based), however due to the increased distance between L1 alphabetic (shallow orthography) and L2 logographic (deep orthography) scripts, the L1 alphabetic readers would not perform as well as their L1 logographic counterparts. Prior research has shown that when L1 and L2 orthographies are congruent (e.g., L1 phonographic – L2 phonographic), L2 readers attain significant performance benefit effects (e.g., Akamatsu, 2003; Chikamatsu, 1996; Koda, 1999, 2000; Mori, 1998). Furthermore, recent neurophysiological evidence has shown that L1 alphabetic readers process L2 logographic text in the same brain regions as they process their L1 alphabetic text. This area is in a topographically different region from where L1 logographic readers process logographic text (Nakada et al., 2001). Hence, it appears likely that L1 logographic and L1 alphabetic readers would process L2 logographic text differently. The measurement of this differential would provide evidence for language transfer from a relativist position.

The present study therefore investigated the hypothesis that an L1 logographic background would provide significant benefit effects for readers when processing a congruent L2 logographic script. The major assumption here was that L1 logographic readers would transfer their specialist L1 reading skills to processing a congruent orthography in an L2. This offers a significant point of departure from most of the research conducted in both the fields of language transfer and L2 reading. First, the present study investigated language transfer from a relativist perspective. That is, the focus of the study was the transfer of specialist L1 reading skills to L2 processing. This theoretical perspective is contrary to most research in the field of language transfer, which has been undertaken from the position that all cognitive processing is universal (Koda, 1994; Odlin, 1989).
Secondly, the focus of the present study was on the detection of L1 – L2 (or L3) transfer effects from the perspective of logographic reading. Of the three writing systems in use today, logography, syllabary and alphabets, most L2 reading research has been conducted from the perspective of alphabetic languages, such as English (see Koda, 1994). Very few cross-linguistic studies have investigated L2 reading from a logographic perspective. In cases where studies have done so (e.g., Wang, Liu, & Perfetti, 2004), these have focused on L1 alphabetic readers who acquired a logographic L2. There appear to be few studies that have focused on L1 logographic language learners processing L2 logographic text (Koda, 1994). Hence, the research area of the present study involves the synthesis of two previously under-researched areas: language transfer from a relativist position and L2 reading from a logographic perspective.

One major hurdle that researchers face when investigating language transfer from a logographic reading perspective (L1 logographic to L2 logographic) is that there is only one logography in use today, namely Chinese characters (which also include Japanese Kanji). Therefore, it is problematic to examine how L1 logographic language learners perform on L2 logographic reading tasks utilizing the languages currently available. However, in the present study, a unique approach to investigate the cognitive processing of L2 logographic text by logographic background language learners is presented. An artificial logographic orthography was constructed by manipulating a basic structure from an ancient writing system (Mesopotamian cuneiform). This artificial orthography was then paired with semantic associations and taught to three learner groups - English monolinguals (alphabetic L1), Chinese-English bilinguals (logographic L1), and English-French bilinguals (alphabetic L1). English-French bilinguals were chosen for several reasons. First, if it is the case that the acquisition of a logographic language enhances visual orthographic processing skills, consequently the selection of an English native speaker group who had acquired a logographic L2 might not have been wise. For example, a number of studies have shown that acquisition of an L2 can affect L1 processing (e.g., Bialystok, Luk, & McBride-Chang, 2005; Wang, Cheng, & Chen, 2006). Hence, English native speakers with a Chinese or Japanese L2 may not have been truly representative of an alphabetic reading group. Therefore, it was desirable to select an English bilingual group with an alphabetic L2. Second, French is a
popular second language among Australian university students and it was anticipated that this would aid recruitment. Also, it would have been desirable to have a monolingual Chinese group as representative of the L1 logographic readers. In this way, any possible (backwards) transfer effects resulting from the acquisition of an alphabetic language could have been avoided. However, the rarity of Chinese monolinguals in Australia made this an impractical option. Therefore, the use of a Chinese-English bilingual group is a limitation of this study.

All three groups were subsequently tested on their performance when processing the newly acquired artificial orthography. The experiments presented here explored the extent to which a logographic language learning background benefited a L2 logographic reading situation, an approach that represents a major point of departure from previous L2 reading studies and language transfer studies in general.

In order to further investigate the cognitive processes involved in reading the artificial logographic script, a series of working memory (WM) experiments were also developed and incorporated into this study. Working memory ability has been linked to L2 reading (Harrington, & Sawyer, 1992; Williams, 1999) and is a crucial component in SLA (e.g., Ardila, 2003; Baddeley, Gathercole, & Papagno, 1998; Robinson, 2001). Furthermore, the incorporation of the artificial logographic script into a series of WM experiments provided a means to observe, in much more detail, the cognitive processing skills that were being transferred by the L1 logographic and alphabetic language learning groups. For example, the WM paradigm provides a methodology to observe visual processing while at the same time restricting access to phonological processing systems and vice versa. That is, through the use of concurrent auditory suppression, it is possible to observe visual processing without the activation of phonological processes. Similarly, through the use of concurrent visuo-spatial interference, phonological processing independent of the activation of visual and spatial processes can be observed. Therefore, the WM paradigm offered a methodological approach particularly suited to the present study which was particularly concerned with the transfer of specific L1 visual processing skills to L2. Working memory and its relation to L2 acquisition and processing will be discussed in detail in Chapter 3.
Both the reading and WM experiments were followed up with a series of questionnaires to determine what cognitive strategies were being deployed during the experiments. These questionnaire data involved cognitive phenomena such as inner speech and mental rehearsal. These data were analyzed via a constructivist theoretical framework in order to understand the complex covert phenomena associated with processing the artificial logographic script. Vygotsky’s (1978, 1986) sociocultural theory was chosen to provide an explanation of how cultural variables can impact on cognitive processing. Upton and Lee–Thompson (2001) have argued the necessity for further research which utilizes a Vygotskian approach in terms of L2 reading acquisition (as have other researchers who promote a Vygotskian approach to SLA in general, see for example, De Guerrero, 1994,1999; Schinke–Llano, 1993). Past studies of sociocultural theory and the L2 acquisition process have focused on the interpsychological rather than the intrapsychological or psychological plane (Upton & Lee-Thompson, 2001; Skehan, 1998). However, this study combined both planes by examining the between-people plane (through the examination of two distinct cultural groups), as well as the cognitive realm (the cognitive processing underlying L2 reading and WM phenomena) and considered the interaction between these two planes as they relate to an L2 processing context.

The experimental framework used in the present study combines the methodology and paradigms used in SLA research, cognitive psychology, and psycholinguistics, to investigate processes involved in L2 (or L3) reading and WM. The experimental methodology adopted here is unique and, as such it may offer a new means of investigating cross-cultural cognitive processes in L2 reading and WM. In particular, the learning of an artificial logographic script by variant cultural groups and the testing of this newly learnt language in an L2 reading and WM context has not been attempted before (at least not on the scale posited in the present study). When artificial orthographic structures have been used in reading experiments, they have primarily been utilized as phonological controls and incorporated into normal passages of text (e.g., Koda, 1989). In some studies (e.g., Byrne, 1984; Byrne & Carroll, 1989) artificial orthographies were taught and utilized in reading contexts, however, these studies were not conducted in a cross-cultural context. The present research study is unique because it
involves the learning of an artificial logographic orthography by L1 logographic and L1 alphabetic language learners. Hence, the nature of this investigation was a highly exploratory one and as a consequence did not rely on things known.

The aim here is to provide further evidence that the L1 orthographic background of language learners directly impacts on processes related to reading cognition and WM. Such evidence would support a form of language transfer from a relativist position, in that the nature of language itself can be seen to have an impact on how users of this language process information. In addition, language transfer research from a relativist position is in itself an under-researched area and this study is an attempt to fill the literature gap in this particular field as well. As will become evident, this research design is significant in terms of its implications for future research.

Furthermore, this study offers a novel approach to an empirical investigation within a controversial L2 reading context. The uniqueness of this approach hinges on its incorporation of a variety of fields, disciplines and theories (e.g., SLA, cognitive psychology, sociocultural theory) to understand the complexity of language transfer in L2 reading. The approach advocated here is significant because it is unorthodox. Prior reading studies investigating the cognitive processing of various cultural members have kept within the parameters of their respective fields of either experimental or cognitive psychology (e.g., Feng et al., 2001). These sorts of studies have not ventured into cultural anthropology to look for explanations. Alternatively, cultural anthropologists have failed to look beyond their field and challenge the universality of cognitive processing (Lucy, 1996). This research design is a genuine attempt at a synthesis of cultural and cognitive variables, provided by the integration of sociocultural and cognitive psychology frameworks.

Scholars, such as Karmiloff-Smith (1992), have argued that theories involving cognition should also take into account developmental and constructivist perspectives. Specifically, Frawley (1997) argues that Vygotskian theory can play an important role in the advance of cognitive science. In Chapter 4, it is argued that Vygotskian sociocultural theory can play a role in the understanding of complex covert L2 processing. As mentioned before, the unification of the interpsychological with the intrapsychological is an approach that has not been explored in any particular depth in
terms of SLA research because the intrapsychological plane has largely been ignored (Upton & Lee-Thompson, 2001, Skehan, 1998). This study fills this gap by an investigation of the interpsychological plane between two diverse cultural groups while not ignoring or brushing over the intrapsychological plane, the cognitive mechanics of mind. Nisbett and Norenzayan (2002) argue that studies investigating linguistic relativism which combine both the fields of cognitive psychology and cultural anthropology may provide a more effective way of exploring the impact of language phenomena on cognitive processes.

The study is significant for the following reasons:

1. It investigates cognitive processes in L2 reading and WM from a logographic rather than an alphabetic or syllabic perspective, which fills a substantial gap in the literature.
2. It investigates language transfer from a relativist position, which also fills a substantial gap in the literature.
3. The experimental methodology offered is unique and may reveal a new means of investigating covert cognitive processes in L2 reading.
4. The incorporation of an interdisciplinary research approach involving the fields of cognitive psychology and cultural anthropology is a direct response to requests for these types of studies.
CHAPTER 2
LANGUAGE-SPECIFIC L1 ORTHOGRAPHIC EFFECTS ON READING ARTIFICIAL LOGOGRAPHS

From the preceding chapter, the following can be concluded:

1. Some fundamental orthographic differences exist between present writing systems.
2. The inculcation of a specific orthography may enhance the development of some cognitive processes.
3. These specialized cognitive processes may facilitate L2 reading when L1 and L2 orthographies are congruent (e.g., both alphabetic or logographic).

The final observation provides the basis for the experiments described here. A finding that supports the observation that an L1 logographic background facilitates the processing of L2 logographic text, whereas an L1 alphabetic background does not, would provide evidence for a logographic transfer effect and hence strengthen the main argument in this study.

Therefore, the following experiments require L1 alphabetic and logographic language learners to acquire and process an L2 logographic script. As mentioned before, there is only one logography in use today, and it is therefore problematic to examine how L1 logographic learners perform on L2 logographic reading tasks. Hence, an artificial logography was created by manipulating a basic structure taken from an ancient writing system (Akkadian cuneiform). This artificial orthography was then paired with semantic associations and taught to three learner groups - English monolinguals (alphabetic L1), Chinese-English bilinguals (logographic L1), and English-French bilinguals (alphabetic L1). All three groups were subsequently tested on their performance when processing this newly acquired artificial orthography. The experiments presented here explored the extent to which a logographic language learning background may benefit an L2 logographic reading situation. The main group of interest are the Chinese-English bilinguals, for whom there is congruency of logographic L1 background and the new script. The English-French bilingual group effectively constitutes a control for the possible positive effect that simply being bilingual may have on acquiring an L3.
In Experiment 1, which comprises a lexical decision task, the focus is on visual (word-form) recognition of complex logographic structures. In Experiment 2, which involves syntactic decision tasks, the focus moves beyond visual word recognition to an examination of more in-depth reading-related processes, in particular, the processing of basic syntactic structures in the artificial logography, as well as in L1. Essentially, a syntactic decision task was included to ensure that the learning of the logographic L2 was achieved at the level of the words’ meaning. Sentence structures were adopted that corresponded to the most common structure in the languages used by the participants. Additionally, the impact of bilingualism on processing an artificial language will be explored.

Experiment 1

In Experiment 1, the ability of L1 logographic and L1 alphabetic monolingual and bilingual language users to recognize previously learnt visual structures as graphemic wholes and to identify these structures from a number of graphemically similar and dissimilar items was investigated using a lexical decision task. A logographic artificial language was constructed in which each novel graphemic unit was associated with a unique meaning. Because of the nature of the structures (see Figure 2.1 and 2.2), this task would benefit from the use of cognitive processes consistent with those underlying logographic reading (visually based) rather than alphabetic reading (phonologically based). Accordingly, logographic background readers were expected to outperform alphabetic background readers on this task. Given the benefit experienced by bilinguals in acquiring an L3, English-French bilinguals were expected also to outperform the monolinguals. However, the congruency in cognitive processing for Chinese-English bilinguals should result in superior performance compared to both English-French bilinguals and English monolinguals.

Method

Participants

The participants were 20 Mandarin-English bilingual speakers from mainland China (mean age = 27, SD = 5), 19 English-French bilingual speakers (mean age = 29, SD = 10), and 20 monolingual English speakers (mean age = 30, SD = 12). All bilinguals were students at Queensland University of Technology (QUT) and were paid
a fee for their participation. All monolinguals were undergraduates recruited from the School of Psychology and Counseling at QUT and were given course credit in exchange for their participation. All participants had normal or corrected vision. A language background questionnaire revealed that the Chinese-English bilinguals had been in Australia for at least six months at the time of testing and all were occupied in full-time study or research in which English was the working language. All of the English-French bilinguals had spent at least one year in a French speaking country and had attended at least one year of French study at a university or a private language college (see Appendix B). On a self-rating scale of 1 – 7 for L2 proficiency averaged across four categories (speaking, reading, comprehension and writing) the English-French bilinguals ($M = 5.32, SD = 1.13$) and the Chinese-English bilinguals ($M = 4.96, SD = 0.87$) were not significantly different, $t(37) = 1.084$, ns. On the basis of these self-ratings, both bilingual groups were assumed to be at a similar level of L2 proficiency.

**Materials**

The stimuli consisted of 12 artificial logographs (target logographs), 12 structural alterations of these artificial logographs (False Friends) and 12 unrelated symbols (Baseline items). The False Friends and the Baseline items together formed the non-targets. The target logographs were created through the manipulation of a basic structure taken from Akkadian cuneiform, an ancient, logo-syllabic language (Marcus, 1978). Previous studies that have utilized artificial orthographies (e.g., Kersten & Earles, 2000) have (arguably) created artificial scripts which bear little structural resemblance to any known writing systems, either past or present. However, it was intended that this artificial script contain a strong connection to an authentic logography. In Akkadian cuneiform, the structure of a triangle joined by a straight line constituted the dominant structural form (see Figure 2.1). This basic structure was adapted and manipulated to create 12 artificial target logographs at two levels of complexity. The Simple targets ($N = 6$) consisted of the configuration of three structures and the Complex targets ($N = 6$) consisted of the configuration of six structures (see Figure 2.2).
As can be seen in Figure 2.2, half of the target logographs at each level of complexity were designated as verbs (V) and the other half nouns (N). Each target logograph was associated with two distinct meanings so as to create two unique sets of target logographs (with their associated meanings), Set A and Set B. Also, it is important to note that the target logographs were not allocated a unique and artificial phonological association. The associated meanings consisted solely as matched L1 English words or Chinese characters. Therefore, any phonological associations of the target logographs would be triggered in the participants’ native language. The associated meanings were selected such that, in both Chinese and English, they met criteria based on semantic relatedness, grammatical form and use, pronunciation uniqueness, word frequency and temporal word length.

In both English and Chinese all nouns were concrete (Benjafield & Muckenheim, 1989) and all the verbs were transitive. In English, all the words had one general meaning and did not share a pronunciation with any other words. The complete set of words was not grammatically interchangeable, that is, nouns could not be used as verbs and vice versa. Overall word frequency was more than 30 times per million words in English (Francis & Kučera, 1982).

Two sets (Set A and Set B) of meaning associations were constructed to accommodate the two syntactic decision experiments (Experiment 2a & 2b). Due to a lack of Mandarin verbs that were unique at the tonal level, it was not possible to create enough meaningful and meaningless word/character strings from just one set of meanings for two syntactic decision experiments. Hence, a second set was created.
Figure 2.2. The artificial script. Target logographs and semantic associations used in Experiment 1 and Experiment 2a (Chinese pronunciation tones are denoted below each character). Note that Set A and B differ only in associated meanings.

The associated Chinese meanings were selected to be virtually identical to their English counterparts in meaning and grammatical function. Each item had one general
meaning as well as a unique pronunciation at the level of tone (Concise English-Chinese Chinese-English Dictionary, 1999). As with the English items, they were not grammatically interchangeable. In cases where precise matches were not possible, items were matched for related meaning. For example, the English word actor was used whereas the Mandarin word 演员 (performer) was used. Even though the two words are not a perfect match, they are related in that performer is a general category of which actors are members. Also, it was necessary to recycle three verbs from Set A (tell, remember, and allow). This was due to a general lack of Mandarin high frequency verbs with unique pronunciations, grammatical use and meanings. Overall word frequency was more than 30 times per million words in Chinese (Modern Chinese Frequency Dictionary, 1986).

In Set A there were no differences in frequency of occurrence between the English nouns and the Chinese nouns, $t(10) = 0.4, ns$, nor between the English verbs and the Chinese verbs, $t(10) = 1.4, ns$. In Set B, similarly, neither the English and Chinese nouns nor the English and Chinese verbs differed in frequency of occurrence, $t(10) = -.56, ns$ and $t(10) = 1.5, ns$, respectively (see Appendix C for full details).

Temporal word length. It is possible that differences in the temporal word length of Chinese and English language items may impact on response times. For example, pronunciation time affects the rate at which an item can be rehearsed in working memory (e.g., Baddeley, Thomson, & Buchanan, 1975, see also Baddeley, 1986). Furthermore, memory span studies have demonstrated that Chinese words can have significantly shorter pronunciation duration than English words (e.g., Stigler, Lee, & Stevenson, 1986). Therefore, a small pilot study was carried out to establish that the temporal word length of the Set A and Set B semantic associations in both Chinese and English were similar and to ensure that for both sets, there were no significant temporal word length differences related to language for either nouns or verbs (see Appendix D for full details).

For Set A, the temporal word length of the English ($M = 579, SD = 93$) and Chinese nouns ($M = 590, SD = 50$) was virtually identical, $t(10) = -.26, ns$, as were the temporal word lengths of the English ($M = 557, SD = 104$) and Chinese ($M = 568, SD = 35$) verb meanings, $t(6) = -.24, ns$. Similarly, for Set B no differences in temporal word
length were found between English \( (M = 531, SD = 78) \) and Chinese nouns \( (M = 572, SD = 42) \), \( t(10) = -1.1, ns \), and neither were there any differences in temporal word length between the English \( (M = 602, SD = 169) \) and Chinese verbs \( (M = 582, SD = 48) \), \( t(6) = 0.3, ns \) (see Appendix E).

**False Friends.** A set of 12 False Friends\(^6\) was created through systematic alterations of the 12 target logographs. One of three types of alterations was made to the targets: (1) an extra structure was added on to a target logograph (Plus One), (2) a structure was removed from a target logograph (Minus One), or (3) the target logograph was rotated 180° clockwise. In all, there were four Plus One, four Minus One and four Rotated False Friend structures (see Figure 2.3).

\[ \text{Figure 2.3. Target logographs and False Friends (left and right panels respectively).} \]

False Friends were created from the target logographs through adding a structure (Plus One), or subtracting a structure (Minus One), or rotating the logograph (Rotated).

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\( ^6 \) The term “False Friends” is used here rather than “Orthographic Neighbors” to avoid comparison with a body of research involving orthographic neighborhood effects (see Andrews, 1997). For example, research investigating orthographic neighborhood effects is primarily concerned with the “N” values of words (Andrews, 1997). “N” refers to the number of words that can be created from a single word by changing a letter (Landauer & Streeter, 1973). That is, some words (e.g., *take*) have high N values because many other words can be made from changing one letter (e.g., *tame*, *tale*, *cake*, *sake*, *tape*, *lake*, *fake*), whereas some words have low N values (e.g., *blue* – *clue*). The focus of research into orthographic neighborhood effects has been the effect of the N value on lexical processing (Andrews, 1997). In the present study, the 12 artificial logographs do not have N values as such. Hence, the classification of the illegal non-words (the False Friends) as “Orthographic Neighbors” would have been somewhat misleading.
Baseline items. An additional set of 12 unrelated symbols was included to provide a baseline measure for the study. They included symbols like ‘Ψ’ and ‘%’ (taken from Wang, Liu, & Perfetti, 2004).

Procedure

Participants were tested individually. First they underwent a learning phase, followed by the testing phase. The entire session lasted about one hour.

The learning phase. The first phase involved the learning of the L2 target logographs and the L2 associated semantic meanings in the participants’ native language (Chinese or English), from either Set A or Set B (counterbalanced across participants). Individual target logographs and their associated meanings were presented on flash cards. To facilitate the acquisition process, participants learned the items in blocks of six. Participants were deemed to have successfully acquired the meaning of each subset of targets when they achieved three consecutive, errorless runs of full recall. To confirm that the structures had been learned, participants were asked to draw each structure from memory and needed to do so accurately only once. Each unsuccessful recall attempt was followed by an opportunity to revise before recall was attempted again. When criteria were met for both subsets, a final overall meaning recall test was administered to the criteria of one errorless run (an analysis on these data can be found in Appendix F). The learning phase lasted approximately 45 - 55 minutes.

The testing phase. The testing phase directly followed the learning phase, and consisted of a lexical decision task. Participants were seated in front of a computer screen. Instructions appeared on the screen in each participant’s native language. Prior to commencing the experiment proper, a short block of 12 practice trials was presented, to be repeated once if needed. For this practice task, a randomized set of four of the original 12 target logographs were displayed with a specially created set of four False Friends and four Baseline items. During the practice trials only, written feedback appeared in the centre of the screen, indicating either a correct or incorrect response in the participant’s native language. The practice block was followed by three blocks of 36 items, each consisting of a random sequence of the 12 target logographs, 12 False

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7 From a pilot study, it was found that the requirement of having to repeatedly draw each item three consecutive times proved too taxing for participants and was hence modified to one accurate reproduction per structure.
Friends, and 12 Baseline items. Each trial was preceded by a fixation point (500 ms) in the centre of the screen. Items remained on the screen until response, for a maximum of 5000 ms. Participants indicated (as quickly and accurately as possible) whether or not the displayed item was one of the 12 target logographs by pressing the appropriate key on the keyboard (counterbalanced across participants). Handedness was controlled for. Participants were required to keep their fingers on the two response keys at all times during the experimental trials. Each subsequent block of trials was initiated by pressing the spacebar, allowing the participants to take a short break in between blocks. Stimulus presentation in this, and all subsequent experiments, was controlled using E-Prime software (Schneider, Eschman, & Zucchiotto, 2001).8

**Design and Analysis**

All the participants were beginner language learners in regard to the artificial script. In applied linguistic research, which deals with beginner language learners and when considerable individual variation is detected among participants, the median is the preferred measure of central tendency (Hatch & Lazaraton, 1991). Response times were measured in milliseconds (ms) from stimulus onset to response, and both RTs and errors were recorded. Accordingly, median9 RTs associated with correct responses only were subjected to one-way analyses of variance (ANOVAs) with Group (Chinese-English bilinguals vs. English-French bilinguals vs. English monolinguals) as the between-subjects factor. Planned comparisons were also conducted to examine the possible effects of L1 orthographic background as well as bilinguality on lexical decision. To establish the extent to which False Friends were effective, mixed ANOVAs were conducted, with Target Type (False Friends vs. Baseline items) as a within-subjects variable. Errors were subjected to identical analyses. Bonferroni adjustments were applied to planned comparisons throughout.

**Results Experiment 1**

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8 In order to ensure millisecond precision timing of this, and all subsequent experiments, Refresh Clock Tests were run on the computer following the recommendations of Schneider et al. (2001).

9 An identical analysis was also carried out using the mean as the measure of central tendency. This did not significantly alter the results.
Separate analyses were conducted to establish any differences that might exist between the two bilingual groups and the monolinguals in the case with which target logographs were correctly identified from a series of structurally similar (False Friends) and structurally dissimilar (Baseline) items.

**Response Times**

*Recognition of target logographs.* Response times associated with the correct identification of target logographs can be seen in Table 2.1. A one-way ANOVA revealed a significant difference between the three groups, $F(2, 55) = 3.45$, $MSE = 172381$, $p < .04$. The Chinese-English bilinguals were marginally faster than both the English monolinguals, $p < .09$, and the English-French bilinguals, $p < .08$. Importantly, the monolinguals and the English-French bilinguals were equally slow in their recognition of the target logographs, suggesting that bilinguality per se did not benefit the recognition of target structures.

Having established a significant difference between the three groups and that bilinguality per se did not impact on the speed with which participants recognized target logographs, a further one-way ANOVA (linear contrast) was conducted (Chinese-English bilinguals vs. both English monolinguals and English-French bilinguals), specifically to examine the effects of L1 orthographic background (logographic vs. alphabetic). A planned comparison revealed that the Chinese-English bilinguals were reliably faster than the combined scores of the English monolinguals and English-French bilinguals, $t(56) = 2.269$, $p < .02$, indicating that a logographic background benefited the recognition of target logographs more than an alphabetic background.
Table 2.1

Mean of Median RTs (in milliseconds) and Mean Percentage (%) of Errors (with standard errors (SE) in parentheses) for Correct Identification of Target Logographs in the Lexical Decision Task (Experiment 1)

<table>
<thead>
<tr>
<th></th>
<th>Bilinguals</th>
<th>Monolinguals</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Logographic (Chin-Eng)</td>
<td>Alphabetic (Eng-French)</td>
<td>Alphabetic (English)</td>
</tr>
<tr>
<td>RTs</td>
<td>914 (46)</td>
<td>1079 (56)</td>
<td>1073 (49)</td>
</tr>
<tr>
<td>% Errors</td>
<td>10 (1.7)</td>
<td>10 (2)</td>
<td>9.6 (1.6)</td>
</tr>
</tbody>
</table>

Note. Chin-Eng = Chinese-English; Eng-French = English-French.

Rejection of non-targets. Table 2.2 shows the mean of median RTs associated with the correct rejection of non-targets separately for each group. Recall that the non-targets were either very similar to the targets (False Friends) or dissimilar (Baseline items). A 3 x 2 mixed ANOVA, with Group (Chinese-English bilinguals vs. English-French bilinguals vs. English monolinguals) as the between-subjects variable and Target Type (False Friend vs. Baseline item) as the within-subjects variable, revealed no Group x Target Type interaction, \( F < 1 \). As predicted, a significant Target Type main effect indicated that the Baseline items were rejected faster overall than the False Friends, \( F(1, 56) = 301.43, MSE = 7935185, p < .001 \). While there was a tendency for the three groups to differ overall, this effect failed to reach significance, \( F(2, 56) = 2.74, MSE = 120139, p = .074 \).
Table 2.2

Mean of Median RTs (in milliseconds) and Mean Percentage (%) of Errors (with SE in parentheses) for the Rejection of Non-targets in the Lexical Decision Task (Experiment 1)

<table>
<thead>
<tr>
<th></th>
<th>Bilinguals</th>
<th></th>
<th>Monolinguals</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Logographic</td>
<td>Alphabetic</td>
<td>Alphabetic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Chinese-English)</td>
<td>(English-French)</td>
<td>(English)</td>
<td></td>
</tr>
<tr>
<td>RTs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>False Friend</td>
<td>955 (56)</td>
<td>1095 (53)</td>
<td>1060 (63)</td>
<td></td>
</tr>
<tr>
<td>Baseline Item</td>
<td>472 (10)</td>
<td>526 (12)</td>
<td>555 (24)</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>714 (33)</td>
<td>811 (33)</td>
<td>808 (43)</td>
<td></td>
</tr>
<tr>
<td>% errors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>False Friend</td>
<td>8 (1.9)</td>
<td>7.2 (1.8)</td>
<td>8.4 (1.8)</td>
<td></td>
</tr>
<tr>
<td>Baseline item</td>
<td>0.4 (0.2)</td>
<td>0.6 (0.3)</td>
<td>0.3 (0.2)</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>4.2 (1)</td>
<td>3.9 (1.1)</td>
<td>4.3 (1)</td>
<td></td>
</tr>
</tbody>
</table>

Errors

No differences were found between the three groups in the false rejection of target logographs, $F < 1$. There were too few errors made when processing the Baseline items to enable meaningful analysis. However, a one-way ANOVA supported the observation that all three groups were equally poor at correctly rejecting False Friends, $F < 1$ (see Table 2.2).

Discussion Experiment 1

As predicted, a beginner learner’s L1 orthographic background significantly affected the ease with which a new script was acquired. Specifically, the Chinese-English bilinguals, with a logographic L1 background, were superior at target logograph
identification than both the monolingual and bilingual L1 alphabetic participants. Because there was no difference between the numbers of errors made by the three groups, a speed-accuracy trade off cannot explain this performance advantage. Furthermore, the virtually identical performance by the English monolinguals and English-French bilinguals indicates that the superior performance by the Chinese-English bilinguals cannot be attributed to benefits derived from bilinguality. Even though this finding is at odds with most studies involving bilinguality and third language acquisition (see Cenoz, 2000), it is consistent with Nayak et al.’s (1990) study, which indicated no overall differences in performance between multilinguals and monolinguals in the acquisition of an artificial third language.

Overall, the performance pattern provides evidence for an L1 logographic transfer effect in the Chinese-English bilingual learners of the artificial script, facilitating their acquisition. The lexical decision task employed here arguably measured the ability to identify a set of complex logographs through a visual analysis of their structural components as a whole unit. In reading Chinese script, language users are confronted with the task of rapid visual identification of complex characters. On average, literate Chinese are required to know approximately 5000 characters (Yu, Zhang, Jing, Peng, Zhang, & Simon, 1985), some of which contain more than twenty individual strokes. Therefore, during processing of saccades of written logographic text, the skill of quickly recognizing complex individual structures as the eye proceeds from character to character is critical.

The results from Experiment 1 suggest that the honing of this skill through the inculcation of learning and reading Chinese characters has led to a degree of cognitive specialization. This finding is consistent with prior L2 reading studies, which have demonstrated L1 orthographic transfer effects (e.g., Akamatsu, 2003; Chikamatsu, 1996; Koda, 1989, 1990, 1999, 2000; Muljani, Koda, & Moates, 1998). Just as the intra-word analysis of phonemes and syllables is a skill that phonographic readers can transfer to an orthographically congruent language-acquisition context, it was demonstrated that logographic background language users can also transfer other specialist processing styles to benefit novel logographic script. In this case, the transferred cognitive skill was the ability to identify complex graphemic units quickly.
It is conceivable, however, that the lexical decision task was carried out solely by focusing on the structural aspects of the logographs, with little or no attention to their meanings. In order to ascertain whether the logographic benefit for the Chinese-English bilinguals transcended more complex processing, Experiment 2a focused on the comprehension of simple syntactic sequences in the newly acquired artificial logography.

Experiment 2a

To test logographic transfer effects at a deeper level of analysis, a syntactic decision task was designed to examine the level of grammatical and semantic processing in the reading of artificial logographic script. “Syntactic decision” is a term used here to describe a very basic form of sentence processing, involving simple, short (three item) strings of noun and verb combinations only. Prior cross-linguistic studies have investigated syntactic and semantic processing through the use of short sentence strings (utilizing two nouns and a verb) (e.g., Gass, 1987; Li, Bates, & MacWhinney, 1993; see Macwhinney, 1997 for review). For example, Li et al. (1993) presented Chinese-English bilinguals with sets of short three-item (e.g., NNV, NVN, VNN) sentence strings. The nouns represented either an animate or an inanimate object and the verbs were transitive. The task was to identify the agent of the sentence (the doer of the action). In these types of studies, the common goal was to determine which “cues” trigger sentence interpretation (MacWhinney, 1997).

However, in the present study, the task involved deciding whether or not strings of logographs (or words) were syntactically correct or not. That is, participants were presented with a number of short three-item artificial logograph strings consisting of nouns and verbs and were subsequently asked to judge whether or not each string was congruent with the target syntactic order (NVN). In other words, the task followed a standard L2 grammaticality judgement procedure such as those found in previous studies (e.g., Klein, 1995; Thomas, 1988), except that here the sentence strings were limited to noun and verb combinations and that the L2 was an artificial logography.

A grammatical judgement task was chosen for several reasons. First, the artificial script contained only six nouns and six verbs, which placed limits on the type of processing task which could be utilized. As a consequence, only simple two noun and
one verb sentence strings were possible. Second, the artificial script was acquired in
only two learning sessions, which placed limits on the difficulty level of any task
created. From a pilot study, it was observed that the grammatical judgement of artificial
logograph strings provided a task that most participants felt comfortable undertaking.

Arguably, the syntactic decision task outlined here could be completed through
the recognition of items as either nouns or verbs without the recall of each logograph’s
associated meanings. Therefore, the division of logographic strings into meaningful and
meaningless combinations provided a way to determine the extent to which meanings
were being used when processing logographic strings. For example, if illegal
meaningful strings were rejected more slowly than meaningless illegal strings, then this
interference effect would indicate that meanings were being accessed from logographic
items.

There is some evidence to suggest that bilinguality aids syntactic processing
(e.g., Galambos & Hakuta, 1988; Galambos & Goldin-Meadow, 1990; Klein, 1995;
Thomas, 1988; see Bialystok, 2001). For example, Thomas (1988) compared English-
Spanish bilinguals with English monolinguals’ performance in an elementary French
class. Performance was measured via two tests: a vocabulary test and a grammar test.
The grammar test involved a grammaticality judgement task, which measured word
order, subject-verb agreement, adjectival agreement and negative sentences. The
English-Spanish bilinguals outperformed the monolinguals on both tasks. Therefore, we
predicted that the bilinguals would outperform monolinguals on the present task. To the
author’s knowledge this study is the first to investigate syntactic processing of artificial
logograph strings. On the basis of the findings obtained in Experiment 1 it was predicted
that, because grammatical judgements were made on logographic items, logographic
background participants (i.e., the Chinese-English bilinguals) would outperform the
monolingual as well as the bilingual alphabetic background participants.

Method

Participants

The same individuals from Experiment 1.

Materials

Two sets of three-item logograph strings were created separately from the Set A
and the Set B semantic associations used in Experiment 1. Each set consisted of 72
strings, divided into two main categories, namely legal strings (targets) and illegal strings (non-targets). The targets consisted of 36 legal NVN strings, half of which were semantically meaningful (e.g., *policeman remember vehicle*), and half were semantically meaningless (e.g., *insect remember movie*). See Figure 2.4 for an example. NVN word order was chosen as the target grammatical form because subject-verb-object (SVO) word order, and hence NVN, is the dominant grammatical form of sentences for both English (MacWhinney, 1997) and Chinese (Sun & Givon, 1985).

The non-targets consisted of 36 illegal strings, half of which were semantically meaningful (VVN strings, e.g., *remember avoid policeman*) and half of which were meaningless. The meaningless non-targets consisted of six NNN strings (e.g., *vehicle policeman woman*), six VNV strings (e.g., *remember insect tell*), and six VVV strings (e.g., *remember become tell*) (See Appendix G for the full list.).

To ensure that the logograph strings were consistently meaningful or meaningless in both English and Chinese, two English native speakers and two Mandarin native speakers (mainland China) were asked to judge 300 word strings in their native language as meaningful, meaningless, or impossible to categorize as such. Each word string mapped directly onto a logographic equivalent, and followed NVN, NNN, VVN, VVV, and VNV order (60 items per combination). The logographic strings used here were selected from those strings that were consistently judged meaningful or meaningless across all speakers.

**Word Frequency.** To ensure that the two sets of logographic strings were equivalent in terms of the frequency of their associated meanings in either language, the total word frequency of each set was calculated by multiplying the number of times each noun and verb occurred with their word frequency and summing the results. No differences were detected in total word frequency between the two sets of logographic strings both in English, \( t(22) = .738, \ ns \), and in Chinese, \( t(22) = .668, \ ns \).
Figure 2.4. An example of legal target NVN strings in the syntactic decision task. Represented are (1) the target logograph string (top), (2) its English equivalent (middle) and, (3) its Mandarin equivalent (bottom).

Temporal word length of stimuli lists. As with the total word frequency, temporal word length for each item was calculated by multiplying the mean temporal word length by the number of times each item occurred within the two sets of symbol strings. No differences were detected in total temporal word length between the two sets of logographic strings, both in English, $t(22) = .369, ns$, and in Chinese, $t(15) = -.07, ns$.

Procedure

Participants were tested individually in a quiet room. They were tested on symbol strings constructed from the set of target logographs they had learnt in Experiment 1 (Set A or B, as appropriate) approximately one week earlier. After revising the 12 target logographs and their semantic associations, and repeating the learning phase as outlined in Experiment 1, the experiment proper began. The three logographs comprising each string were presented simultaneously in the centre of a computer screen. All 72 unique logographic strings were presented randomly, in four blocks of 18 strings each. A fixation point appeared in the centre of the screen for 1000 ms prior to the appearance of each logographic string. On appearance of each symbol string participants were required to decide, as quickly and as accurately as possible, if the displayed string had the syntactic form NVN by pressing the appropriate key on the keyboard. Each symbol string remained on the screen until response (for a maximum of 20 seconds).

Participants underwent a practice session before the experimental trials began, consisting of eight symbol strings. During the practice trials only, written feedback appeared in the centre of the screen, indicating either a correct or incorrect response in the participants’ native language. The practice session could be repeated once. After
each block of trials a short break was possible. Upon pressing the spacebar, the next block of trials started.

**Design and Analysis**

Response times were measured in milliseconds from stimulus onset to response. Median RTs associated with correct responses only associated with the identification of legal (NVN) symbol strings were subjected to mixed ANOVAs with Group (Chinese-English bilinguals vs. English-French bilinguals vs. English monolinguals) and Set (Set A vs. Set B) as the between-subjects factors, and Meaning (NVN meaningful strings vs. NVN meaningless strings) as the within-subjects factor. To establish the extent to which meaning affected the ability to correctly reject illegal strings, mixed ANOVAs were conducted, with Meaning (VVN meaningful strings vs. NNN, VVV, and VNV meaningless strings) as the within-subjects variable. Errors were subjected to identical analyses.

**Results Experiment 2a**

The following analyses focus on the differences in speed and accuracy between Chinese-English bilinguals, English-French bilinguals, and English monolinguals, in their ability to identify syntactically correct semantically meaningful and meaningless NVN strings versus syntactically illegal strings composed from the artificial logographs.

**Response Times**

*Legal Strings.* Table 2.3 shows the mean of median RTs and errors associated with correctly recognizing a legal NVN string. A 3 x 2 x 2 mixed ANOVA, with Group (Chinese-English bilinguals vs. English-French bilinguals vs. English monolinguals) and Symbol Set (Set A vs. Set B) as the between-subjects variables and Meaning (meaningful vs. meaningless strings) as the within-subjects variable revealed no interactions. There was no three-way interaction, $F < 1$, and neither the Group x Meaning interaction nor the Meaning x Set interaction were significant, $F(2, 53) = 1.41$, $MSE = 330510$, $ns$, and $F(1, 53) = 3.28$, $MSE = 771239$, $ns$, respectively. The lack of a Meaning main effect, $F < 1$, indicated that the meaningfulness of a legal NVN string did not facilitate its processing. All groups were equally fast at identifying legal strings, $F < 1$. Set A logographic strings were processed faster than Set B logographic strings, $F(1,
53) = 4.54, \( MSE = 5178134, p < .04 \), but this effect did not interact with any other factors.

Table 2.3

*Mean of Median RTs (in milliseconds) and Mean Percentage (%) of Errors (with SE in parentheses) for Recognition of Legal NVN Strings in the Syntactic Decision Task (Experiment 2a)*

<table>
<thead>
<tr>
<th></th>
<th>Bilinguals</th>
<th></th>
<th>Monolinguals</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Logographic</td>
<td>Alphabetic</td>
<td>Alphabetic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Chinese-English)</td>
<td>(English-French)</td>
<td>(English)</td>
<td></td>
</tr>
<tr>
<td><strong>Legal Strings</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>RTs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meaningful</td>
<td>2872 (262)</td>
<td>3142 (274)</td>
<td>3071 (257)</td>
<td></td>
</tr>
<tr>
<td>Meaningless</td>
<td>3093 (304)</td>
<td>3039 (164)</td>
<td>2982 (306)</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2982 (283)</td>
<td>3090 (219)</td>
<td>3026 (281)</td>
<td></td>
</tr>
<tr>
<td><strong>% Errors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meaningful</td>
<td>6.05 (1.95)</td>
<td>2.05 (1.25)</td>
<td>4.35 (1.45)</td>
<td></td>
</tr>
<tr>
<td>Meaningless</td>
<td>4.10 (1.64)</td>
<td>2.10 (0.90)</td>
<td>1.95 (1.15)</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>5.08 (1.80)</td>
<td>2.08 (1.08)</td>
<td>3.15 (1.30)</td>
<td></td>
</tr>
</tbody>
</table>

*Illegal strings.* Table 2.4 shows the mean of median RTs and errors associated with correctly rejecting illegal strings, again categorized according to their meaningfulness. A 3 x 2 x 2 mixed ANOVA, with Group and Set as the between-subjects variables and Meaning as the within-subjects variables revealed no interactions, all \( Fs < 1 \). As with the processing of the legal strings there was no significant Group main effect, \( F (2, 53) = 1.37, MSE = 1259124, ns \), again indicating that language specific experience with logographs did not advantage the Chinese-English bilinguals in
processing syntactic structures. A significant Set main effect was obtained here too, $F(1,\ 53) = 7.01, MSE = 6468505, p < .02$, indicating that Set A logographic strings were rejected faster. Again, this effect did not interact with any other variables. As with the pattern for legal NVN combinations, the processing of illegal strings was not facilitated by meaning, $F(1,\ 53) = 2.27, MSE = 1109974, ns$.

Table 2.4  
*Mean of Median RTs (in milliseconds) and Mean Percentage (%) of Errors (with SE in parentheses) for Rejection of Illegal Strings during Syntactic Decision (Experiment 2a)*

<table>
<thead>
<tr>
<th></th>
<th>Bilinguals</th>
<th></th>
<th>Monolinguals</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Logographic (Chinese-English)</td>
<td>Alphabetic (English-French)</td>
<td>Alphabetic (English)</td>
<td></td>
</tr>
<tr>
<td>Illegal Strings</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RTs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meaningful</td>
<td>2213 (245)</td>
<td>2494 (366)</td>
<td>1933 (237)</td>
<td></td>
</tr>
<tr>
<td>Meaningless</td>
<td>2456 (243)</td>
<td>2465 (254)</td>
<td>2304 (241)</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2334 (244)</td>
<td>2479 (310)</td>
<td>2118 (239)</td>
<td></td>
</tr>
<tr>
<td>% Errors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meaningful</td>
<td>6.50 (2.30)</td>
<td>8.45 (3.00)</td>
<td>9.30 (3.50)</td>
<td></td>
</tr>
<tr>
<td>Meaningless</td>
<td>3.10 (1.20)</td>
<td>4.23 (1.60)</td>
<td>6.10 (2.40)</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>4.80 (1.75)</td>
<td>6.34 (2.30)</td>
<td>7.70 (2.95)</td>
<td></td>
</tr>
</tbody>
</table>

Errors

*Legal strings.* The errors when failing to correctly identify legal NVN strings are shown in Table 2.3. A $3 \times 2 \times 2$ mixed ANOVA revealed no Group x Set x Meaning interaction, $F(2,\ 53) = 1.62, MSE = .964, ns$, nor were the Meaning x Group and Meaning x Set interactions significant, $F < 1$ and $F(1,\ 53) = 3.31, MSE = 1.974, ns$, respectively. There was no Meaning main effect, $F(1,\ 53) = 3.31, MSE = 1.974, ns$, and
neither was there a Set main effect, \( F(1, 53) = 1.3, MSE = 1.042, ns \), in contrast to the RT pattern. There was a Group main effect, \( F(2, 53) = 3.87, MSE = 3.089, p < .03 \). Planned comparisons revealed that the English-French bilinguals committed fewer errors than the Chinese-English bilinguals on this task, \( p < .03 \). No other comparisons were significant.

Illegal strings. Table 2.4 shows the mean percentage of errors when failing to correctly reject illegal strings. No Group x Set x Meaning interaction was found, \( F(2, 53) = 1.295, MSE = 1.99, ns \), and neither were there any two-way interactions, all \( Fs < 1 \). No main effects were found for Set, \( F(1, 53) = 1.36, MSE = 2.988, ns \), or for Group, \( F(2, 53) = 1.32, MSE = 2.915, ns \). There was a significant Meaning main effect, \( F(1, 53) = 7.95, MSE = 12.231, p < .008 \), indicating that meaningful strings were more difficult to reject than meaningless strings.

Preliminary Discussion Experiment 2a

The findings of the syntactic decision task using artificial logograph strings were inconsistent with the results of the lexical decision task (Experiment 1). The lexical decision task indicated a logographic background advantage when making lexical judgements on artificial logograph items. On the basis of this finding, it was predicted that a logographic background advantage might also extend to processing artificial logograph strings. However, no such advantage was detected. Instead, all groups were equally fast at identifying syntactically legal strings and rejecting illegal strings. Furthermore, the English-French bilinguals were more accurate than the Chinese-English bilinguals at recognizing target symbol strings but not at rejecting illegal symbol strings.

Based on prior research indicating that bilinguality aids syntactic processing (e.g., Galambos & Hakuta, 1988; Galambos & Goldin-Meadow, 1990; Klein, 1995; Thomas, 1988) it was predicted that the bilinguals overall would outperform the monolinguals when processing artificial logograph strings. Contrary to this prediction, no measurable differences were found between the English monolinguals and both the English-French bilinguals and Chinese-English bilinguals, suggesting that bilinguality did not provide any significant language-specific benefits in regard to this type of syntactic processing. However, this finding is consistent with Nayak et al.’s (1990)
study, which indicated that bilingualism did not provide any significant benefits when processing an artificial linguistic system.

While meaning did not differentially affect the ease with which syntactic decisions were made for legal strings, more errors were made when illegal strings were meaningful, suggesting that semantic processes did play a role in processing the target logograph strings. This effect suggests that participants were retrieving the semantic associations of target logographs and were then classifying them as either nouns or verbs, rather than identifying them as nouns or verbs directly. The semantic meaningfulness of the logograph strings and their subsequent rejection may have resulted in a Stroop-like interference effect and consequently a higher error rate.

In all, no L1 logographic transfer effect was detected. While a logographic transfer effect was identified in Experiment 1 when using a lexical decision task, indicating a superior performance by the Chinese-English bilinguals, this dissipated when the logographs had to be processed in a grammatically meaningful way. It is possible that potential logographic transfer effects were inhibited or masked because English and Chinese language users process sentences in different ways. Even though both English and Mandarin Chinese are predominantly SVO languages, syntactic processing and word order plays a primary role in English sentence interpretation (e.g., Bates, McNew, MacWhinney, Devescovi, & Smith, 1982), whereas it plays a secondary role (to semantic processing) in Mandarin Chinese sentence interpretation (e.g., Li, Bates, & MacWhinney, 1993). Therefore, it is conceivable that the syntactic decision task may have advantaged the English L1 participants. In Experiment 2b, this notion is tested through the requirement that the English monolinguals, English-French bilinguals and Chinese-English bilinguals undertake the syntactic decision task of Experiment 2a in their respective native languages.

**Experiment 2b**

To determine the extent to which performance on the syntactic decision task in Experiment 2 was a reflection of an L1 bias, potentially providing English L1 speakers with an advantage, participants were required to undertake the same task in their respective L1.
Method

Participants
The same individuals from Experiment 2a.

Materials
The same Set A and Set B symbol strings were used as in Experiment 2a but in direct translation to English and Chinese. English words were displayed in Times New Roman font size 24 and Chinese characters were displayed as Simsun font, size 28.

Procedure
The same procedure as in Experiment 2a was adopted here. Participants made syntactic judgements based on word strings identical to those used in Experiment 2a but presented in L1 (English for English-French bilinguals and monolinguals, Chinese for Chinese-English bilinguals). Participants were presented with word strings from the other set (i.e., if they had processed Set A in Experiment 2, they were now presented with Set B, and vice versa). Experiment 2b was undertaken during the same session as Experiment 2a. The two experiments were counterbalanced.

Design and Analysis
As in Experiment 2a.

Results Experiment 2b

Response Times

Legal strings. Mean of median RTs associated with correctly identifying a legal NVN string (as well as percent errors) are shown in Table 2.5 for the three groups. As in Experiment 2, a 3 x 2 x 2 mixed ANOVA, with Group and Symbol Set as the between-subjects variables and Meaning as the within-subjects variable, revealed no interactions, all Fs < 1. There was no significant Meaning main effect, F(1, 53) = 2.78, MSE = 141392, ns, indicating that meaningful strings were not recognized faster than meaningless strings. Carrying out the syntactic decision task using the native language revealed a significant Group main effect F(2, 53) = 15.13, MSE = 1705638, p < .001. Contrary to our expectations, planned comparisons revealed that the Chinese-English bilinguals recognized legal NVN strings significantly faster than the monolingual English speakers, p < .001, and were marginally faster than the English-French bilinguals, p < .06, indicating that they could not have been disadvantaged (in
Experiment 2a) by the task demands. The monolinguals were outperformed by the English-French bilinguals, \( p < .02 \). There was no Symbol Set main effect, \( F(1, 53) = 1.15, \text{MSE} = 129361, \text{ns} \), indicating that overall, the two symbol string sets did not differ.

Table 2.5

<table>
<thead>
<tr>
<th></th>
<th>Bilinguals</th>
<th>Monolinguals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Logographic (Chinese-English)</td>
<td>Alphabetic (English-French)</td>
</tr>
<tr>
<td>Legal Strings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RTs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meaningful</td>
<td>1072 (51)</td>
<td>1259 (120)</td>
</tr>
<tr>
<td>Meaningless</td>
<td>1151 (67)</td>
<td>1331 (135)</td>
</tr>
<tr>
<td>Mean</td>
<td>1111 (59)</td>
<td>1295 (128)</td>
</tr>
<tr>
<td>% Errors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meaningful</td>
<td>0.80 (0.40)</td>
<td>0.95 (0.40)</td>
</tr>
<tr>
<td>Meaningless</td>
<td>1.15 (0.70)</td>
<td>1.35 (0.95)</td>
</tr>
<tr>
<td>Mean</td>
<td>0.98 (0.55)</td>
<td>1.15 (0.68)</td>
</tr>
</tbody>
</table>

Illegal strings. Table 2.6 shows the mean of median RTs associated with correctly rejecting illegal strings (as well as percent errors). As in Experiment 2a, no Group x Symbol Set x Meaning interaction was found, \( F < 1 \). Neither was there a Meaning x Group interaction, \( F(2, 53) = 1.97, \text{MSE} = 58002, \text{ns} \), nor a Meaning x Symbol Set interaction, \( F < 1 \). There was a significant Meaning main effect, \( F(1, 53) = \)
28.66, \( MSE = 842566, \ p < .001 \), indicating that, overall, meaningful illegal strings were rejected faster than meaningless strings. Unlike for the processing of logographic symbol strings, there was a Group main effect when carrying out the syntactic decision in the native language, \( F(2, 53) = 4.81, \ MSE = 665508, \ p < .02 \). Planned comparisons indicated that the Chinese-English bilinguals were faster at rejecting illegal strings than the English monolinguals, \( p < .02 \), but did not differ from the English-French bilinguals, \( ns \). The English-French bilinguals in turn did not differ from the monolinguals in the ease with which illegal strings were rejected, \( ns \). There was no Symbol Set main effect, \( F < 1 \).

Table 2.6

*Mean of Median RTs (in milliseconds) and Mean Percentage (%) of Errors (with SE in parentheses) for Rejection of Illegal Strings during Native Language Syntactic Decision (Experiment 2b)*

<table>
<thead>
<tr>
<th>Illegal Strings</th>
<th>Bilinguals</th>
<th>Monolinguals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Logographic (Chinese-English)</td>
<td>Alphabetic (English-French)</td>
</tr>
<tr>
<td>RTs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meaningful</td>
<td>1031 (70)</td>
<td>1174 (105)</td>
</tr>
<tr>
<td>Meaningless</td>
<td>1152 (60)</td>
<td>1304 (110)</td>
</tr>
<tr>
<td>Mean</td>
<td>1091 (65)</td>
<td>1239 (107)</td>
</tr>
<tr>
<td>% Errors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meaningful</td>
<td>2.80 (1.20)</td>
<td>3.45 (1.80)</td>
</tr>
<tr>
<td>Meaningless</td>
<td>3.30 (1.15)</td>
<td>5.45 (2.45)</td>
</tr>
<tr>
<td>Mean</td>
<td>3.05 (1.18)</td>
<td>4.45 (2.13)</td>
</tr>
</tbody>
</table>
Errors

Legal strings. A 3 x 2 x 2 mixed ANOVA, with Group and Symbol Set as the between-subjects variables and Meaning as the within-subjects variable, revealed a three-way interaction, $F(2, 53) = 3.46$, $MSE = .81$, $p < .04$ (see table 2.5 for the data). However, an analysis of the simple interaction effects revealed no significant differences. There were no significant two-way interactions, all $Fs < 1$. The lack of a Meaning main effect indicated that illegal meaningful and meaningless strings were equally difficult (or easy) to reject, $F < 1$. Error rates did not differ across groups, $F(2, 53) = 1.09$, $MSE = .241$, $ns$. No Symbol Set main effect was obtained, $F < 1$, indicating that both sets were of equal difficulty.

Illegal strings. A 3 x 2 x 2 mixed ANOVA revealed no significant three-way or two-way interactions, all $Fs < 1$. Here also there was no Meaning main effect, $F(1, 53) = 2.05$, $MSE = 1.93$, $ns$, indicating that the rejection of illegal strings in one’s native language was equally difficult (or easy), irrespective of whether the strings were meaningful. Again no Symbol Set main effect was detected, $F(1, 53) = 2.08$, $MSE = 2.75$, $ns$. As was the case with legal strings, the groups did not differ in error rates on illegal strings, $F(2, 53) = 1.6$, $MSE = 2.12$, $ns$.

Discussion Experiment 2a and 2b

When considering the unanticipated results obtained in Experiment 2a, it was proposed that the syntactic decision task itself may have favoured the English monolinguals and English-French bilinguals. That is, because SVO word order is a stronger facilitator of meaning for English sentence processing than for Chinese sentence processing, the NVN focus of the syntactic decision experiment using the target logograph strings may have confounded the findings. However, the results of Experiment 2b clearly demonstrate that this was not the case. The Chinese-English bilinguals were significantly better than the English monolinguals in processing syntactic strings in their native language and their performance was marginally better than the English-French bilinguals.

Another concern that can be put to rest by these results is that the two sets of logograph/word strings may not have been adequately balanced. In Experiment 2a, Set A was processed faster than Set B. In the present experiment, no differences in
performance were found related to the sets used. Therefore, the anomalous results of Experiment 2a cannot be attributed to the combinations of word associations of logograph strings. Recall that both sets of logograph strings consisted of an equal number of complex and simple target logographs, resulting in target logograph strings that were equivalent in regard to structural complexity. It is likely that the reason for the difficulty of the Set B symbols during logograph processing was related to recall of logograph meaning associations.

In terms of the possible impact of bilinguality, the English-French bilinguals clearly outperformed the English monolinguals at recognizing target NVN strings suggesting that bilingualism aids L1 syntactic processing. It is likely that the English-French bilinguals were more familiar with explicit L1 grammatical knowledge (e.g., nouns and verbs) than the monolinguals and were hence able to classify items as either nouns or verbs faster. This finding is consistent with studies that have documented the positive effects of bilingualism on metalinguistic awareness (e.g., Bain & Yu, 1978; Bialystok, 1987; Cummins, 1978; Thomas, 1988). Specifically, very little research has been conducted on the effects of an L2 on L1 syntactic processing (Cook, Iarossi, Stellakis, & Tokumaru, 2003). However, Cook et al. (2003) investigated the effect of an L2 English background on the syntactic processing of short NVN, VNN, and NNV word strings by bilingual and monolingual Greek, Spanish and Japanese NSs. It was found that the bilinguals processed the word strings differently to the monolinguals. The present finding, which indicated a superior performance by the bilingual language learners, is generally consistent with Cook et al.’s study.

However, there was no effect of bilingualism when processing target logograph strings in Experiment 2a. Even though this finding is seemingly at odds with the majority of research involving the benefits of bilingualism on the processing of a third language (see Cenoz, 2000), it is important to remember that Experiment 2a involved the processing of an artificial writing system. Even though few studies have investigated the impact on bilingualism on the L3 acquisition of artificial linguistic systems, at least one study (Nayak et al., 1990) has found that bilingualism does not provide any overall performance-related benefits. The present study supports this finding. The importance of this finding rests in the fact that, other than possible advantage of cognitive processing
congruency, there were no other factors that could have aided transfer. That is, the artificial script had no overlap with any other known script.

Common to both Experiment 2a and 2b, the meaningfulness of word/logograph strings during the processing of legal NVN targets did not significantly benefit syntactic decisions. However, RTs were significantly faster when native language word strings were meaningful during the rejection of illegal non-targets. This result was possibly an artifact of the syntactic decision task. Recall that meaningful illegal strings took the form of VVN and that a third of the meaningless illegal strings were of the form NNN. When making fast NVN syntactic judgements in L1, participants could quickly reject a VVN string by focusing only on the first verb, whereas with a NNN string, participants would have to process at least the first two words. Therefore, the difference in processing speeds was probably more a reflection of the task than an indication of semantic processing. Indeed, if semantic processes were involved, the meaningfulness of illegal strings would have made them harder to reject.

However, during the processing of logographic strings in Experiment 2a, the meaningfulness of the VVN string associations disrupted performance, in that more errors were committed rejecting illegal meaningful VVN strings than illegal meaningless (NNN, VVV and VNV) combinations. In this case, semantic processing was evident when rejecting illegal logographic associations of words. This suggests that two very different types of processing were taking place in the syntactic processing of Experiment 2a and Experiment 2b. When processing illegal VVN strings in L1, participants were most likely focusing only on the first word and then quickly rejecting the string as illegal whereas when logograph strings were being processed, the meanings of each item within each string were processed before they were deemed illegal. Therefore, these results indicate the importance of semantic factors during the syntactic processing of artificial logograph strings.

In summary, these results indicate that performance during syntactic processing of target logographs cannot be attributed to either unbalanced sets of logograph/word strings or syntactic task bias favouring English L1 participants. In addition, participants demonstrated flexibility in their processing strategies, changing from a focus on semantic processing when judging logograph strings (Experiment 2a) to a focus on word
order when judging L1 strings (Experiment 2b). In Chapter Four, participants’ cognitive strategies used when acquiring and processing the artificial logographs will be examined.

General Discussion

Prior research indicated that language learners can transfer L1 background reading skills to L2 reading when both L1 and L2 orthographic systems are congruent (e.g., Akamatsu, 2003; Chikamatsu, 1996; Koda, 1999, 2000; Muljani et al., 1998). Based on the idea of the language transfer hypothesis, it was predicted that, by virtue of their logographic L1 background, Chinese-English bilinguals would outperform both English-French bilinguals and English monolinguals. A logographic transfer effect was only supported in the lexical decision task (Experiment 1).

In Experiment 1, Chinese-English bilinguals, English-French bilinguals and English monolinguals were required to learn L2 target logographs from an artificial logography, each coupled with a unique meaning. In a lexical decision task on these target logographs (Experiment 1) the Chinese-English bilinguals outperformed both the English-French bilinguals and English monolinguals, indicating a logographic transfer effect. In Experiment 2a, the target logographs were arranged into short legal (NVN) and illegal (NNN, VVV, VVN, VNV) strings and participants were required to make syntactic judgements. On this task no logographic transfer effect was obtained. In Experiment 2b, the syntactic judgement task was carried out in the native language to determine whether the findings of Experiment 2a (i.e., the lack of a logographic transfer effect) were confounded by task bias favouring the English native speakers. This was not found to be the case: Chinese-English bilinguals outperformed the English monolinguals and were marginally better than the English-French bilinguals. Therefore, considering the superior performance of the Chinese-English bilinguals at processing the target logographs (Experiment 1) and the finding that the syntactic decision task was not biased towards English native speakers (Experiment 2b), their comparable performance with the English monolinguals and the English bilinguals on the syntactic decision task using the logograph strings (Experiment 2a) was somewhat surprising. However, it is possible that the heavy cognitive demands of the task itself may have prevented the detection of any performance advantages based on L1 logographic background.
In Experiment 1, it is possible that the verbal associations of target logographs were not accessed when making lexical decisions. Prior reading research has demonstrated that lexical decision judgments on visually presented words can be made without accessing phonological information (e.g., Davelaar, Coltheart, Besner, & Jonasson, 1978; Martin, 1982; McQuade, 1981). Furthermore, neuropsychological studies involving individuals with lexical-phonological processing difficulties provide strong evidence that the lexical access of words can be attained through visual information only (e.g., Miceli, Benvegnù, Capasso, & Caramazza, 1997; Rapp & Benzing, 1997; Shelton & Weinrich, 1997; see Coltheart & Coltheart, 1997, for review). Therefore, the lexical decision task using the artificial logographs could have been carried out based solely on the visual properties of the target logograph structures. Moreover, recent research has shown that perceptual processing, not lexical access, is critical to extracting orthographic information from L2 words. For example, Vaid and Frenck-Mestre (2002) found a right-hemisphere-mediated processing bias in a group of French-English bilinguals when identifying orthographically marked L2 words, indicating the important role of perceptual processing. In the present study, because the lexical decision task elicited fast judgements based on the surface characteristics of each item’s orthographic form and did not require semantic associations in order to successfully complete the task, it is likely that visual (or perceptual) processing played a central role.

It is highly likely that both the lexical and syntactic decision tasks of Experiment 1 and Experiment 2a would have relied heavily on working memory (WM). That is, the target logographs’ structures and verbal associations would have been stored and retrieved via WM processes, i.e., the visuo-spatial sketchpad for target logograph orthographic structures and the phonological loop for their verbal associations (see Baddeley, 1986). In regard to Experiment 2a, WM storage and retrieval would have been particularly crucial to task completion. For example, each individual target logograph’s visual and verbal association would have to have been stored while processing each saccade of items. That is, after the first target logograph had been identified and its verbal association accessed, it would have to be stored while the next
target logograph was being processed and so on until the syntactic decision on the whole string was made.

Prior cross-linguistic WM research has indicated that L1 logographic language users are better than L1 alphabetic language users at visuo-spatial tasks but not at central executive (mixed visual and verbal) tasks (e.g., Demetriou, Kui, Spandoudis, Christou, Kyriakides, & Platsidou, 2005). Recall that, in Experiment 1, the lexical decision task could have been completed by visual processing only, while in Experiment 2a, the syntactic decision task using the target logographs involved a combination of both visual and verbal processing. Hence, the findings of both Experiment 1 and Experiment 2a are consistent with Demetriou et al.’s study in that L1 logographic language users’ visual superiority over L1 alphabetic language users disappears when tasks involve a combination of both visual processing and verbal processing.

In other words, the task demands, which rely on central executive processing, may cancel out any visual advantage Chinese have over their alphabetic counterparts. Therefore, from a WM theoretical perspective, the results of the syntactic decision task, with its dependence on central executive processing, may have been more a reflection of central executive functioning than a lack of a logographic language background effect. In the next chapter, the focus moves away from L2 reading to investigate the WM processes that might be differentially involved in the acquisition and recall of an artificial logographic script.

Only Experiment 1 supports the language transfer hypothesis outlined in Chapter 1 of this study. It was argued that the inculcation of an L1 logographic orthography enhances visual processing skills, whereas the inculcation of an alphabetic or syllabic L1 orthography enhances phonological processing skills. In Experiment 1, the L1 logographic participants demonstrated a processing advantage over their L1 alphabetic counterparts in the visual recognition of target logograph structures. This finding tentatively supports the language transfer hypothesis. However, the present findings are inconclusive and further investigation will be pursued in Chapter 4 of this study, which will focus on participants’ cognitive strategies that were deployed during Experiment 1 and 2a.
Even though the major focus of this study is on the effect of a language learners’ L1 background on the acquisition and use of an artificial logographic orthography, the findings of these experiments may have some significance for researchers investigating the effects of bilingualism on both foreign and native language processing. The present findings suggest that bilinguality increases metalinguistic awareness, which benefits syntactic processing in L1. However, these bilingual benefit effects do not appear to translate to syntactic processing in an artificial logographic L2.
CHAPTER 3

In Experiment 1 (the lexical decision task) the Chinese-English bilinguals outperformed both the English monolinguals and the English-French bilinguals when processing artificial logographs. It was argued that their logographic background was the probable cause of this. That is, the inculcation of a highly visual orthographic system resulted in specialized visual skills, which were transferable to processing a congruent writing system. The alphabetic L1 participants, who lacked such a visual background, were therefore less capable on this task. Numerous studies have provided evidence for such processing differences, both in performance (e.g., Chen & Tsoi, 1990; Koda, 1989, 1990; Mann, 1985; Tavasolli, 2002) and neuroanatomically (e.g., Chen et al., 2002; Tan et al., 2001; Yamaguchi et al., 2002).

From the previous discussion in Chapter 2 it was argued that the verbal associations of these artificial logographs were not required in order to successfully make lexical decision judgements. However, during Experiment 2a (the syntactic decision task using the logographs), the access of the artificial logographs’ meanings (and hence their verbal associations) was crucial for task completion, and the performance advantage demonstrated by the Chinese-English bilinguals dissipated. This finding suggests that when processing artificial logographs, the Chinese-English bilinguals’ advantage over their alphabetic counterparts may be limited to visual processing.

In order to further investigate this line of argument, a series of experiments were designed focusing on working memory (WM). Working memory paradigms provide a means to investigate visual and verbal processing systems in isolation from each other. For example, Jonides (2000) has described WM as a set of subsystems which are responsible for different sorts of information processing. These subsystems handle verbal (through the phonological loop) and visual information (through the visuo-spatial sketchpad) (Baddeley, 1986). Access to these verbal and visual subsystems can be restricted by verbal and visual interference during various concurrent tasks (Baddeley, 2002). For example, verbal interference tasks disrupt the ability to verbally rehearse items in WM and, consequently, result in a greater reliance on processing in the visual subsystem. Alternatively, interference tasks that disrupt visuo-spatial processing
result in a greater reliance on processing in the verbal subsystem. What is important here is that disruption affects reliance on one or the other subsystem. Therefore, a WM processing task using artificial logographs combined with concurrent interference tasks would provide a means to examine variant L1 orthographic background language learners’ reliance on visual and verbal processing. That is, if the L1 logographic background language learners were less affected by verbal interference than their alphabetic counterparts when processing artificial logographs, then it could be argued that L1 logographic background participants were more visually orientated in their processing style. Conversely, if the L1 alphabetic background participants were more affected by verbal interference than their L1 logographic background counterparts then it could be argued that verbal processing was more critical to L1 alphabetic background participants when processing artificial logographs.

The following section (1) describes the concept of WM in more detail, provides (2) a review of relevant WM and visual STM studies (involving L1 logographic language learners) and (3) a rationale for the incorporation of a WM paradigm into the present research study, and (4) outlines a method to measure visual and verbal processing within a serial recall WM paradigm involving the artificial logographic script.

**Working Memory**

Working memory refers to the “temporary maintenance and manipulation of information” (Baddeley, 2002, p. 85). It is on this point that it differs from short-term memory (STM), which involves the maintenance of information but not its manipulation (Jonides, 2000). According to Baddeley, WM consists of a central processing mechanism, known as the central executive, which has two slave systems, the phonological loop and the visuo-spatial sketchpad (VSSP). These two slave systems perform specific functions relating to the retention and rehearsal of information, such as verbal information in the phonological store and visual information in the visual cache. Recently, a fourth component known as the Episodic buffer has been added to the three-part model. The episodic buffer has two main roles: (1) sharing information between the two subsystems and (2) incorporating long-term memory (LTM). Each of these components will be discussed in turn.
The phonological loop. The phonological loop comprises a subsystem that is responsible for the storage and rehearsal of verbal or speech-based information. The phonological store can retain verbal information for up to two seconds but begins to fade after this time unless it is ‘rehearsed’ via the phonological loop. This process of rehearsal is called subvocal rehearsal, which functions to prevent memory loss in STM (Baddeley, 1986). There are two main types of subvocal rehearsal: maintenance and elaborative. Maintenance rehearsal constitutes the subvocalization of words in order to maintain them in STM, whereas elaborative rehearsal is a more complex process necessary for memory retention beyond the short term (Craik & Watkins, 1973). Access to these rehearsal mechanisms can be blocked through a concurrent task known as articulatory suppression, whereby irrelevant words (e.g., “blah”, “Coca Cola”, “hi yah’, “the”, “double-double”) are repeated while processing items in either STM or WM (Baddeley).

Evidence to support the existence of a phonological loop can be found in an early study by Baddeley et al. (1975). Baddeley and colleagues conducted a number of experiments involving immediate memory span, the word length effect, and articulatory suppression in a variety of conditions. In Baddeley et al.’s (1975) experiment, participants were presented with two word lists comprising words with one syllable and words with five syllables. Essentially, words were presented in varying sequences and the participants had to immediately verbally recall the sequences of words. This procedure was enacted under two conditions, in which the words were presented visually or via auditory presentation. In addition, word presentation occurred either with or without articulatory suppression. It was found that articulatory suppression abolished the word length effect during the recall of visually presented items (words) but not with items presented in an auditory manner. In other words, when articulatory suppression was enforced during the visual presentation of these words, recall was not dependent on whether the words were long or short. This was not the case when words were presented orally. Here, recall was determined by the length of the word, that is, the longer the word was, the less easy it was to recall. Baddeley et al. argued that this was in keeping with the rehearsal/decay hypothesis which simply suggests that the longer a word takes
to say, the longer it takes to rehearse and, as a consequence, shorter words are memorized faster than longer words.

As well as storage and rehearsal, the phonological loop is believed to have a language learning function (e.g., Ardila, 2003; Baddeley, Gathercole, & Papagno, 1998; Cook, 1997; Ellis & Sinclair, 1996; Papagno et al., 1991; Robinson, 2001). For example, the phonological loop plays an important role in L2 vocabulary (e.g., Papagno et al., 1991) and L2 syntax acquisition (e.g., Ellis & Sinclair, 1996) (these two aspects will be discussed in more detail later). The phonological loop has also been linked to L2 reading (e.g., Harrington & Sawyer, 1992; Leung, 2006; Williams, 1999). However, most L2 WM studies have been investigated from the perspective of an alphabetic L2. While L1 logographic Chinese WM and STM functions have been explored to some degree (e.g., Hue & Erickson, 1988; Luer, Becker, Lass, Yunqiu, Guopeng, & Zhongming, 1998; Mou & Anderson, 1981; Stigler, Lee, & Stevenson, 1986; Zhang & Simon, 1985), the issue of L2 logographic WM has mostly been avoided. Furthermore, the idea that language transfer may play a role in L2 WM also has not received much attention. It is assumed here that if L1 orthographic processing skills can be transferred to L2 reading, then L1 orthographic processing skills may also impact on L2 WM, considering that WM is a cognitive mechanism closely associated with L2 reading. It is possible that L1 orthographic processing skills may be transferred to an L2 WM processing capability.

In summary, the phonological loop is a limited capacity storage and rehearsal subsystem. In this subsystem, the temporal word length of items determines their articulatory rate. Shorter words can be rehearsed faster in the phonological loop than longer words. Because shorter words can be rehearsed faster than longer words, more shorter words than longer words can be retained, and rehearsed in WM. The phonological loop also plays an important role in SLA. To date, only L2 alphabetic WM has been explored and the investigation of L2 logographic WM has largely been ignored.

The Visuo-Spatial Sketchpad. The VSSP mirrors the phonological loop as a subsystem of WM. However, the specific function of the VSSP has to do with visual-spatial information and concerns of storage and rehearsal of visual-spatial information.
Much effort has been expended to try and separate visual and spatial processing within the subsystem. However, Baddeley (2002) argues that this has been difficult to achieve. Strong evidence to support Baddeley’s position comes from a neurological study. In a series of experiments examining visual, spatial and verbal WM, as well as retrieving visuo-spatial information from LTM, Hanley, Young, and Pearson (1991) found that a right hemisphere damaged patient (ELD) had significant impairment with visuo-spatial WM but not with verbal WM, supporting the notion of two separate systems: a visuo-spatial system and a verbal system.

Logie (1995) has argued that visual information can be rehearsed as a function of the visuo-spatial sketchpad, mirroring the function of the phonological loop. There is some evidence to support this contention (e.g., Anderson, 1982; Watkins, Peynircioğlu, & Brems, 1984). For example, in Watkins et al.’s study, an investigation into verbal and visual mental rehearsal was undertaken through the use of a memory test paradigm. Sequences of pictures were presented and during presentation participants were allocated time to either rehearse items verbally by saying them silently to themselves or to rehearse them visually by repeatedly scanning the image of the item in their minds. In addition, there were conditions in which presentation items were not rehearsed. Next, fragments were presented as word and visual cues. For example, word fragments consisted of words used in presentation but with several letters removed, and visual cues consisted of visual items that were muddled and difficult to discern. Visual cues were beneficial to the pictorial rehearsal group but not to the verbal rehearsal group and vice versa, thus supporting the idea that visual information can be rehearsed in the visual modality, just as verbal information is rehearsed within the phonological loop.

As with the phonological loop, rehearsal in the VSSP can be blocked through concurrent interference tasks. For example, interference in the VSSP can occur through repeatedly tapping keys, either in a specific location or order, as well as through the use of visual noise such as the presentation of unattended patterns (Baddeley, 2002, see Baddeley, 1986). Importantly, such interference tasks are modality-specific.

It is possible that the processing of logographic script may rely more on processing in the VSSP than alphabetic script. Recall that behavioural (e.g., Tavasolli, 2002) and neuroimaging studies (e.g., Tan et al., 2001) have shown that visuo-spatial
analysis is more critical to processing logographic script than alphabetic script. Furthermore, an L1 Japanese study by Kimura (1984) found that articulatory suppression interfered with the processing of Kana (syllabic) script but not Kanji (logographic) script. Pairs of words that were related (e.g., *tax/import, order/number*) and unrelated (*safe/teapot, desert/debate*) in meaning were visually displayed in Kana and Kanji scripts to Japanese native speakers. Written judgements were made on whether these word pairs were semantically related. This task was completed under concurrent articulatory suppression. The selective effect of articulatory suppression on syllabic script suggests that the processing of phonographic script relies on rehearsal in the phonological loop. In contrast, the processing of logographic script can bypass the phonological loop through substitution with the VSSP (or some other capability). However, no research to date has investigated the role of the VSSP (or the phonological loop) in regard to L2 logographic processing. To fill this gap in the literature, the experiment presented here will involve the processing of an L2 artificial logographic script in WM under the conditions of articulatory suppression and visuo-spatial interference. In terms of articulatory suppression, the aim is to disrupt phonological rehearsal to determine the extent of reliance on the phonological loop when processing L2 logographic items. Additionally, the extent to which the VSSP is involved in the processing of L2 logographic items will also be determined by a concurrent interference task that disrupts visuo-spatial processing.

*The Central Executive.* Less is known about the central executive than either the phonological loop or the VSSP (Baddeley, 1990). The idea for the central executive is based on the Supervisory Attentional System (SAS) proposed by Norman and Shallice (1986). Arising out of neuropsychology, the SAS accounts for how normal and routine activities can be performed in the face of new challenges. The SAS accounts for how new environmental stimuli are incorporated into existing schemata resulting in the formation of newly planned actions (Baddeley, 2002). Following from the SAS, the central executive is the overall processor of WM, and is responsible for focusing attention, dividing attention and switching attention (Baddeley, 2002). Therefore, based on incoming information, either verbal or visual-spatial, the central executive makes decisions related to what is being focused on at any point and directs how the two slave
systems are to be used. It is therefore seen as an engine that oversees the whole WM process.

*The Episodic Buffer.* Some of the problems with the tripartite model of WM were its inability to account for the access of information from LTM to the subsystems and how information was communicated from one modality to the other (Baddeley, 2002). The incorporation of the episodic buffer overcomes these limitations. The episodic buffer functions as a storage system, which holds information from episodic LTM and also acts as a buffer between the phonological loop and the VSSP. In Baddeley’s new WM model, the subsystems can directly access both verbal and visual LTM. The function of the episodic buffer is to combine information from LTM with the two slave systems. However, this is yet to be tested empirically.

*Summary.* Working memory involves the maintenance and manipulation of information during specific cognitive tasks. Baddeley’s WM model consists of a system involving four parts: a central executive with two subsystems, the phonological loop, which process verbal information and the VSSP, which processes visual-spatial information. The central executive overrides these two subsystems through the allocation of attentional resources. The episodic buffer acts as an episodic LTM storage facility and also as an interface for the two subsystems to access information from their counterpart modality. Concurrent interference, such as articulatory suppression and finger tapping, can (respectively) disrupt phonological and visuo-spatial processing during WM tasks.

It is possible that different orthographic systems may influence the degree to which languages are processed in the phonological loop and the VSSP. There is some L1 evidence to indicate that the VSSP may play a more critical role in the processing of a logography than a phonographic writing system (e.g., Kimura, 1984; Tan et al., 2001; Tavasolli, 2002). However, it is not known if this is the case in L2. Therefore, the present study will investigate the WM processing of an L2 artificial logography under the concurrent conditions of articulatory suppression (to impede the phonological loop) and finger tapping (to impede the VSSP) to explore the extent to which phonological and visuo-spatial processing is involved. Because the focus of this investigation will
involve the role of WM in L2 processing and acquisition of L2 (and, for some, an L3) it is necessary to investigate the relationship between SLA and WM.

Second Language Acquisition and the Role of WM

A number of studies have found that WM plays a significant role in SLA (e.g., Ardila, 2003; Baddeley et al., 1998; Cheung, 1996; Cook, 1997; Daneman & Case, 1981; Ellis & Sinclair, 1996; Papagno et al., 1991; Robinson, 2001; Service, 1992). For example, Papagno et al. investigated the role of short-term phonological storage in the acquisition of L2 vocabulary. The study involved a STM recall paradigm in which foreign (Russian) and native word pairs (Italian) were presented under various concurrent conditions (e.g., tapping or articulatory suppression). Articulatory suppression was found to prevent the recall of newly acquired words but not of well-known ones, suggesting that the phonological loop played an important role in learning new words (see Baddeley et al., 1998, for a detailed extension to this argument).

Investigations into the role of the phonological loop and L2 vocabulary acquisition have not been limited to studies on L1 alphabetic language learners. For example, Cheung (1996) found that for L1 logographic Chinese high school students learning English, non-word span was a predictor of new English vocabulary items. For the memory span task, sequences of two syllable English non-words were read aloud. Responses entailed the verbal recall of items in their correct order of presentation. The L2 vocabulary acquisition task involved learning the English pronunciation and Chinese meanings of a small set of English words. A strong association was found between phonological non-word span and learning L2 English words. However, this was only true for the Chinese high school students who were less proficient in English. Phonological memory did not predict the vocabulary acquisition of L2 learners who had a high level of proficiency in English. Cheung conjectured that the more proficient L2 learners were able to draw on their long term English language knowledge to facilitate the acquisition of the new vocabulary items, whereas the less proficient L2 learners, who were lacking in this knowledge, had to rely on their phonological memories. Lower proficiency in the language implies more limited phonological knowledge to draw on and consequently, a greater need to rehearse new items in the phonological loop. Therefore, the phonological loop as a facilitator of L2 learning plays a critical role in the
earlier stages of SLA. However, this role may become less important as language learners become more proficient in their L2.

Working memory has also been found to correlate with L2 reading ability (e.g., Harrington & Sawyer, 1992; Williams, 1999). For example, Harrington and Sawyer investigated the relationship between L2 WM capacity and reading skill of Japanese-English bilinguals. Three tests were used involving word span, digit span, and reading span, each carried out in both languages. A significant correlation was found between L2 digit/word span and L2 reading ability, suggesting a general advantage related to the phonological loop and L2 reading.

In addition to pronunciation and vocabulary acquisition, and L2 reading ability, verbal STM was found to play an important role in the language acquisition of L2 syntax. For example, Daneman and Case (1981) found that verbal STM was a reliable predictor of L2 syntactic processing in young children (aged 2 – 6 years) who had acquired an artificial language system. Using toy animals, made-up verbs with specific meanings were taught. Prefixes and suffixes were added to embellish the meanings of these verbs in some particular way. For example, the made up verb “pum” signified the action of flying through the air. When the suffix “abo” was added (e.g., “pum-abo”) the meaning was embellished to signify the action of flying through the air while being watched by a spectator. New verbs were then taught to which the same prefix and suffix configurations were added. Children were tested on their ability to discern the semantic and syntactic rules resulting from the new combinations of verbs, prefixes and suffixes. For the measurement of verbal STM, small sequences of one-syllable nouns were presented one at a time. Children were required to verbally repeat the items in their correct order of presentation.

However, the children who participated in Daneman and Case’s (1981) study were very young and this would have precluded them from utilizing the phonological loop to facilitate their L2 syntactic processing. While studies have shown that young children can store information as phonological codes, the actual silent rehearsal of this phonological information does not arise until around seven years (e.g., Cowan & Kail, 1996; Flavell, Beach, & Chinsky, 1996; see Vygotsky, 1986). Therefore, the findings of
Daneman and Case relate to phonological storage only and not rehearsal in the phonological loop.

In Ellis and Sinclair’s (1996) study, the phonological loop was found to play a significant role in the facilitation of L2 syntactic processing. However, it was also found that the role of the phonological loop varied according to the specific tasks used in the investigations. Non-Welsh speakers learnt 30 Welsh stimulus words and grammatical forms under three conditions (silent, articulatory suppression, and forced verbal rehearsal) and were then required to orally reproduce what they had learnt. Individuals who were forced to verbally rehearse were significantly better than those in the articulatory suppression condition in terms of their accuracy of pronunciation and grammatical fluency and accuracy. However, when required to make fast syntactic judgements on combinations of legal and illegal Welsh word strings, they did not demonstrate a performance advantage. Hence, the prior rehearsal of L2 items in the phonological loop did not facilitate the making of L2 syntactic judgements. Ellis and Sinclair attributed this finding to the inherent difficulty of the grammatical decision task itself.

Ellis and Sinclair’s (1996) findings indicate that when L2 language tasks involve verbal speech production, the phonological loop facilitates syntactic processing. However, when the task involves making grammatical judgement decisions on legal and illegal L2 word strings, the phonological loop plays no significant role in processing. This observation conflicts with the argument presented in Chapter 2 of the present study. In Experiment 2a, it was found that language learners’ L1 and L2 backgrounds did not facilitate the making of syntactic judgements on artificial L2 strings. It was conjectured that WM processing may have been responsible for this lack of an effect. It was argued that making syntactic judgements on artificial L2 strings would heavily involve WM, particularly central executive processing. For example, central executive processing, which involves switching between the two modalities (the phonological loop and the VSSP) would invariably consume a lot of cognitive resources. Consequently, these heavy cognitive processing demands may have masked any benefit effects resulting from L1 language transfer or bilingual-related processing skills. Therefore, it was
argued that WM processing may have prevented the detection of any L1 or L2 processing benefit effects.

However, Ellis and Sinclair (1996) failed to find a connection between the phonological loop and the making of L2 syntactic judgements. On the surface, it would appear that this finding undermines the argument that the results of Experiment 2a were attributed to the heavy task demands of central executive processing in WM. However, there were some fundamental differences between Ellis and Sinclair’s study and Experiment 2a that make a direct comparison difficult. First, the L2 learners in Ellis and Sinclair’s study were required to acquire L2 Welsh, which was orthographically the same as their L1 (alphabetic English). In contrast, the L2 learners in the present study were required to learn unfamiliar orthographic structures. It was true that the artificial script was logographic and was therefore congruent with the Chinese writing system. However, the artificial script was as structurally new to the Chinese-English bilinguals as it was to the two alphabetic groups. Therefore, this extra processing capability of having to recall new visual orthographic structures in Experiment 2a may have required more intense WM processing than Ellis and Sinclair’s syntactic judgement task.

Furthermore, in Experiment 2a, the syntactic processing of L2 logographic strings may have involved VSSP processing. Recall that Kimura (1984) found that VSSP processing may be more critical for logographic processing than phonographic processing. Hence, it is likely that the VSSP played an important role in the artificial logographic processing of Experiment 2a. Ellis and Sinclair did not investigate the role of the VSSP in their L2 syntactic decision task. Therefore, the L2 syntactic decision task of Experiment 2a and the one used in Ellis and Sinclair’s study may have involved the measurement of different types of WM processing, e.g., the VSSP versus the phonological loop (respectively). Thus, any interpretation of the findings of Ellis and Sinclair in relation to the present study is highly speculative. The extent to which the phonological loop and the VSSP were involved in the WM processing of the artificial script will be explored later in this chapter. The findings attained from this exploratory research may shed some light on the cognitive processes involved in Experiment 2a of the present study.
In summary, WM has important functions related to SLA and L2 reading. In particular, the phonological loop in the verbal subsystem plays an important role in the acquisition of L2 vocabulary and syntax. In terms of L2 vocabulary, the phonological loop plays a critical role in the early stages of SLA (e.g., with lower proficiency L2 learners). The phonological loop facilitates the grammatical fluency and accuracy of L2 learners but this facilitation does not extend to tasks involving grammatical judgements on L2 word strings. Therefore, the contribution of the phonological loop depends on L2 proficiency and the types of syntactic processing tasks engaged in. Additionally, verbal STM facilitates L2 syntactic processing of an artificial language system, whereas the role of the phonological loop is yet to be determined. Overall, WM, particularly the phonological rehearsal subsystem, ranks as an important language-learning device.

Considering that WM performance has been correlated with L2 reading, it is possible that a relationship may exist between the type of WM processing (e.g., phonological loop or the VSSP) and the type of orthographic script being processed. That is, just as the processing of different orthographic systems may result in different types of reading cognition (e.g., Hanley & Huang, 1997), so too might different orthographic systems impact on WM processing. There is some evidence to suggest that this may be the case. Recall that Kimura (1984) found that under concurrent articulatory suppression logographic Kanji could still be processed during a semantic categorization task. However, this was not the case for Japanese Kana (a syllabic script). The implication here is that logographic script can be processed in the VSSP while the processing of phonographic script may be less flexible. Hence, to investigate this possibility further the next section reviews WM research conducted on the Chinese language.

**Bilingual advantages in WM**

Because the WM experiments described in this chapter involve both bilinguals and monolinguals, a brief discussion of bilinguality and WM follows. Prior research has indicated that bilinguals have an advantage over monolinguals when acquiring a third language (Cenoz, 2000; Cenoz & Valencia, 1994; Jessner, 1999). However, most studies investigating bilingual WM performance have used within-subjects designs that examine bilingual processing of their two languages (Bialystok, Craik, Klein, &
Viswanathan, 2004). Comparatively little research has been conducted which compares adult bilingual and monolingual performance on WM processing (Bialystok et al., 2004; Cook, 1997).

However, some research has shown that a bilingual background may benefit WM performance (e.g., Ardila, Rosselli, Ostrosky-Solis, Marcos, Granda, & Soto, 2000; Bialystok et al., 2004). For example, Adrila et al. administered a series of subtests from the Wechsler Memory Scale (Wechsler, 1987) to a group of Spanish-English bilinguals and compared their results with normative data of Spanish monolinguals. In terms of digit span (forward) it was found that the Spanish-English bilinguals attained higher than average spans in their L1 (6.2) compared with Spanish monolinguals (5.8). This suggests that a bilingual background may benefit L1 recall. In another study, Bialystok et al. investigated the effect of aging on WM between a group of English monolinguals and Tamil-English bilinguals. An Alpha span task was used as a measurement of verbal WM. In this task, words were presented auditorily in random order and participants had to repeat back in alphabetical order. Another task, similar to the Alpha span task, tested digit recall. It was found that the bilinguals’ WM was less affected by age-related costs than that of the monolinguals. This study suggests that bilinguality per se has a positive effect on adult WM performance. Hence, the implication for the present study is that bilinguals may outperform monolinguals when processing L1 items in WM.

**Review of Chinese WM studies.** A number of studies have compared L1 logographic and alphabetic language learners and found that a logographic background appears to enhance visual processing performance. For example, the visual recognition and recall of items (e.g., Flaherty, 2000; Mann, 1985), as well as in tests involving spatial ability (e.g., Salkind, Kojima, & Zelniker, 1978; Stevenson, Stigler, Lee, Lucker, Kitamura, & Hsu, 1985; Stevenson & Lee, 1990; Tamaoka, Saklofske, & Ide, 1993; Tavasolli, 2002), L1 logographic language learners outperformed their alphabetic counterparts. However, few studies have investigated logographic vs. alphabetic L1 WM performance. Fewer still have investigated L2 WM (Service, Simola, Metsanheimo, & Maury, 2002). Of the L1 WM studies conducted thus far, most have not found any superiority in performance by logographic L1 participants over their alphabetic L1 counterparts, (e.g., Luer, Becker, Lass, Yunqiu, Guopeng, & Zhongming,
1998; Leung, 2006; Stigler et al., 1986), however these studies have focused more on
the phonological loop of WM than the VSSP.

For example, Luer et al. (1998) investigated the WM spans of Chinese and
German university students. In this study, the bilinguality status of participants was not
specified but it was likely that the two groups consisted mostly of bilinguals. In
Experiment 1, participants were required to recall a randomly presented set of items in
correct order. Each set consisted of geometrical shapes or their verbal labels in either
Chinese or German. Items were either recalled verbally in L1 or by pointing to the items
in their order of presentation on a touch screen. The Chinese speakers were found to
have a superior WM span ($M = 4.82$) compared to the German speakers ($M = 3.93$), a
finding that could not be attributed to IQ differences. In a second experiment, this time
using four different sets of familiar stimuli (numerals, words denoting numbers,
coloured squares, and words denoting colours) the Chinese speakers again demonstrated
larger WM spans. In addition, as the likelihood of verbal encoding of items to be
memorized increased, so did the performance of the Chinese. However, pronunciation
times were also recorded and found to be shorter for the Chinese speakers. Luer et al.
attributed the WM span superiority of the Chinese over the Germans as a result of the
shorter articulation times of Chinese words.

In a final experiment, the stimuli consisted of random shapes as well as the
familiar geometric shapes. Again, the Chinese WM span for the geometric shapes ($M =
4.44$) was superior to the Germans ($M = 3.7$). However, there was no difference in WM
spans for the random shapes (items that could not be verbalized). Therefore, Luer et al.
(1998) argued that the Chinese WM span superiority on verbalized items was a result of
the phonological loop. That is, shorter pronunciation times enabled more articulatory
rehearsal of items, which increased WM span. However, when items consisted of
random shapes, which could not be verbalized, the WM span superiority of the Chinese
over the Germans dissipated. This study highlights the importance of controlling for the
temporal word length of items when conducting cross-linguistic WM research. It should
be noted that the temporal word length of all cross-linguistic items used in the
experiments of the present study (e.g., Experiments 1, 2a & 2b) and the coming WM
experiments (e.g., 3a & 3b), were tightly controlled for temporal word length (again refer to Appendix C for details).

Similar findings were attained in an earlier study by Stigler, Lee, and Stevenson (1986). Chinese and American children were tested on their STM and WM for digit span. The digit span tasks measured forward, backward and grouped digit span. All items were presented visually. For the forward and backward digit span task, cards were placed on a table and were then covered up. Children had to repeat each item orally in either forward or backward order (and hence this backward digit task qualifies as WM, not STM, because the manipulation of items was involved). For the grouped task, items were presented in sets of three. Interestingly, the Chinese performed marginally better than the Americans on the forward and grouped tasks (STM) but were significantly worse than the American children on the backward digit span task (WM).

In addition, Stigler et al. (1986) measured number word duration in the respective L1 of Chinese and American university students. In the first task, participants had to repeat orally presented words. In the second task, participants were tested as in the previously described digit span tasks. The Chinese speakers had faster pronunciation times for digits, which explained their superior digit span. Interestingly, when the task involved WM (the backward digit task) the Chinese performed worse than the Americans but were superior at the two STM recall tasks (Stigler et al.). When the Chinese were processing the backward digit task, the manipulation of the items (the reverse configuration of a set of numbers) consumed processing resources to the extent that the Chinese articulatory rehearsal advantage was completely neutralized. Therefore, an important implication of this study is that WM research specifically investigating the phonological loop should avoid the incorporation of complicated concurrent manipulation tasks with the measurement of digit span, as in a backward digit span task. Otherwise, the WM task may be more a reflection of the cognitive processes involved in manipulation rather than maintenance.

Chincotta and Hoosain (1995) investigated the relationship between reading rate, digit span and articulatory suppression using balanced English-Spanish and nonbalanced Chinese-English bilinguals. In the balanced bilinguals, asked to name randomly presented numbers, English labels were given at a faster rate than Spanish labels.
However, articulatory suppression eliminated the word length advantage of English over Spanish. The results also showed that faster reading rates predicted larger digit spans. For the non-balanced Chinese-English bilinguals a faster reading rate for Chinese predicted a larger digit span, and articulatory suppression erased differences in digit span between languages. The pattern of results indicates that articulatory suppression eliminates word length differences in digit span among bilinguals, regardless of whether the bilinguals were balanced or not.

Cheung and Kemper (1993) investigated the word span and the articulation rate of groups of English monolinguals, Chinese (Cantonese L1) monolinguals and Chinese-English bilinguals who were required to recall the correct order of sequences of visually presented single words (in their respective L1s and L2s). The sequences were learned with and without articulatory suppression. For the Chinese-English bilinguals, a linear relationship was found between articulatory rate and word span, indicating that faster articulation rates were associated with greater recall for both Chinese and English words. However, as articulation rates increased incrementally, the word spans increased more for Chinese words than for English words. When articulatory suppression was enforced this differential effect disappeared, indicating that the articulation of Chinese words triggers an encoding process other than verbal rehearsal via the phonological loop.

This finding suggests that Chinese-English bilinguals were processing Chinese and English words in WM in a different way. Even though the rate of rehearsal in the phonological loop was tightly controlled, the Chinese-English bilinguals were able to recall more Chinese than English words. However, they were unable to do so when they were prevented from rehearsing in the phonological loop. Therefore, the rehearsal of Chinese words in the phonological loop may be closely associated with another processing capability that facilitates the recall of Chinese language items only. Cheung and Kemper conjectured that this other processing capability may constitute either (1) a visuo-spatial store or (2) a non-articulatory phonological store. Hence, an important conclusion that can be drawn from Cheung and Kemper’s (1993) study is that logographic Chinese words may require a different type of processing in WM than
alphabetic English words. Importantly, the nature of this WM processing differential cannot be accounted for by variant articulatory rehearsal rates in the phonological loop.

In a later study, Cheung and Kemper (1994) again investigated the effect of language on the recall span of monolingual English speakers and Chinese-English bilinguals (comprising mixed Mandarin and Cantonese speakers). There were two main tasks in this study - an articulation rate task and a recall span task. For the recall span task, there were lists of English words (consisting of one, two, or three syllables) and Chinese words (consisting of one, two, or three monosyllabic characters). Articulation rates for the L1 words were measured. The interference task consisted of a digit preload condition (rather than articulatory suppression) on the assumption that it would use up general memory resources and would therefore reduce the possibility of the Chinese-English bilinguals incorporating visual memory to supplement their rehearsal of items (as in Cheung & Kemper, 1993). The digit preload task consisted of the presentation of two, four, or six Arabic single-syllable digits which were shown for two, four, or six seconds respectively. This display immediately preceded the sequential presentation of the target words for serial recall. Participants had to memorize the digits and recall their correct order before attempting the recall of the presented target words. As in Cheung and Kemper (1993), the results indicated support for the use of the phonological loop and again language differences in the relationship between recall and word length were detected. For English words, as the digit preload increased, the relationship between recall and articulation rate was relatively unaffected. Because the digit preload condition was thought to divert WM resources away from the VSSP, this finding suggests that the phonological loop was primarily involved in the recall of English words. However, this was not the case for the Chinese words. Here, as the digit preload increased, the relationship between recall and articulation rate became more and more affected. For one syllable Chinese words, when there was a small digital preload, Chinese participants were able to recall more items than could be articulated in the phonological loop. However, as the digit preloads increased, the ability to recall more items than could be articulated in the phonological loop was reduced, completely diminishing at a preload of six digits. This finding suggests that other non-articulatory processes (e.g., the VSSP) may be involved in the recall of Chinese items (Cheung & Kemper, 1994).
In a more recent study, Cheung, Kemper, and Leung (2000) again investigated serial recall and the articulation rate of Chinese-English bilinguals. In Experiment 1, the stimulus items consisted of one-syllable, two-syllable, and three-syllable words in both Chinese and English. Items were presented individually on cards and participants were required to write down their order of presentation. A concurrent articulation condition was included as well. In the word articulation task, word pairs were presented visually. Participants then had to repeat aloud the word pairs as quickly as possible. The findings indicated that increasing word length negatively affected Chinese recall more than English recall. Even though the word length effect was significantly reduced for Chinese words, it did not disappear completely under the condition of articulatory suppression. For English words, the word length effect completely disappeared under articulatory suppression. Prior studies (e.g., Baddeley et al., 1975) have shown that the word length effect disappears under the condition of concurrent articulatory suppression. The implication here is that articulatory suppression takes away the capacity to rehearse items in the phonological loop, thereby forcing the utilization of other, non-articulatory WM processes (e.g., the VSSP). In order to control for any processing differences arising from the use of two different scripts (logography vs. alphabet), the experiment was repeated with the Chinese language items spelled in English (pinyin). Again, the interaction between word length and language was replicated. Because the effect held even for Chinese words written in an alphabetic language, Cheung et al. conjectured that the VSSP was not playing a significant role in recall. The finding that the word length effect did not completely disappear when the Chinese-English bilinguals were recalling Chinese words under articulatory suppression indicates that some phonological process was still being utilized in recall. Cheung et al. described this as a non-articulatory phonological store.

Because the Chinese-English bilinguals were less fluent in English than in Chinese (Cantonese) it was possible that this inequity may have impacted on the recall of English words. Therefore, parts of the experiment were repeated with an American monolingual group. This suspicion was found to be unwarranted as the pattern for English words was repeated, even with native speakers.
The findings of these studies (e.g., Cheung & Kemper, 1993, 1994; Cheung et al., 2000) have important implications for the present study. First, these studies reveal that differences between L1 Chinese and L1 English word span cannot entirely be accounted for by the articulation rate of items in the phonological loop. Therefore, a language specific non-articulatory phonological store may be utilized in the recall of logographic language items. The activation of this store appears to be tied somehow to the phonological loop, even though it is not articulatory in nature. Thus, there are some fundamental differences between L1 WM processing of logographic and alphabetic language items. Just as L1 orthographic processing differences were detected in a number of reading studies (e.g., Koda, 1989, 1990), the research of Cheung and colleagues demonstrates that L1 WM processing differences may also arise specific to L1 orthography. However, the extent to which these orthography-related processing differences can be transferred to L2 WM is not known. To date, this line of research has not been empirically investigated. In order to fill this research paucity, the impact of L1 orthography on L2 logographic WM processing will be explored later in this chapter.

The studies reviewed thus far have focused on the phonological loop. The following review of WM studies focus on the role of the VSSP in Chinese language processing. For example, Demetriou, Kui, Spandoudis, Christou, Kyriakides, and Platsidou (2005) found that L1 logographic background Chinese outperformed L1 alphabetic background Greek school children on a number of WM tasks that did not involve rehearsal in the phonological loop (e.g., visuo-spatial processing). School children were compared on a number of tasks involving WM, reasoning and processing efficiency. The WM tasks consisted of the serial recall of concrete words and digits written on cards in either Chinese or Greek. In the visuo-spatial WM task, participants were shown a card depicting a number of geometrical figures (e.g., rectangle and a triangle). Participants were shown the target card and were then required to recall its contents by choosing the appropriate cut-outs from amongst different shapes. A central executive WM task was also included and it involved the recall of mixed verbal and visual information. Here, there were two tasks. The first one was a verbal/numerical task, which consisted of sets of short sentences (SVO), e.g., “The man ate three apples.” After the presentation of these sentences, participants were required to answer “who”
and “how many” (e.g., “man”, “three” respectively). The other task comprised a visual/verbal task reminiscent of the Stroop task. Here, colour words were written on cards with congruent or incongruent coloured backgrounds. Participants were required to recall either the ink colour or the colour words in their presentation order. Other tasks included two spatial reasoning tasks, which consisted of a mental rotation task and a version of Piaget and Inhelder’s (1967) water level task. The Chinese children reliably outperformed the Greek children on all aspects of visuo-spatial WM processing. They were marginally superior at phonological WM processing, but demonstrated similar performance to the Greek children during the central executive WM tasks. However, it should be noted that the articulation rate of verbal items was not investigated in this study, which brings into question the reliability of the phonological WM results. Nonetheless, Demetriou et al.’s study did reveal a difference between L1 logographic and alphabetic language users when performing a visuo-spatial WM recall task.

Some studies have found that the VSSP plays a role in the retention and recall of Chinese characters (e.g., Hue & Erickson, 1988; Mou & Anderson, 1981; Zhang & Simon, 1985). For example, Hue and Erickson found evidence to support the notion of a separate visual STM storage system for Chinese characters by Chinese-English bilinguals. A free immediate recall paradigm was used with visually presented cards containing random lists of high and low frequency Chinese characters. The lists were controlled for character frequency, complexity and pronounceability. Participants were required to quickly write down in any order as many Chinese characters as they could remember. Also, there were two interference tasks, namely a verbal-acoustic intervening task and a visual intervening task. In the verbal-acoustic intervening task, immediately after the presentation of Chinese characters, participants were presented with a single target Chinese character followed by a further list of different characters from which they had to select one which was homophonic to the target character. After this, they had to list as many radicals as they could remember from the initial display presentation. The visual intervening task followed the same procedure as the verbal-acoustic intervening task but now a random pattern of dots was used to generate interference. Short-term memory for high frequency characters was affected more by the verbal interference task, whereas STM for low frequency characters was affected more by the
visual interference task. Hence, Hue and Erickson argued that high frequency Chinese characters were stored verbally in contrast with low frequency Chinese characters, which were stored visually in STM. This finding has an important implication for the present study. Later in this chapter the WM processing of a newly acquired artificial script will be explored. Because the logographic items of this artificial script will be acquired after a relatively brief acquisition period they will constitute extremely low frequency items. Hence, in accordance with Hue and Erickson’s findings, the use of a newly acquired artificial script may impact on the degree to which visual processing is involved.

In a similar study, Mou and Anderson (1981) investigated graphemic and phonemic similarity in WM capacity of Chinese-English bilinguals (from Taiwan). Chinese characters which shared the same vowel sounds and radicals (visual structures) were selected as target characters and distracter items. The assumption here was that the recall of characters with the same vowel sounds would interfere with oral processing, and similarly, the characters sharing the same radicals would interfere with visual processing. For the oral interference task, participants were required to repeat a list of orally presented distracter items immediately after the presentation of a set of target characters. For the visual interference task, immediately after the display of the target items participants were required to copy distracter characters from a visually presented interference list and simultaneously count the number of strokes of each item. Target characters had to be recalled in their order of presentation. The oral interference task had a greater negative effect on serial recall of items than the visual interference task, indicating the importance of phonological processing to the recall of Chinese characters. However, it was also found that the visual interference task significantly disrupted participants’ recall, suggesting that some visual encoding of characters was also taking place. It would appear that both graphemic and phonemic information can be called upon to store information in STM.

Zhang and Simon (1985) investigated the STM capacity of Chinese-English bilinguals to recall homophonic and unprounceable Chinese characters. In a series of six related experiments, it was shown that acoustical (phonological) encoding was primary in storing Chinese characters in STM. Furthermore, it was also demonstrated that there
was a capacity for limited visual (or semantic) STM at approximately two to three items. For example, in Experiment 2, Chinese-English bilinguals were presented with sequences of homophonic or unpronounceable Chinese characters on cards in order to measure STM processes that were not reliant on phonological coding. Each item on the card had to be named and then the whole sequence written down as accurately as possible. An average of 2.7 items could be stored in STM without phonological facilitatory effects (visual STM span) and approximately seven items could be retained with the facilitatory effects of phonology (verbal STM span).

These findings are important, because they reveal that Chinese language items can be stored in the VSSP. However, for English words there is little evidence that the VSSP plays a role in the storage of English language items (e.g., Baddeley, 1966; Cheung & Kemper, 1994; Cimbalo & Laughery, 1967). For example, in an early study, Baddeley (1966) investigated the effects of acoustic, visual and semantic similarity on the STM recall of English words. Words were selected to be acoustically similar but visually dissimilar (e.g., *bought*, *taut*), visually similar but acoustically dissimilar (e.g., *rough*, *cough*, *dough*) and unrelated (e.g., *plea*, *friend*). Sequences of items were presented orally and participants responded in writing. Strong effects were found for acoustic similarity but not for the semantic or visually similar group. In fact, there was no difference between the recall of the unrelated words and the visually similar items, indicating that visual encoding had not been taking place. In summary, even though the phonological loop is critical to the recall of Chinese language items, there is evidence that the VSSP may play a role as well. This finding contrasts with studies on English words, where no relationship was found.

In a detailed review of Chinese language STM studies, Yu, Zhang, Jing, Peng, Zhang, and Simon (1985) argued that the particular paradigms deployed to measure STM recall span can greatly affect the storage capacity of participants. For example, in Yu, Jing, and Sima (1984, as cited in Yu et al., 1985), a technique known as the serial-cumulative method was used to measure STM recall span of Chinese characters. The technique involves presenting each stimulus item on a screen, one after another, with all the stimulus items remaining on screen until the last item has been presented. Yu et al. compared three similar studies on STM of Chinese characters utilizing the immediate
recall paradigm but with different procedural methods (sequential, serial-cumulative and simultaneous). The results indicated that memory span was greater for sequential presentations than serial-cumulative presentations, with simultaneous presentations resulting in a markedly reduced memory span. Hence, the sequential immediate recall paradigm was adopted for use in the present study in order to maximize participants’ WM spans and avoid the possibility of a floor effect.

There is little research that investigates WM span in an L2. However, of those studies, one area of focus has been on the degree to which L2 proficiency can affect WM processing (e.g., Service, Simola, Metsanheimo, & Maury, 2002; Van den Noort, Bosch, & Hugdahl, 2006). For example, Van den Noort et al. investigated the impact of foreign language proficiency on WM capacity of balanced Dutch-German bilinguals at the early stages of acquiring L3 Norwegian. Reading span, digit span and a letter-number ordering task involving the recall of mixed numbers and letters (e.g., S–9-A-3) were tested. Reading span was measured by the speed of recall of target words embedded at the end of visually presented sentences. For both the digit span and the letter-number ordering task, there were two conditions of recall. In the forward condition, items were recalled in their order of presentation while in the backward condition they were recalled in their reverse order. In terms of reading span, the Dutch multilinguals were able to recall more L1 than L2 items and more L2 items than L3 items. This effect was repeated for digit span (backward) and for letter-number ordering. These tasks were also undertaken by a group of German and Norwegian native speakers. It was found that there were no differences between the L1 Dutch, L1 German and L1 Norwegians in their recall of items in their respective L1s on these tasks. This finding indicates that the articulation rates of the Dutch, German and Norwegian language items were comparable and hence cannot account for the Dutch multilinguals’ L2 and L3 WM performance. Van den Noort et al. concluded that language proficiency can impact on foreign language recall. That is, the higher the proficiency in an L2 or an L3, the more items can be recalled. Therefore, an important implication to the present study is that the L2 language proficiency of bilingual participants should be strictly controlled for, otherwise the findings may be more a reflection of L2 proficiency than WM capability.
Most L2 WM studies, as in Van den Noort et al. (2006), have investigated L2 alphabetic languages and very few (if any) have investigated L2 WM from the perspective of a logographic language. However, some studies have investigated logographic Chinese and Japanese background participants’ performance on L2 alphabetic WM tasks (e.g., Harrington & Sawyer, 1992; Juffs, 2004; Leung, 2006). For example, in a recent study, Leung (2006) compared Chinese-English bilinguals (Mandarin native speakers) with Spanish-English bilinguals and English monolinguals on an L2 word span task. Familiar English words (e.g., bag, cat, door) were presented individually on a computer screen and had to be recalled in order of presentation. No difference in word span was found between the Chinese-English bilinguals ($M = 3.47$) and the Spanish-English bilinguals ($M = 3.32$). However, the English native speaker control group ($M = 4.4$) outperformed both the Chinese-English and the Spanish-English bilinguals. These findings suggest that the Chinese and Spanish native speakers were able to rehearse L2 English items in the phonological loop at a comparable rate, whereas the English native speakers were probably rehearsing these English items at a faster rate thus allowing them to increase their span size.

One problem with interpreting the results of this study is that Leung did not measure the temporal word length of the English items used to measure span size. During the word span task the English items were randomly selected from a list of 144 items. Therefore, it was likely that different items were used for different participants. The use of different items would also result in different combinations of words with longer and shorter temporal word lengths invariably affecting rehearsal rates in the phonological loop. Even though an attempt was made to control for the temporal length of the English items by including only monosyllabic words, it was still possible that there were significant differences in the English items’ temporal word length. Recall that Baddeley et al. (1975) found that syllable length was not a reliable predictor of temporal word length of English language items. Hence, the reliability of Leung’s WM findings are questionable. Again, this study highlights the importance of exercising tight controls over the temporal word length of any language items used in WM research.

It should be noted that the findings indicating the importance of phonological processing in the recall of Chinese characters (e.g., Hue & Erickson, 1988; Mou &
Anderson, 1981; Zhang & Simon, 1985) do not conflict with the main argument posited in this study. Phonological processing is critical to the recall of language items in STM and WM, regardless of orthographic type. The main argument in the present study is that the inculcation of a logographic L1 may enhance visual processing skills which can be transferred to L2 orthographic processing. Here, enhancement should not be taken to mean replacement. Phonological processing plays an important part in Chinese WM and in reading (particularly after words have been identified). When it is argued that the inculcation of a logographic orthography orients language learners toward visual processing it is meant relative to the degree to which the inculcation of a phonographic language may do so. Thus, the important role that phonology plays in processing Chinese characters in WM does not detract from the argument that visual processing may be more important to Chinese character processing than English word processing.

**Summary**

Few studies have investigated WM involving logographic languages. Of those studies, the focus has mostly been on the phonological loop. Overall, the phonological loop has been found to play a critical role in the recall of language items irrespective of the type of orthography being processed in WM. In most cases, span differentials between Chinese L1 and English L1 items of respective native speakers have been explained by differences in articulation rates arising from the shorter word length of Chinese language items relative to English language items. However, in a series of studies, Cheung and colleagues (e.g., Cheung & Kemper, 1993, 1994; Cheung et al., 2000) found that articulation rates cannot completely account for these differences and that Chinese language items may be processed differently to English language items. Furthermore, the VSSP has been associated with the recall of Chinese language items (e.g., Kimura, 1984) but not with the recall of English language items (e.g., Baddeley, 1966; Cheung & Kemper, 1994; Cimbalo & Laughery, 1967). Hence, there is some evidence that language-related processing differences have been found in both the phonological loop and the VSSP of WM and that these processing differences are most likely related to orthographic difference (e.g., logographic Chinese vs. alphabetic English). In addition to orthographic differences, a number of other factors, such as L2 proficiency (e.g., Service et al., 2002; Van den Noort et al., 2006), bilingualism (e.g.,
Ardila et al., 2000; Bialystok et al., 2004), the type of recall paradigm (e.g., Yu et al., 1985), and word frequency (e.g., Hue & Erickson, 1988) can all impact on WM capability. In the next section, a rationale will outline the reasons for the inclusion of a WM investigation in the present study.

Rationale for WM Experiments

Even though WM plays an important role in language acquisition and is closely related to L2 reading ability, language transfer research has not investigated the possibility that L1 WM processing skills may be transferable to an L2. Specifically, there have been few WM studies that have examined L1 orthographic background effects, especially in an L2 context. However, from the previous review, L1 orthographic background effects (i.e., differences related to the processing of logographic and alphabetic language items in WM) were found. These findings satisfy a fundamental assumption necessary for language transfer to occur. For example, if all languages were processed in the same way, then language transfer would not be a tangible and observable phenomenon. Therefore, the findings of language-related differences in WM processing are encouraging for any investigation seeking to explore the possibility of language transfer in L2 processing. In addition, prior L2 WM studies have been conducted mostly from an alphabetic perspective, not a logographic one. Furthermore, the focus of these studies has been on verbal WM processes (e.g., Juffs, 2004; Leung, 2006; Service et al., 2002, Van den Noort et al., 2006). These studies have neglected the VSSP. The present study will focus on L2 WM processes involving a logography and will include an investigation involving the VSSP. Hence, this highly exploratory study represents a unique attempt to fill the gaps in the literature.

The present study will also fill gaps in the literature in the area of bilingualism and L2 WM processing. Even though bilinguality per se has been found to provide positive WM-related performance benefits, very little research has been conducted in this area (Bialystok et al., 2004). Therefore, in the present study, there will be three groups of language learners, Chinese-English bilinguals, English-French bilinguals and English monolinguals. By including English monolinguals and bilinguals, the impact of bilinguality on L2 WM processing can be investigated. Furthermore, because L2 proficiency can impact on WM span size, all bilingual participants recruited must be at a
comparable level of L2 proficiency. If this is not controlled for, then it is possible that any WM span differences attained may be more of a reflection of L2 proficiency than WM span.

At least one reliable study (Demetriou et al., 2005) has demonstrated a WM visuo-spatial superiority of L1 logographic Chinese over L1 alphabetic (Greek) language users. This suggests that within the WM research paradigm, language background effects can influence processing styles, and importantly, can be detected. Moreover, Cheung and colleagues (e.g., Cheung & Kemper, 1993, 1994; Cheung et al., 2000) found that, during the recall of Chinese characters in a WM serial recall task, either a visual-spatial processing or a non-articulatory phonological store was playing an important role in recall. Furthermore, it was found that Chinese-English participants were not completely dependent on verbal rehearsal. This is in stark contrast with their findings on the recall of English words, which were completely dependent on verbal rehearsal via the phonological loop. Therefore, the results of these WM studies suggest an orientation toward visual processing by L1 logographic Chinese which is consistent with the findings of Experiment 1 (the lexical decision task) and consistent also with other research discussed in Chapter 1.

As previously stated in the introduction of this section, the major attraction of the WM research paradigm (in the context of the present study) lies in the dual interference tasks. The use of interference tasks, such as articulatory suppression and repeated finger tapping, can restrict access to verbal and visual subsystems during WM rehearsal for recall. This was highly desirable for the present study. The crux of this investigation involved the premise that L1 logographic language learners could transfer their visual skills to processing an L2 logographic script, which would provide evidence for the language transfer hypothesis. This was demonstrated to a modest degree in Experiment 1 (the lexical decision). However, the argument could be further strengthened if it could be demonstrated that during the processing of artificial logographs in a WM task involving concurrent articulatory suppression (and hence the restricting of access to the phonological loop), L1 logographic language learners were less impeded than their L1 alphabetic counterparts. This would suggest a language background effect indicating an orientation toward visual processing by L1 logographic language learners. Conversely,
if the L1 logographic language learners were more impeded by concurrent visuo-spatial interference than the L1 alphabetic language learners then the argument could be further strengthened (in the opposite direction). Therefore, the WM research paradigm could offer a method to investigate performances on cognitive tasks that could be analysed from the dichotomous perspective of verbal versus visual processing.

The incorporation of a WM research paradigm to the artificial script was a logical extension to Experiment 2a (the syntactic decision task). For example, a WM theoretical framework could offer an explanation for the results of the syntactic decision task using the artificial logographs. In this task the Chinese-English bilinguals performed at about the same level as the English monolinguals and bilinguals. Now, in order to complete the syntactic decision task, WM processes would have been automatically involved. That is, participants would have maintained the meanings of the logographs in WM while they were processing their syntactic order. In terms of WM theory, this would largely involve the central executive processor, because this task would rely heavily on switching between the VSSP to recognize the orthographic structures of each logograph and the subsequent verbal rehearsal of their associated meanings via the phonological loop. Because the syntactic decision task largely involved central executive WM processing, the results of the syntactic decision task using the artificial logographs was consistent with prior WM studies. For example, Demetriou et al. (2005) demonstrated that L1 logographic Chinese were better than L1 alphabetic Greeks at visuo-spatial WM tasks but not at central executive WM tasks. The task demands, which rely on central executive processing, may cancel out any visual or phonological advantage L1 logographic Chinese have over their alphabetic counterparts. Therefore, from a WM theoretical perspective, the results of the syntactic decision task, with its dependence on central executive processing, may have been more a reflection of central executive functioning than a lack of an L1 logographic background effect. The further investigation of this notion through a WM study may reveal more insight into this possibility and offer a plausible explanation for the lack of a logographic transfer effect in the syntactic decision task of Experiment 2a.

Finally, there are a series of direct implications for the study presented here. First, the WM paradigm adopted will be a serial order paradigm, because such
paradigms have been found to produce the longest WM spans (Yu et al., 1985). It is important to adopt a WM task that maximizes output, because processing an artificial logographic script can be cognitively challenging for participants (see Experiment 2a). Second, articulation rate plays a critical role in WM processing. Hence, the articulatory rate of the words to be used have been strictly controlled for (see Appendix D). Third, word frequency has been found to impact on how Chinese characters are processed in WM. That is, characters with a low word frequency were stored visually whereas high word frequency characters were stored phonologically (e.g., Hue & Erickson, 1988). However, the use of an artificial script automatically involves the use of low frequency language items. The implication here is that, in terms of logographic processing, an artificial script may elicit a strong orientation toward visual processing in WM. However, an attempt was made to address this imbalance by controlling for the word frequency of the L1 English and Chinese meaning associations of the artificial logographs by including high frequency items only (see Appendix I). Even though the visual structures of the artificial script is newly acquired and, as such, constitutes a low frequency linguistic phenomenon, their meaning associations consist of high frequency Chinese and English word associations. Therefore, a balance of sorts will be achieved to reduce the effect of using a (completely) low frequency artificial script.

Experiment 3a

Recall that, in Experiment 1, the L1 logographic participants outperformed their L1 alphabetic counterparts during the processing of L2 artificial logographic script. This advantage was believed to occur as a result of enhanced visual processing skills, which logographic L1 participants acquired through the inculcation of their logographic orthography. This provided some evidence for the language transfer hypothesis, the argument that language learners utilize orthographic processing skills specific to their L1 when processing in an L2. In order to further investigate the idea of the language transfer hypothesis, a series of WM tasks was created involving the artificial script. Concurrent interference (articulatory suppression and finger tapping) was used in order to restrict access selectively to visual/spatial and verbal processing subsystems. If logographic L1 participants have an enhanced visual processing capability over
alphabetic L1 participants, then they should demonstrate superior performance, especially when processing solely in the visual subsystem.

It was predicted that the L1 logographic participants would outperform the L1 alphabetic participants on the WM task involving concurrent articulatory suppression, which impedes phonological activations. By contrast, the L1 logographic background participants should demonstrate inferior performance to the L1 alphabetic background participants when undertaking the concurrent spatial interference task. This prediction was based on the strong connection of Chinese orthographic processing to visual/motoric skills (Endo, 1988; Sasaki, 1987). The task without any interference is (arguably) a central executive task, in that it is likely that both visual and verbal subsystems would be activated in the retrieval of the artificial logographs. It was predicted that both groups would perform equally well (or equally poorly) on this task. This prediction was based on the study by Demetriou et al. (2005), which found no performance benefits of L1 logographic Chinese over L1 alphabetic Greeks during WM central executive tasks.

Method

Participants

The participants were 17 Mandarin-English bilingual speakers (8 males, 9 females) from mainland China (mean age = 25, SD = 4), 13 English-French bilingual speakers (4 males, 9 females) (mean age = 27, SD = 6), and 22 monolingual English speakers (4 males, 18 females) (mean age = 22, SD = 6). All bilinguals were students at Queensland University of Technology and were paid a fee for their participation. All monolinguals were undergraduates recruited from the School of Psychology and Counseling at Queensland University of Technology and were given course credit in exchange for their participation. All participants had normal or corrected vision. None had participated in the previous experiments.

A language background questionnaire revealed that the Chinese-English bilinguals had been in Australia for at least 12 months at the time of testing and were occupied in full-time study or research in which English was the working language. On a self-rating scale of 1 – 7 for L2 proficiency averaged across four categories (speaking, reading, comprehension and writing), the English-French bilinguals (M = 5.1,
SD = 1) and the Chinese-English bilinguals (M = 5.6, SD = 0.7) were not significantly different, t(28) = -1.57, ns. On the basis of these self-ratings, both bilingual groups were at a similar level of L2 proficiency (for more L2 background details see Appendix H).

Finally, prior research established a link between bilingualism and intelligence (e.g., Peal & Lambert, 1962). To control for any differences in WM performance that might be related to differences in IQ, the Raven’s Advanced Progressive Matrices Test (1962) was administered. It is considered a culture fair test and has been used in prior WM studies which compared Chinese and English native speakers (e.g., Luer et al., 1998). A one-way ANOVA supported the observation that all three groups performed equally on the Raven Test, F(2, 51) = 1.99, MSE = 24.67, ns.

Materials

Ten Target logographs (Targets) and ten meaning associations (concrete nouns) were selected from Set A and Set B of Experiment 1 and matched to create a new artificial logographic script. Half of the Targets were taken from the Simple condition (consisting of three elements per structure) and the other half were taken from the Complex condition (consisting of six elements per structure) (see Figure 3.1). As with Experiments 1 and 2a, the meaning associations were balanced across English and Chinese in regard to temporal word length and word frequency. For temporal word length, there were no differences between the Chinese nouns (M = 578, SD = 46), and the English nouns, (M = 574, SD = 81), t(18) = -.162, ns. Similarly, for word frequency, the Chinese nouns (M = .011, SD = .009) and English nouns (M = .009, SD = .009) did not differ, t(18) = -.361, ns. (See Appendix I and J for the respective word frequency and temporal word length tables.)

For the measurement of artificial logograph memory span, random combinations of single artificial logographs were presented on a computer screen, in blocks consisting of either Simple or Complex logographs (displayed alternately). Each block consisted of four trials at a specific sequence length. Sequence lengths began with two items and continued to nine items per trial. The sequence length of items increased by one after each consecutive block of Simple and Complex logographs (at the same sequence length) were displayed. For sequences of 2 - 5 items, no item occurred more than once
per trial. For sequences of between 6 - 9 items, individual items could occur up to twice per trial but never consecutively.

In order to record participants’ responses, a specially modified keyboard was constructed and connected to the laptop. The pictures of the ten artificial logographs were pasted onto the number keys at the top of the keyboard. Keys 1 – 5 displayed the Simple condition artificial logographs and keys 6 – 0 contained Complex condition artificial logographs. The remaining keys were blacked out to facilitate the ease of recognition of the response keys.

Following from Rumiati and Tessari (2001), a wooden touch pad was created in order to provide a uniform tapping space for the spatial interference task. Four wooden plates (70 mm x 70mm) were attached in a square formation to a square wooden block (25 cm x 25 cm). Each wooden plate was equidistant by 25 mm.

Procedure

Learning Phase. As in Experiment 1. Recall that participants were required to learn the artificial logographs, including their structures and meaning associations, to criteria. Unlike Experiment 1, participants were timed (with a stop watch) on how long it took them to fulfill the learning criteria requirements.10

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10 A one-way ANOVA indicated no difference in the amount of time taken to acquire the artificial logographic script by the Chinese-English bilinguals, English-French bilinguals and English monolinguals, $F < 1$. 
Figure 3.1. The new artificial logographic script consisting of 10 artificial logographs and 10 meaning associations in English and Chinese (tonal pronunciation provided below each character).

**Testing Phase.** The testing phase directly followed the learning phase, and consisted of a standard serial recall WM task (for convenience, this task was called the WM Normal task) and two serial recall WM tasks which included suppression and were administered in a counterbalanced order. Participants were seated in front of a laptop computer. Instructions appeared on the screen in the participant’s native language. Prior to commencing the experiment proper, a short block of 8 practice trials was presented. During the practice trials only, written feedback appeared in the centre of the screen, indicating either a correct or incorrect response in the participants’ native language. The practice trials were repeated only if participants performed below 75% accuracy.

To initiate the start of the experimental trials, participants hit the space-bar. After a period of 4 seconds, a fixation point appeared in the centre of the screen for 500 ms. This was immediately followed by the random presentation of artificial logographs, one at a time, for a period of 1 second per item. Four seconds after the display of the final artificial logograph, a large question mark appeared in the centre of the screen prompting participants to respond by typing in the displayed artificial logographs in
their correct order of presentation as quickly and accurately as possible. Participants were required to respond using the index finger of their dominant hand only. Each subsequent sequence of trials was initiated by pressing the spacebar, allowing the participants to take a short break in between trials. The experiment terminated when the accuracy response rate of two consecutive blocks of Simple and Complex logograph items fell below 75%. For example, if two mistakes were made when processing a block of Simple logographs (accuracy 50%) at a sequence length of two items per trial, followed by only one mistake when processing the following block of Complex logographs (accuracy 75%) at the same sequence length, then the experiment continued to the next longer sequence length (three logographs per sequence). However, if the accuracy of any two consecutive blocks of Simple and Complex logographs fell below 75% then the experiment terminated. In the WM Normal task, no concurrent suppression was carried out while viewing the items. Stimulus presentation and data collection in this, and all subsequent WM experiments, was controlled using E-Prime (Schneider et al., 2001).

In the Auditory Suppression task, participants were required to repeat the phrase “Coca-Cola”\textsuperscript{11} at a rate of two phrases per second at a level audible to the researcher. Participants began repeating the phrase 4 seconds prior to the presentation of the first stimulus item and continuing to 4 seconds after the presentation of the last item. A computer-generated tone signaled the beginning and end of the suppression utterances. Before the experiment proper began, participants were timed repeating the suppression phrase to ensure that the speed of articulation was approximately two phrases per second. Participants’ utterances were monitored and corrected as needed by the researcher for the duration of the entire experiment.

In the Visuo-Spatial Suppression WM task, participants were required to tap a zigzag pattern on the wooden touch pad plates with the index finger of their right hand. Tapping was conducted at an approximate rate of three taps per second. As with the

\textsuperscript{11} The choice of articulation phrase is widely considered to be unimportant (Baddeley, 1990). Furthermore, studies have shown that the language of the suppression phrase does not affect WM recall (e.g., Chincotta & Hoosain, 1995). However, Coca Cola was chosen because it is a well-known phrase and has been used in prior WM studies (see Baddeley, 1986).
Auditory Suppression WM task, the task began 4 seconds prior to the display of the first stimulus item and concluded 4 seconds after the display of the last stimulus item. Participants were timed on their tapping prior to the experiment proper to ensure an approximate rate of three taps per second. At test, participants’ tapping was monitored and corrected as needed. All concurrent interference tasks were counterbalanced to avoid order effects.

*Raven test.* The Raven Intelligence Test was administered using Set II, which consisted of 36 items. Set I, consisting of 12 items, was used as a demonstration and practice set. The Raven test was administered when participants were suitably rested after all WM tasks. The instructions were standardized and participants undertook the test with a 30-minute time limit.

**Design and Analysis**

For this and all subsequent analyses, memory span for items was determined by the longest item sequence attained with a minimum accuracy of 75%. In order to control for the effect of any possible IQ differences, a mixed Analysis of Covariance (ANCOVA) with Group (Chinese-English bilinguals vs. English-French bilinguals vs. English monolinguals) as the between-subjects factor, Task (WM Normal vs. WM Auditory Suppression vs. WM Visuo-Spatial Suppression) and Structure (Simple vs. Complex) as the within-subjects variables, and the Raven score as the covariate. However, the assumptions of the ANCOVA were not met, and therefore mixed ANOVAs were done. Greenhouse-Geisser corrections were applied as needed.

**Results Experiment 3a**

Mean memory spans with and without concurrent auditory and visuo-spatial suppression for the three groups are shown in Figures 3.2 (Simple logographs) and 3.3 (Complex logographs). A 3 x 3 x 2 mixed ANOVA, with Group as the between-subjects variable and Task and Structure as the within-subjects variables, revealed no significant three-way interaction, $F < 1$. However, there was a significant Group x Task interaction, $F(3.516, 97.861) = 2.86, MSE = 6.84, p < .04$. Groups did not differ on the WM Normal span. However, on the Auditory Suppression task, the Chinese-English bilinguals experienced significantly less interference than the English monolinguals. On the WM Visual-Spatial suppression task, both the Chinese-English bilinguals and the English-
French bilinguals experienced less interference than the English monolinguals. All other planned comparisons failed to reach significance. Concurrent auditory suppression significantly reduced memory spans in monolinguals, as did concurrent visuo-spatial suppression. Concurrent auditory suppression only significantly reduced memory spans for the bilinguals. A significant Task x Structure interaction was attained, $F(2, 95.978) = 3.29, MSE = 0.75, p < .05$. For the Simple structures, only auditory suppression significantly interfered with recall. Recall was more difficult under auditory than visuo-spatial suppression. However, for the Complex structures, both auditory suppression and visuo-spatial suppression significantly interfered with recall. Also, recall was equally difficult under auditory and visuo-spatial suppression. This overall pattern indicates that visual processing was more important for processing structurally complex artificial logographs than for structurally simpler ones. There was a significant Task main effect, $F(1.758, 97.861) = 18.13, MSE = 43.29, p < .001$, as well as a significant Group main effect, $F(2, 49) = 8.78, MSE = 46.40, p < .002$. There was no Structure main effect, $F < 1$, indicating that the visual complexity of the target logographs did not impact on participants’ serial recall of items overall.
Figure 3.2. Mean memory span for structurally simple artificial logographs (+ SE) in Chinese-English bilinguals (n = 17), English-French bilinguals (n = 13), and English monolinguals (n = 22) with (Auditory and Visuo-Spatial Suppression) and without concurrent interference (Normal).

Figure 3.3. Mean memory span for structurally complex artificial logographs (+ SE) in Chinese-English bilinguals (n = 17), English-French bilinguals (n = 13), and English monolinguals (n = 22) with (Auditory and Visuo-Spatial Suppression) and without concurrent interference (Normal).
Discussion Experiment 3a

As predicted, performance by the three groups was fairly even on the WM normal task (without any concurrent interference). This task was categorized as a central executive task, because it was likely that both visual and verbal processing subsystems were activated in the recall of the artificial logographic items. This finding was consistent with prior research such as Demetriou et al. (2005), which has found no performance differences between logographic and alphabetic language users on central executive tasks.

It was also predicted that the Chinese-English bilinguals would demonstrate superior performance over their alphabetic counterparts when processing the artificial logographs under the condition of concurrent auditory suppression. Recall that under this condition processing would rely on the VSSP and access to the phonological loop would be restricted. While the Chinese-English bilinguals (mean span = 2.8) outperformed the English monolinguals (mean span = 1.6), they did not outperform the English-French bilinguals (mean span = 2.2). Therefore it cannot be claimed that a L1 logographic background provides a superior VSSP processing capability during the recall of artificial logographic items. Furthermore, because the English-French bilinguals did not outperform the monolinguals, no evidence was attained to indicate that bilingualism per se facilitates the ease of visually processing artificial logographs in WM. Additionally, the finding that the Chinese participants were able to retain approximately 2.8 logographic items in their WM is consistent with Zhang and Simon’s (1985) study, which found that without the facilitatory effects of phonological processing, Chinese participants could retain approximately 2.7 items (unpronounceable Chinese characters) in STM.

In terms of the WM Visuo-Spatial Suppression task, the Chinese-English bilinguals’ performance was relatively unaffected by concurrent spatial tapping. It was predicted that the L1 logographic language learners, when deprived of their visuo-spatial processing capability, would demonstrate a significant performance decrement. However, this was not the case. Clearly, the Chinese participants were able to compensate for the lack of a visuo-spatial capability through the substitution of an alternative processing subsystem. A likely candidate is the phonological loop (see also
Cheung & Kemper, 1994; Luer et al., 1998). That is, the Chinese-English bilinguals were able to verbalize the presented items and rehearse them in the phonological loop while performing concurrent spatial tapping. This demonstrates considerable processing flexibility. The English-French bilingual group was also not impeded under the condition of concurrent spatial tapping. However, this was not the case for the English monolinguals (see Figures 3.2 and 3.3). The English monolinguals’ WM span for artificial logographs was halved under the condition of concurrent spatial tapping, while the English-French bilinguals’ span was relatively unaffected. As predicted, the present finding indicates that a bilingual background provides L2 WM performance benefits, i.e., the ability to substitute phonological processing for visuo-spatial processing when recalling logographic items in WM. Furthermore, differences in general intelligence cannot account for the superior WM performance of the bilingual participants. In the present study, the Chinese-English and English-French bilinguals and the English monolinguals did not differ on their scores on the Raven intelligence test.

Therefore, the present finding provides evidence that the bilinguals’ acquisition of an L2 helped to facilitate the ease of recall of the artificial logographic script. Hence, this finding supports prior research (e.g., Ardila et al., 2000, Bialystok et al., 2004) which has found that bilinguality aids performance on WM tasks. The finding that the bilinguals outperformed the monolinguals on a task which impeded processing in the VSSP indicates that they may have more control over their executive functions, i.e., they can switch between processing in one subsystem with processing in an alternate system. In this case, the bilinguals were able to substitute processing in the VSSP with processing in the phonological loop.

Prior research has found that bilingual children develop greater control and attention than monolinguals on problem-solving tasks (e.g., Bialystok, 1997, 1999, see Bialystok, 2007 for review). For example, Bialystok (1999) compared a group of Chinese-English bilingual and English monolingual children on a series of cognitive tasks requiring high levels of control and attention. Children were tested on two problem-solving tasks respectively - a Moving Word and a Dimensional Change Card Sort task. For the Moving Word Task, children were required to match cards comprising pictures of everyday objects with their written labels while being distracted by toy
animals. For the Dimensional Change Card Sort Task, children were required to sort cards by playing a game. Cards were controlled for shape (squares and circles) and colour (red and blue). First, children were required to sort by colour (the Colour game) and then by shape (the Shape game). They were then told to play either the Colour or Shape game with new target cards (having to reclassify the cards according to dimension is difficult for young children). Bialystok found that the bilinguals outperformed the monolinguals on both tasks. The bilinguals were thus able to exercise higher levels of control and attention on problem solving tasks than the monolinguals. An increased level of attention and control might similarly explain the bilingual advantages attained in the present findings. Under the condition of visuo-spatial suppression the bilinguals may have been able to exert higher levels of control and attention to the task of processing in the phonological loop when deprived access to the VSSP.

The present findings could also be explained by superior phonological processing skills of bilinguals. There is some empirical support for the idea that bilinguals are better than monolinguals on phonological processing tasks. For example, Campbell and Sais (1995) found that English-Italian bilingual children were superior to English monolingual children on a series of phonological processing tasks. Kindergarten children were tested on their ability to sort pictures which contained semantically inappropriate (e.g., cow – cat – cup – dog) and phonologically inappropriate targets (e.g., moon – sun – saw – star). The idea here was to pick out the odd picture. Other tasks included a morpheme deletion game where children had to repeat the end parts of orally presented words (e.g., rainbow – bow, teapot – pot). The preliterate bilingual children outperformed their monolingual counterparts on these tasks indicating greater phonological awareness. In the present study, a superior phonological processing capability would explain why the English-French bilinguals outperformed the English monolinguals on the Visuo-Spatial suppression task. That is, the acquisition of a second language, which invariably would have involved the phonological mapping of sounds to lexical items in two languages, may have led to an enhanced phonological processing capacity. This may have facilitated the ease of rehearsing items in the phonological loop when deprived of a visuo-spatial capability.
Additionally, studies have shown that (for alphabetic languages) the phonological loop plays a crucial role in SLA (e.g., Baddeley et al., 1998; Cheung, 1996; Ellis & Sinclair, 1996; Papagno et al., 1991). The English-French bilinguals as L2 learners, would have had a lot of practice developing their phonological skills in order to acquire the French language. This extended period of phonological development may have contributed to their superior phonological processing capability over the English monolingual group. However, this is highly speculative. Arguably, the bilingual advantages attained in the present study were either a result of superior control of executive functioning or a superior phonological rehearsal capability (or possibly both of these). In Baddeley’s (2002) WM model, the phonological loop is a slave system of the central executive, whose primary function is to control and switch between the verbal and visual processing modalities. Because the central executive and the phonological loop are closely related and act together, it is likely that the bilingual advantages attained here were a result of a superior processing capability involving both the central executive and the phonological loop. The extent to which these two processing systems were responsible for the bilingual processing benefits is a matter for future research.

The finding that the Chinese-English bilinguals did not outperform the English-French bilinguals when processing in the VSSP does not support the argument that L1 logographic background language learners have an enhanced visual processing capability which can be transferred to congruent L2 processing. Even though the Chinese-English bilinguals had consistently higher spans than the English-French bilinguals on all WM tasks, these results were not statistically significant. For example, on the Auditory Suppression task, a span differential of .6 was attained. It was possible that the WM experimental trials were not sensitive enough to detect a difference. Furthermore, from the questionnaire data (see Chapter 4), it was found that the Chinese-English bilinguals rated the L2 logographic WM Normal task as significantly easier than the English-French bilinguals and the English monolinguals. This suggests the possibility of an L1 logographic transfer effect. Hence, research should pursue this line of inquiry.
It might be valuable to repeat the present experiment with two groups of monolinguals (Chinese vs. English). In this way, the strong (and potentially confounding) bilingual effects that have been attained here might be avoided. This may increase the likelihood of detecting an L1 logographic transfer effect. For example, because the Chinese native speakers were fluent in English, it was not known how this might have impacted on their performance. A number of studies on children (e.g., Bialystok, Luk, & McBride-Chang, 2005; Wang, Cheng, & Chen, 2006) and on adults (e.g., Su, 2001) have shown that the acquisition of alphabetic English can impact on how Chinese native speakers process language. For example, Su (2001) tested animacy and word order as cue strategies during sentence processing in a second language. Simple transitive sentences in English were presented and participants had to decide the agent in the sentence. It was found that, as the Chinese became more proficient in their use of English, the more native English like they became (when compared with Chinese monolinguals). Therefore, it is possible that the Chinese-English bilinguals’ history of English language acquisition may have had an impact on their performance. Thus, it would be desirable to repeat the present experiment with two monolingual groups.

Overall, the phonological loop was found to play a critical role in the recall of L2 artificial logographs for both structurally simple and structurally complex items. This provides more evidence for Baddeley’s (1990, 2002) WM model. This finding indicates the importance of phonology in WM of L2 logographic items and is consistent with a number of L1 Chinese language studies (e.g., Hue & Erickson, 1988; Mou & Anderson, 1981; Zhang & Simon, 1985) which found that phonology is critical to the recall of logographic items. Consistent also with these L1 Chinese studies was that the phonological loop played a far superior role in the recall of logographic items than the VSSP. In the present experiment, the VSSP only played a significant role when structurally complex logographs were processed. For example, the findings indicated that when processing the structurally simple logographs (consisting of three elements per structure) auditory suppression only impeded recall. This meant that phonological processing was playing the critical role in the recall of structurally simple items. However, when the structurally complex logographs (consisting of six elements per structure) were being recalled, both auditory and visuo-spatial suppression impeded
recall. This meant that as the structures of items increased in visual complexity the role of the VSSP became more critical. Therefore, this finding indicates the supremacy of the phonological loop in processing logographic items in WM.

Additionally, the present finding supports Logie’s (1995) contention that visual information can be rehearsed as a function of the VSSP, mirroring the function of the phonological loop. In the present study, the pattern was that visuo-spatial processing becomes more important as items increase in visual complexity. This finding suggests that the complexity of visual items can be compared to the word length effect found in the phonological loop. For example, in the word length effect, the temporal word length of items determines their rate of rehearsal in the phonological loop. The longer the temporal word length of an item the longer it takes to rehearse in the phonological loop (Baddeley et al., 1975). Now, the present finding indicates that the structural complexity of items impacts on rehearsal in the VSSP. That is, when the artificial logographs were structurally simple there was no significant rehearsal in the VSSP, whereas when the artificial logographs were structurally complex, rehearsal in the VSSP became significant. Therefore, just as the temporal word length of items is critical to the rate of rehearsal in the phonological loop, so too is the structural complexity of visual items critical to rehearsal in the VSSP. Hence, the present findings suggest that visual mental rehearsal functions parallel to verbal mental rehearsal as has been found in previous studies (e.g., Anderson, 1982; Avons & Mason, 1999; Watkins et al., 1984). However, the present findings are unique, because the items used in recall were L2 logographs. Research has, until now, ignored L2 WM for logographic language items in regard to visuo-spatial processing. Therefore, the present findings are particularly significant. The implication here is that structurally complex L2 logographic language items require rehearsal in the VSSP. This is in direct contrast with L1 alphabetic language items which do not appear to require rehearsal in the VSSP (e.g., Baddeley, 1966; Cheung & Kemper, 1994; Cimbalo & Laughery, 1967).

In summary, performance by the Chinese-English bilinguals, English-French bilinguals and English monolinguals did not support the argument that logographic background language learners were transferring their L1 processing skills to a L2 WM situation. It was also found that bilinguals were better than monolinguals at L2 WM
processing. It was speculated that this bilingual advantage may have been the result of either a greater control of executive processing or superior phonological processing skills (or a combination of the two). Overall, it was found that the phonological loop was critical to recalling L2 artificial logographs regardless of the L1 background of language learners and that only when the artificial logographs were structurally complex did the VSSP play a significant role. Evidence was also found to support the claim that visual information can be rehearsed in the VSSP mimicking the function of the phonological loop. In the next part of this experiment, WM recall for artificial logographs, which were not pre-learnt and lacked meaning associations, was tested. It was assumed here that if the artificial logographs had no meaning associations then they could not be verbalized, or, if so, with difficulty. Lacking the ability to verbalize items would invariably force language users to rely on other types of processing (e.g., visual processing). Hence, it was predicted that the L1 logographic Chinese-English bilinguals would outperform the L1 alphabetic background language users on this task.

Additionally, L1 span for the Chinese and English language meaning associations that were used in Experiment 3a was also investigated to explore the effect of an L2 background on L1 processing.

**Experiment 3b**

In the previous WM tasks, recall was measured in relation to a set of recently acquired artificial logographs with accompanying meaning associations. In the present experiment, recall was tested on WM for a set of artificial logographs that participants had not seen before. Because the new set of artificial logographs were not associated with any meanings (and hence had no phonological associations) it was assumed that the structures would be more difficult to verbalize, and arguably, would impede phonological recall strategies. Therefore, it was assumed that, during this task, visual processing strategies would be predominant. On this basis, it was predicted that the L1 logographic participants would outperform their L1 alphabetic counterparts.

In addition, WM for the meaning associations of words from Experiment 3a was tested in participants’ respective L1s (Chinese and English). Working memory research has mostly ignored the issue of “word span” and has tended to focus on digit span (Ardila, 2003). However, prior studies have shown that Chinese language items
(particularly digits) can have a shorter temporal duration compared to English language items (e.g., Stigler et al., 1986). This differential allocated the Chinese speakers a rehearsal advantage (and hence superior WM spans). Therefore, as in the previous experiments, the Chinese and English meaning associations were balanced for temporal word length in order to eliminate this bias favouring Chinese speakers (refer to Appendix J). Therefore, it was predicted that the Chinese-English bilinguals would not outperform the English monolinguals and English-French bilinguals on the L1 WM task. However, if a bilingual advantage operates on WM (as the findings for Experiment 3a suggest), it is conceivable that both bilingual groups will outperform the monolinguals on this task.

Method

Participants

The same individuals from Experiment 3a.

Materials

Meaningless Artificial Logographs. A new set of 10 artificial logographs was created. This new set was created in the same way as the Target logographs of Experiment 1. However, this new set of artificial logograph structures was not paired with meanings. The Meaningless set also consisted of five Simple condition structures and five Complex condition structures (see Figure 3.4). In order to measure participants’ responses, the pictures of the 10 new artificial logographs were pasted onto the keys as in Experiment 3a.

![Artificial Logographs](image)

*Figure 3.4. Ten new artificial logograph structures without meaning associations.*
Native language items. The 10 Chinese and English meaning associations of the artificial logographs used in Experiment 3a served as the stimuli. An additional keyboard was used. Onto this keyboard the 10 English meaning associations were pasted (analogous to experiment 3a). The 10 Chinese character meaning associations were pasted directly underneath the English items. When the English native speaker participants were undertaking the experiment the Chinese language items were covered on the keyboard and vice versa for the Chinese participants and the English language items. Additionally, all other keys were blacked out to facilitate the ease of recognition of the Chinese and English items.

Procedure

For the Meaningless Artificial logographs the procedure was as in the WM Normal task of Experiment 3a, except that the artificial logographs were not pre-learnt. Also, before the experiment proper began, participants were given a one-minute period to familiarize themselves with the shape and location of the new stimulus items on the keyboard.

Again, the same procedure was used for the Native language items, except that instead of artificial logographs, either Chinese characters or English words were displayed. Consistent with Experiment 2b, English words were displayed in Times New Roman font size 24 and Chinese characters were displayed as Simsun font, size 28. The two tasks were counterbalanced.

Design and Analysis

ANCOVA assumptions were met. Accordingly, memory spans were subjected to a mixed ANCOVA with Group (Chinese-English bilinguals vs. English-French bilinguals vs. English monolinguals) as the between-subjects factor, Task (WM Meaningful vs. WM Meaningless) and Structure (Simple vs. Complex) as the within-subjects variables, and Raven scores as the covariate. Here, the data from the WM Normal task of Experiment 3a was reused in this analysis (WM Meaningful) to explore the effect of meaning on processing the artificial logographs. Bonferroni adjustments were applied to all planned comparisons throughout.
Results Experiment 3b

Mean memory spans for meaningful and meaningless artificial logographs for
the three groups are shown in Figures 3.5 (Simple logographs) and 3.6 (Complex
logographs). IQ, as measured by the Raven, accounted for significant variation in span
size, $F(1, 48) = 7.23, MSE = 39.14, p < .02$. The ANCOVA revealed no significant
Structure x Nationality and Structure x Meaning interactions, $F(2, 48) = 1.298, MSE =
3.96, ns$, and $F(1, 48) = 1.037, MSE = 0.91, ns$, respectively. All other within subjects
effects and interactions were also not significant, $Fs < 1$. As with Experiment 3a, there
was a significant Group main effect, $F(2, 48) = 3.184, MSE = 17.24, p = .05$. Planned
comparisons revealed that overall, the Chinese-English bilinguals were better at
processing the artificial logographs than the English monolinguals. All other planned
comparisons failed to reach significance, $ns$.

In order to investigate group performance on the memory spans of the artificial
logographs relative to L1 word span, another mixed ANCOVA was conducted. Here,
because neither meaningfulness nor structural complexity impacted on WM
performance, these conditions were pooled together and an average span for artificial
logographs (Experiment 3b only) was attained. This was then compared to L1 word
span. Mean memory spans for artificial logographs (combined across meaningfulness
and structural complexity) and L1 words for the three groups are shown in Figure 3.7. A
3 x 2 mixed ANCOVA, with Group (Chinese-English bilinguals vs. English-French
bilinguals vs. English monolinguals) as the between-subjects factor, Task (Logographs
vs. Words), and Raven score as the covariate, revealed no Task x Group interaction,
$F(2, 48) = 1.61, MSE = 1.19, ns$. However, Raven scores accounted for significant
variation in span size, $F(1, 48) = 7.77, MSE = 12.83, p < .009$. There was a significant
Task main effect, $F(1, 48) = 4.79, MSE = 3.53, p < .04$, indicating that L1 words were
easier to recall than artificial logographs. There was also a significant Group main
effect, $F(2, 48) = 6.69, MSE = 11.05, p < .004$. Planned comparisons revealed that the
Chinese-English bilinguals outperformed both the English-French bilinguals and the
English monolinguals, all $ps < .02$. All other comparisons failed to reach significance,
$ns$. 
In order to investigate Group comparisons on recall for Logographs and Words separately, further ANCOVAs were conducted. For Logographs, a one-way ANCOVA with Group (Chinese-English bilinguals vs. English-French bilinguals vs. English monolinguals) as the between-subjects factor, and Raven score as the covariate, revealed a significant Group effect, $F(2, 48) = 3.18$, $MSE = 4.31$, $p = .05$. Planned comparisons revealed that the Chinese-English bilinguals outperformed the monolinguals only, $p < .05$. All other comparisons failed to reach significance, $ns$. For Words, a one-way ANCOVA also revealed a significant Group effect, $F(2, 48) = 7.67$, $MSE = 7.93$, $p < .002$. Planned comparisons revealed that the Chinese-English bilinguals outperformed both the English-French bilinguals and the English monolinguals, all $ps < .01$. All other comparisons failed to reach significance, $ns$.

![Figure 3.5](image)

*Figure 3.5. Adjusted mean memory span (+ SE) for structurally simple meaningful and meaningless artificial logographs in Chinese-English bilinguals ($n = 17$), English-French bilinguals ($n = 13$), and English monolinguals ($n = 22$).*
Figure 3.6. Adjusted mean memory span (+ SE) for structurally complex meaningful and meaningless artificial logographs in Chinese-English bilinguals ($n=17$), English-French bilinguals ($n=13$), and English monolinguals ($n=22$).

Figure 3.7. Adjusted mean memory span (+ SE) for artificial logographs (combined across meaningfulness and structural complexity) and L1 words in Chinese-English bilinguals ($n=17$), English-French bilinguals ($n=13$), and English monolinguals ($n=22$).

Discussion Experiment 3b

It was predicted that the Chinese-English bilinguals would outperform the two L1 alphabetic language learner groups on their recall of Meaningless logographs. The assumption here was that items lacking phonological associations would be harder to verbalize thus requiring intensive visuo-spatial processing. It was believed that the Chinese-English bilinguals would transfer their L1 visual processing skills to facilitate the ease of recall of the Meaningless artificial logographs. This would result in a
performance advantage over the L1 alphabetic groups. Contrary to this prediction, the Chinese-English bilinguals outperformed the English monolinguals but performed similarly to the English-French bilinguals. Furthermore, this general pattern of results was repeated when the memory scores for the artificial logographs were collapsed across tasks (Meaningful vs. Meaningless) and conditions (Simple vs. Complex structures). Therefore, it was possible that the Chinese-English bilingual advantage over the monolinguals was a result of their L2 background but not of any advantages because of their L1.

Moreover, it was assumed that a set of artificial logographs without any meaning associations would be difficult to verbalize and hence participants would rely on their visual processing capabilities to compensate. However, it seemed unlikely that the participants were relying solely on their visual processing capability. That is, the WM spans for the Meaningless logographs were higher than those attained during the recall of artificial logographs with auditory suppression. Recall that the condition of auditory suppression disrupted phonological processing, and, as a consequence, visual processing only was relied on to recall items. The Chinese-English bilinguals’ span under the condition of auditory suppression was \(M = 2.8\), whereas their span for artificial logograph structures without meaning associations was \(M = 3.9\), a difference of more than one span. Similarly, the spans of the two English-speaking groups increased by approximately .6. Therefore, when recalling the Meaningless logographs it is probable that participants were not relying completely on visual processing and were most likely using verbal strategies to aid recall. This confounds the findings somewhat. For example, if participants were arbitrarily verbalizing the artificial logograph shapes in their minds to aid recall, then the rehearsal rates of these conjured verbal items would invariably differ from person to person. Hence, it is not known whether the performance advantage of the Chinese-English bilinguals over the English monolinguals was a result of a WM superiority or simply a selection of verbal associations which had a shorter rehearsal rate in Chinese than in English. Recall that a number of studies have found that Chinese language items tend to have shorter temporal length than English language items (e.g., Stigler et al., 1986). Because it was not possible to control the temporal word length of phonological associations of Meaningless artificial logographs, the
advantage of the Chinese-English bilinguals over the English monolinguals must be regarded with caution. Therefore, the results of the present task are inconclusive. Overall, the case for an L1 logographic transfer effect cannot be argued here.

It was also found that there was no difference in the WM spans of Meaningless and Meaningful logographs. This suggests that semantic processing may not have played a critical role in the recall of artificial logographs in WM. This is inconsistent with the findings of Experiment 2a, where the meanings of the artificial logographs significantly affected participants’ rejection of illegal logograph strings. These findings suggest that the degree to which the semantic associations of artificial logographs affect processing may be highly dependent on the type of task used to measure cognition. Semantic processing was more critical for making syntactic judgements on illegal logographs strings than for WM processing. Additionally, it was likely that the Meaningless logographs were verbalized to facilitate recall. This verbalization may have involved a semantic aspect as well. For example, participants may have associated both a verbal label and a semantic connotation to the Meaningless logographs to help recall them. Therefore, the extent of the involvement of semantic processing of the Meaningless artificial logographs is uncertain.

The structural complexity of the Meaningless artificial logographs also did not impact on participants’ ability to recall them. In Experiment 3a, it was found that auditory rehearsal only played a role in the recall of structurally simple logographs while both auditory and visuo-spatial rehearsal played a significant role in the recall of structurally complex logographs. Therefore, it was likely that participants were utilizing both auditory and visuo-spatial processing when processing the Meaningless structurally complex logographs. This dual processing may have compensated for the extra cognitive load of processing complex logographic structures. This may have prevented the detection of any effects of structural complexity of artificial logographs on recall.

It was also predicted that the Chinese-English bilinguals would demonstrate equal performance to the L1 alphabetic groups when recalling L1 items in WM. This prediction was also not borne out. The Chinese-English bilinguals outperformed the English-French bilinguals and the English monolinguals. Because the temporal word length of the Chinese and English language items was strictly controlled, it was unlikely
that the present finding was the result of a faster rehearsal rate in the phonological loop. Therefore, the superior performance of the Chinese-English bilinguals indicates that they were utilizing more than just the phonological rehearsal of items. For example, both the Chinese-English bilinguals and the two English native speaker groups were rehearsing L1 language items in the phonological loop in order to recall them. These Chinese and English items did not differ in respect to their temporal word length (or their word frequency). The two English native speaker groups attained the same size word spans but the Chinese-English bilinguals were significantly higher. This suggests that the Chinese-English bilinguals were processing their L1 items differently from the English-French bilinguals and English monolinguals. This result is consistent with the findings of Cheung and colleagues (e.g., Cheung & Kemper, 1993, 1994; Cheung et al., 2000) who found evidence for a quantitatively different short-term store regarding the recall of Chinese words. For example, Cheung and colleagues found that, in direct contrast with the recall of English words, which have a strong linear relationship between the length of the word to be recalled and its articulation rate, the relationship between the length of Chinese words and their articulation rate is less clearly defined. It is well documented that the word length effect, (i.e., the longer a word takes to say, the longer it takes to rehearse in the phonological loop), completely disappears for English speakers recalling English language items under concurrent articulatory suppression (Baddeley et al., 1975; see Baddeley, 1986). However, Cheung et al. (2000) found that the word length effect did not completely disappear under the condition of articulatory suppression during the recall of Chinese language items by Chinese native speakers. They attributed this to a short-term phonological store that was independent of articulatory rehearsal. This means that a specialized from of processing is associated with the storage of Chinese characters in WM. This specialized storage system, acting independently of articulatory rehearsal of items in the phonological loop, may have been responsible for the increased L1 WM capacity of the Chinese-English bilinguals. Importantly, the existence of a short–term store in WM that is only connected to the processing of Chinese characters indicates that specific L1 orthographies require specific L1 cognitive processing. This constitutes evidence for a fundamental assumption of the language transfer hypothesis (see Chapter 1).
Also contrary to predictions, a similar performance by the English-French bilinguals and the English monolinguals on processing the artificial logographs (and the L1 words) indicated that bilingualism per se did not facilitate WM performance. Recall that the bilingual advantage in WM processing over monolinguals in Experiment 3a was only attained under the conditions of concurrent visuo-spatial interference indicating (arguably) either superior phonological processing skills or a superior capability to control executive functions (e.g., an enhanced ability to switch the processing focus from the VSSP to the phonological loop). The present finding that the English-French bilinguals were not superior to the English monolinguals when rehearsing L1 words suggests that the bilingual processing advantage attained in Experiment 3a may have been a result of superior control rather than superior phonological rehearsal skills. For example, in the recall of English language items, the phonological loop plays a relatively autonomous role (e.g., Baddeley et al., 1975; Cheung & Kemper, 1994; Cimbalo & Laughery, 1967). That is, the temporal length of the word determines its rate of rehearsal in the phonological loop. The fact that the English-French bilinguals did not outperform the English monolinguals when recalling English words, suggests that both bilinguals and monolinguals were rehearsing items at the same rate in the phonological loop. It is reasonable to argue that if the bilinguals had a phonological processing advantage over the monolinguals then they would have been able to rehearse words faster in the phonological loop and hence attain longer word spans. Therefore, it was more likely that the bilingual processing advantage attained in Experiment 3a (recalling meaningful logographs under the condition of concurrent visuo-spatial interference) was related to a superior ability to exert control and attention when processing in the WM subsystems. Considering that prior research (e.g., Bialystok, 1997, 1999, see Bialystok, 2007 for review) has found that bilinguals tend to have higher levels of control and attention than monolinguals, and that attention and control plays an important role in skilled L2 processing (e.g., Segalowitz & Frenkiel-Fishman, 2005), the present argument is plausible.

In summary, no evidence was found to support the argument that the Chinese-English bilinguals were transferring L1 orthographic processing skills to facilitate the recall of L2 artificial logographs in WM. However, in terms of L1 processing, the
Chinese-English bilinguals outperformed both the L1 alphabetic background groups. Because the L1 language items used here were controlled for temporal word length, this finding indicated a cross-linguistic processing differential. The finding that Chinese words were processed differently to English words supports prior research which has found that the phonological loop may not be autonomous in the recall of Chinese words. Hence, it was likely that some hidden processing capability was being utilized in the recall of the Chinese characters. It was also found that neither meaningfulness nor structural complexity of the artificial logographs affected participants’ ability to recall them.

**General Discussion**

Overall, the present findings did not support the case that an L1 logographic background facilitates the ease of processing L2 artificial logographs in WM. The general pattern of results revealed that the L1 logographic Chinese and the L1 alphabetic groups performed equally well on most of the WM tasks. Furthermore, no evidence was found to support the idea that the Chinese-English bilinguals were transferring specific L1 visual processing skills to facilitate the ease of processing the artificial logographs. On the Auditory Suppression task, where participants relied almost exclusively on recalling the artificial logographs in the visual processing subsystem, the Chinese-English bilinguals performed the same as the English-French bilinguals. This indicates that the logographic Chinese-English bilinguals possessed no such superior visuo-spatial rehearsal capability in the VSSP which facilitated their recall.

However, some tentative evidence was attained that suggests that an L1 logographic background may have had some positive impacts on processing an L2 artificial script in WM. First, the Chinese-English bilinguals had consistently higher WM spans than their English native speaker counterparts on all WM tasks. Even though these spans did not differ statistically, it was conceivable that the experimental WM paradigm may not have been sensitive enough to detect any logographic transfer effects. Second, indirect evidence was found to support one of the fundamental assumptions of the main argument presented in this study. That is, different orthographies require specific types of cognitive processing. It was found that Chinese-English bilinguals were able to recall significantly more words in their L1 than the English monolinguals and
bilinguals. Because both sets of L1 language items were controlled for temporal word length, it was likely that the Chinese-English bilinguals were utilizing additional processing resources other than rehearsing items in phonological loop. That the English-French bilinguals and the English monolinguals performed at the same level suggests that both L1 alphabetic groups were processing their L1 items the same way. The finding of the superior L1 WM recall of the Chinese-English bilinguals is consistent with prior research that has discovered evidence for a non-articulatory storage system associated with the recall of Chinese words in WM (e.g., Cheung & Kemper, 1993, 1994; Cheung et al., 2000). An L1 processing differential between Chinese and English language items supports the argument that variant orthographic systems require different types of cognitive processing.

Even though the logographic Chinese-English bilinguals and the English monolinguals and bilinguals were processing their respective L1 words differently, no evidence was found to indicate that the Chinese-English bilinguals were transferring their specific L1 orthographic processing skills to recalling L2 artificial logographs in WM. Additionally, a bilingual history provided positive performance benefits for recalling L2 items but not for L1 language items. This finding begs the question - if bilinguality per se affected L2 WM performance, why then, were no bilingual effects detected on the L1 WM tasks? On the L1 WM task the English monolinguals and the English-French bilinguals had the same size word spans. Arguably, bilinguality per se had no effect on the L1 WM task because high levels of executive control and attention were not required to recall the L1 words. Previously, it was argued that when processing the artificial logographs under the condition of concurrent visuo-spatial suppression the bilingual advantage over the monolinguals was a result of their superior ability to control executive functions. That is, the bilinguals were able to selectively focus their attention solely on rehearsing items in one WM subsystem (the phonological loop) when deprived access to the other (the VSSP). In contrast, the task of recalling L1 language items in WM was not undertaken with concurrent auditory or visuo-spatial interference, therefore, less executive control would have been required to perform the L1 task. A bilingual advantage concerning superior control of executive functions would explain why strong WM effects were attained for the L2 task but not for the L1 task. This
contention also supports prior research which has found that bilingualism per se improves performance on tasks requiring high levels of executive control (e.g., Bialystok, 1992, 1997, 1999).

It is also possible that the inculcation of an L1 logographic language may only result in the enhancement of specific types of visual processing skill. For example, in Experiment 1 of the present study, the Chinese-English bilinguals outperformed the English bilingual and monolingual groups when recognizing prelearnt artificial logographs from a structurally altered set of items, indicating a superiority of visual processing skills closely related to recognition. However, this visual processing advantage of the logographic background Chinese-English bilinguals did not extend to WM processing (even though some tentative evidence was attained). Therefore, the findings of the present study indicate that L1 logographic processing skills may be limited to cognitive processing involved only in the recognition of the structural features of logographic items, not their storage and rehearsal in WM. This would explain why the logographic Chinese-English bilinguals were able to outperform their L1 alphabetic counterparts on the lexical decision task of Experiment 1 but failed to do so on the other L2 tasks requiring deeper levels of processing.

Even though no conclusive evidence was found to support the main argument of this study, a number of peripheral findings were attained which might be significant to the fields of cognitive psychology and SLA. First, evidence was found that the phonological loop played a significant role in the WM processing of an L2 artificial script. Concurrent auditory suppression significantly interfered with processing both the structurally simple and complex artificial logographs. This finding is consistent with Baddeley’s (1986, 1990, 2002) theory that the phonological loop plays a primary role in the processing of language in WM. Furthermore, it was also found that the VSSP played a significant role in the recall of structurally complex L2 artificial logographs. This finding supports prior L1 research that has found that logographic language items require a combination of phonological and visuo-spatial processing (e.g., Hue & Erickson, 1988; Mou & Anderson, 1981; Zhang & Simon, 1985). Moreover, evidence was found to indicate that the VSSP begins to take on a prominent role in the recall of L2 artificial logographs only when they increase in structural complexity. Hence, it is
possible that the visual orthographic structures of language items may be rehearsed in the VSSP in the same way that verbal items are rehearsed in the phonological loop. That is, just as temporal word length is critical to the rehearsal of verbal items in the phonological loop, then it may be that visual complexity is critical to the rehearsal of visual items in the VSSP. The present finding is an encouraging one for researchers who are interested in pursuing this line of study.

Summary

Overall, conclusive evidence was not attained to support the argument that the inculcation of a logographic L1 results in the enhancement of specialist L2 orthographic processing skills which can be transferred to orthographically congruent L2 processing in WM. In a series of L2 logographic WM tasks, the Chinese-English bilinguals did not outperform the English-French bilinguals. Contrary to what was predicted, the logographic Chinese did not demonstrate an enhanced visual processing capability. When the Chinese-English bilinguals were visually processing the artificial logographs (i.e., the WM Auditory Suppression task) they were equal with the English-French bilingual group. Hence, no evidence was found to support the argument that the inculcation of a logographic orthography results in an enhanced visuo-spatial processing capability.

Even though bilingualism was not the primary focus of the present study, some interesting results were obtained. It was found that a bilingual background appears to provide language learners with better L2 WM processing skills. It was argued that these bilingual skills were closely related to an ability to exert greater control and attention over executive functions related to WM. However, no bilingual performance benefits were present when processing L1 items in WM. It was also found that the phonological loop played a critical role in the recall of L2 artificial logographs. Additionally, it was found that the VSSP was important in the recall of L2 artificial logographs but only when items were structurally complex.

In the next chapter, the covert mental processing strategies (e.g., inner speech) that participants utilized to aid their acquisition and processing of the artificial logographs will be discussed. This investigation will examine the covert mental processing strategies of participants through a Vygotskyan sociocultural perspective in
order to understand the complex processing that has taken place during the reading and WM experiments.
CHAPTER 4
DO LEARNING STRATEGIES DIFFER DEPENDING ON L1 ORTHOGRAPHIC BACKGROUND?

Central to the argument of language transfer outlined in Chapter 1 of this study is the theory that the inculcation of a L1 logographic writing system can result in specialized reading skills that orients readers toward visual processing, whereas the inculcation of an L1 alphabetic writing system orients readers toward a stronger reliance on phonological processing. This was described as an interpretation of the Orthographic Depth Hypothesis, which stipulates that the higher the degree of correspondence between graphemes and phonemes, the more important becomes the role of phonology in attaining the lexical access of words. Therefore, logographic Chinese, which ranks as a deeper orthography than alphabetic English, would require less phonological recoding than alphabetic English when being read. Hence, a finding that indicated that the L1 logographic language learners were relying less on phonological recoding and more on visual orthographic processing when processing the artificial logographic script would support the general argument of this study.

So far, in a series of reading and WM experiments, some evidence was attained that supports the general argument of this study. In Experiment 1, the logographic background Chinese-English bilinguals outperformed their L1 alphabetic background counterparts when recognizing newly acquired artificial logographs from a set of structurally similar but altered ones. Arguably, this finding indicated a superior visual processing capability by the Chinese-English bilinguals arising out of their L1 orthographic processing experience. However, in Experiment 2a, which required the making of grammatical judgements on artificial logograph strings, no Chinese-English bilingual processing advantage was attained. In Experiment 2b, participants made grammatical judgements on L1 word strings instead of the artificial logographs. It was found that the Chinese-English bilinguals outperformed the English-French bilinguals and the English monolinguals. It was found that the English-French bilinguals also outperformed the English monolinguals indicating that bilingualism per se facilitated the ease of L1 syntactic processing. It was argued that the bilingual advantage on this task was a result of a greater metalinguistic awareness on the part of bilinguals.
Following on from these reading experiments a series of WM experiments was designed. The paradigm of WM was chosen because it offered a means to investigate the processing of artificial logographs independently in the visual and verbal processing subsystems. It was predicted that when processing solely in the visual subsystem, the logographic Chinese-English would outperform their L1 alphabetic counterparts. However, this was not found to be the case. In two WM experiments (3a and 3b) involving artificial logographs, no evidence was attained to indicate that the Chinese-English bilinguals were transferring L1 orthographic processing skills to L2 WM. However, it was found that the Chinese-English bilinguals were processing their L1 (Chinese characters) differently to the processing of English words by the English-French bilinguals and English monolinguals. This provided some evidence to support an important part of the main argument of this study, that is, different orthographic systems require different types of cognitive processing. As with the reading experiments, strong L2 effects were also found in the WM experiments. In Experiment 3a, bilinguality per se was found to aid processing artificial logographs under the condition of concurrent visuo-spatial interference. On this task, a high level of control was needed to focus on rehearsing the artificial logographs when deprived of processing in the VSSP. Hence, it was argued that the bilinguals had better control than monolinguals when switching between the WM processing subsystems.

In summary, the inculcation of a logographic L1 may result only in the enhancement of highly specific visual processing skills. The present findings suggest that as a result of their L1 orthographic background, the L1 logographic language learners have developed visual processing skills pertaining only to recognizing and identifying highly visual orthographic structures. However, these visual skills did not appear to play a significant role when deeper processing tasks were involved, such as L2 syntactic and WM processing. Additionally, it was found that a language learner’s bilinguality had the potential to strongly impact on both L1 and L2 processing. To further investigate these patterns of behaviour the Chinese-English bilinguals, English-French bilinguals, and English monolinguals who participated in the reading and WM experiments of the present study were probed on the cognitive strategies that they deployed when acquiring and processing the artificial logographic script. If it can be
shown that the L1 logographic Chinese-English bilinguals used different cognitive strategies from the English-French bilinguals and English monolinguals when processing the artificial logographs, particularly cognitive strategies that are inclined toward visual processing, then the case for the language transfer hypothesis can be made.

Of particular interest to the present study was the role that inner speech played when language learners were processing the artificial logographs. Inner speech is defined here as the generation of any language of the mind and hence is a broad term encompassing any inner verbal activations. Inner speech plays a crucial role in Vygotskian sociocultural theory (1978, 1986) and is an important phenomenon embedded in cognitive processing, including SLA (De Guerrero, 1994, 1999; 2004; Ushakova, 1994) and L2 reading (Sokolov, 1972). According to Vygotsky (1986), inner speech arises ontogenetically at around age seven in children. Prior to this point, speech is social, even in terms of self-regulation. For example, when children are challenged cognitively they think aloud (as egocentric speech or private speech), utilizing social speech as a device to solve problems. At approximately seven years of age, egocentric speech becomes covert (as inner speech) and acts as a means by which to regulate thought and plan language (Vygotsky, 1986). However, in adults, after egocentric speech has been internalized, it may resurface as a problem-solving tool (as private speech). Both inner speech and its overt form, egocentric/private speech, have no communicative functions, their purpose is related to problem solving, language development and planning (Vygotsky, 1986). The role of both private and inner speech in SLA will be revised here.

To date, few studies have attempted to combine a Vygotskian sociocultural perspective within an L2 reading context. Of those studies that have (e.g., De Guerrero, 2004; Sokolov, 1972; Upton & Lee-Thompson, 2001) the focus was on L1 alphabetic readers processing L2 alphabetic text. Moreover, few (if any) studies have attempted a Vygotskian investigation of L1 alphabetic and logographic background readers processing L2 logographic text. Therefore, the approach taken here represents a major point of departure from previous L2 reading studies. Furthermore, to date there have been no cross-cultural investigations of WM from a Vygotskian perspective (Al-
A number of studies have shown that inner speech has an important SLA function. For example, De Guerrero (1994) argued that inner speech may provide insight into the complex processes of second language acquisition. Her study combined an analysis of inner speech linguistic forms and functions of adult university level ESL learners of Puerto Rican background during the mental rehearsal of an L2. The study consisted of two phases: an examination of responses to a questionnaire in the participants’ L1 (Spanish) and two L2 communicative activities. These communicative activities were followed up by interview protocols. The linguistic characteristics of inner speech related to sound, structure, meaning, and vocabulary, as well as the functional roles of inner speech in second language learning at various proficiency levels were examined. The findings revealed that a significant majority of participants experienced inner speech in their L2. Inner speech was revealed to have a multifunctional role when learners mentally rehearse in their L2. The findings also revealed that, as the proficiency level of the L2 of the students increased, so did inner speech (that is the length and complexity of L2 inner speech structures). De Guerrero attributed this to the developmental nature of inner speech, as described by Vygotsky (1962). This study also revealed auditory and visual components, which play a role in inner speech during L2 mental rehearsal. That inner speech is mentally rehearsed in order to facilitate language acquisition indicates its close connection to WM processing. Recall, that WM studies have linked the rehearsal of verbal information in the phonological loop to language acquisition (e.g., Ardila, 2003; Baddeley et al., 1998; Cheung, 1996; Daneman & Case, 1981; Ellis & Sinclair, 1996; Papagno et al., 1991). De Guerrero concluded that L2 inner speech should be viewed as a developmental phenomenon, with a strong...
correlation between increased L2 proficiency and increased structural (syntactic and semantic) complexity in the inner speech of language learners.

Several years later, De Guerrero (1999) again investigated inner speech as mental rehearsal in an L2 context. The experiment consisted of a questionnaire asking the participants to comment on various aspects of inner speech during mental rehearsal. The questions were designed to investigate the functional role of inner speech in relation to mnemonic, instructional, evaluative, textual, interpersonal, intrapersonal, playful, and affective variables. The participants in the study consisted of advanced ESL university students. The findings revealed that the learners produced a large amount of inner speech during mental rehearsal in their L2. The higher the proficiency of the ESL learners the more inner speech they generated; however, some of the functions associated with silent rehearsal were reduced. The advanced level learners demonstrated a higher degree of structural complexity in their L2 inner speech than the lower level proficiency groups (compared with prior research, e.g., De Guerrero, 1994). The advanced level proficiency group revealed typical abbreviated inner speech forms but, in addition, was able to think in more complex structures such as sentences and conversations. In conclusion, De Guerrero posited that L2 inner speech moves through a series of transitional stages in a similar fashion to the movement of L1 inner speech.

In a more recent study, De Guerrero (2004) analysed the L2 inner speech of beginner level ESL university students who were native Spanish speakers. The participants were required to make weekly reports pertaining to their L2 inner speech production in a diary, involving L2 inner language generated both inside and outside of the classroom. The diaries were collected on a regular basis and the ESL students’ inner speech was categorized into four main areas: concurrent processing of language heard or read (e.g., subvocal rehearsal), recall of any language heard, read or used (e.g., spontaneous recall of words), planning (e.g., preparation before speaking), and silent verbalization of thoughts (e.g., spontaneously thinking in L2, imagining conversations). It was found that L2 inner speech was commonly generated when processing language on reading and listening tasks and to facilitate the spontaneous recall of language heard or read. Additionally, it was found that subvocal rehearsal was commonly generated in order to focus on unfamiliar or difficult L2 words. This latter finding again indicates a
close relationship between inner speech and the phonological loop of WM. As mentioned before, the rehearsal of verbal items in the phonological loop of WM has been linked to L2 vocabulary acquisition (e.g., Ellis & Sinclair, 1996).

In an experimental SLA study, Ushakova (1994) examined inner speech as a mechanism embedded in the L1, which serves as a type of blueprint for SLA. Ushakova defined inner speech as “mechanistic” (p.145), that is, as consisting of several functional levels, which are hierarchical in nature, distinguished by their particular function. The first level of inner speech structure is the “lower level”, which consists of “base elements”. This level has the following components: the labeling of objects (referents); the formation of conceptual structures, which generalize and classify them; and the sound characteristics of words and the processes involved in pronunciation. These components are stored in long–term memory. The next level is a system of interrelated structures known as a “verbal network”. This verbal network links the base elements in the first level of inner speech and creates a new level of generalization and abstraction. This new level is signified by word meanings, which are not derived through objective labeling, but through other words. The third level of inner speech structure relates to a network of grammatical structures. This network contributes to the processes involved in the formation of grammatically correct sentences. The highest level of inner speech structure is the communicative level, which accounts for motivation of the speaker and the means of speech production. In the experiment, adult speakers of Russian acquired an artificial language in the form of a series of made up words from three grammatical categories: nouns (animals and food), adjectives (colours) and verbs (ways of eating). First, the pronunciation of each word was taught followed by the meaning of each word (this was accomplished by a listen and repeat system with the aid of a tape recorder). Participants were then tested on how fast they were able to identify and orally reproduce the newly acquired artificial language. The assumption here was that the stronger the connection between words and their structures the faster would be their reproduction. The identification of the artificial words was strongly influenced by the grouping or grammatical classification of the words (interpreted as a lower level inner speech function). For example, nouns were identified much more easily than verbs and adjectives. Also, when there was confusion of words, it was
mostly with words that belonged to the same semantic category, e.g., *dog* and *animal*. The major implication was that the use of inner speech (in regard to SLA) is dependent on linguistic structures already determined through L1.

In terms of L2 reading, inner speech studies are particularly rare (Ehrich, 2006; Upton & Lee-Thompson, 2001). To date, there has only been one in depth study of the relationship between inner speech and L2 reading. In this study, Sokolov (1972) conducted a series of experiments in order to measure the amount of muscle activity connected with speech (tensions in the tongue and lower lip) during complex L2 reading tasks. These reading tasks consisted of text in the subjects’ native language (Russian) and texts in a foreign language (English, chosen at a proficiency level above that of the participants). The muscle activity was detected through a measure of electrical activity. The findings revealed that strong motor speech impulses were detected during the reading of foreign language texts when the participants’ mastery of the foreign language was insufficient and when the participants read texts in their own language during complex phrases in these texts. It was also discovered that when the difficulty level of the task was reduced, the levels of speech musculature were also reduced. This study clearly linked inner speech (as inner mouth movement) to problem solving in an L2 reading setting as well as L1. Hence, there is evidence to support the notion that inner speech plays an important role in the reading process in general.

In the reviewed studies so far, inner speech has been defined as a strictly verbal or phonological phenomenon. However, there is some evidence that indicates that inner speech may not be limited to verbal or phonological items. For example, empirical studies have indicated that inner speech can also contain visual components (e.g., De Guerrero, 1994, 1999; Sokolov, 1972). For example, De Guerrero’s (1994) study revealed visual components in L2 inner speech. Her findings revealed that auditory and visual components play a role in inner speech during mental rehearsal in a second language. For example, the participants in her study substituted graphic images for vocabulary and language. De Guerrero (1994) concluded that inner speech in an L2 context does not constitute solely a linguistic phenomenon.

Furthermore, a number of studies have demonstrated that visual inner speech can be generated and mentally rehearsed to provide positive benefit effects on learning
outcomes. For example, studies such as Anderson (1982) and Watkins et al. (1984) have shown that visual images can be rehearsed in a manner similar to verbal mental rehearsal and that this visual mental rehearsal can aid in visual, memory related tasks. Hence, there is evidence that inner speech can be generated in a visual modality. Again, there is an inner speech and WM connection here. In Baddeley’s WM model (1986, 1990, 2002), the central executive controls the two slave systems, the phonological loop and the VSSP which processes verbal and visual information respectively. Similarly, inner speech can be generated in either a verbal or visual modality and be rehearsed as such.

In summary, inner speech is an important function in SLA in terms of alphabetic L1 and L2s. Overall, L2 inner speech generation is largely determined in the L1 and is transferred to an L2 language-learning context. In addition, L2 inner speech complexity increases relative to language proficiency. Inner speech has also been strongly associated with both L1 and L2 reading. In terms of L2 reading, it was found that the more difficult texts are to read the more inner speech is generated. Inner speech can also take on visual imagery and can be rehearsed in a similar way to verbal inner speech.

**Private Speech Studies and SLA**

According to Vygotsky (1986), egocentric or private speech is an overt form of inner speech and is an important phenomenon related to the regulation of thought, problem solving and language development. Private speech does not, in itself, constitute thought per se, but is an important part of a process through which thought is extracted from language usage (Frawley, 1997). There have been numerous studies which have documented the cognitive and problem-solving role of private speech usage by adults (e.g., Duncan & Cheyene, 1999; John-Steiner, 1992; Frawley & Lantolf, 1985; Appel & Lantolf, 1994; Roebuck, 1998). If the inculcation of language, and its variant forms and patterns, has no influence on cognitive processes, then private speech usage should not differ between cultural members from different linguistic backgrounds. That is, in terms of solving problems and undertaking challenging linguistic tasks, private speech as a function of problem solving and cognition, should demonstrate a sameness or universality between diverse cultural/language groups. If language users all think the
same then invariably they should solve problems in a similar fashion, regardless of their linguistic background.

However, the studies by McCafferty (1992, 1998) have demonstrated fundamental private speech differences between two variant language-using groups (Asians and Hispanics). In McCafferty’s (1992) study, the private speech of two ESL groups (Asians and Hispanics) was compared. All the participants were adult ESL students at three L2 proficiency levels: low–intermediate, intermediate and advanced. Using Frawley and Lantolf’s (1985) categorization system, private speech was identified by object–, other– and self–regulation (Wertsch, 1979). These components have a strategic function (Wertsch, 1980) and aid in problem solving. In the ontogenetic development of children, other–regulation is evident through an inability to self–regulate and therefore guidance by an adult is required. Object–regulation is depicted in the situation of a young child who is guided by immediate environmental concerns in the absence of another who can assist with the task at hand. Self–regulation is the ability to solve problems utilizing the cognitive know–how acquired through acculturation. From other–, object– and self–regulation, Frawley and Lantolf (1985) posit the theory of continuous access, which states that adults can call upon other– and object–regulation in order to meet cognitive challenges when self–regulation is not possible. This continuous access is demonstrated through private speech utterances.

In McCafferty’s (1992) study, participants were shown a series of six related pictures and were asked to tell a story based on these pictures in their L2 (English). Their utterances were recorded and then categorized according to instances of private speech. Utterances were identified as private speech if they fulfilled three essential criteria. First, the utterance had to be tangential to the narrative, secondly the utterance had to be self–directed (an attempt at self–guidance), and thirdly, the utterance had to be concerned with some aspect of mastering a task–related difficulty. In addition to meeting these criteria, the form–function relationship of private speech was defined in accordance with object–, other– and self–regulation as categories of private speech. For example, instances of other–regulation were defined as any self–directed questions. Object–regulation was defined in regard to the use of specific grammatical constructions such as the use of tense. Here, the use of tense, specifically the past tense, was
considered a strategy that allowed the language users to exert some control over their environment. That is, they could take away the immediacy of having to describe the pictures by controlling their temporal framework (native speakers of English usually tell stories in the present tense to give the narrative a sense of immediacy). Self-regulation was defined in terms of any self-correcting comments (e.g., “Five monkeys are playing with a man – no – the man is angry”) (p. 184).

The results revealed that there was a significant difference in terms of other–regulation between Hispanics and Asians. In terms of object–regulation and self–regulation, there were no significant differences. McCafferty (1992) concluded that on the basis of the results of other–regulation, there is evidence that private speech varies across cultures.

In a more recent study, McCafferty (1998) explored the relationship between private speech and gesture in a cross–cultural context. Private speech was defined in accord with earlier studies (McCafferty, 1992), and was analyzed in relation to five categories of gestures based on McNeill’s (1992) classification system: iconics, metaphorics, beats, deictics and emblems. In addition to these categories, three levels of narrative discourse were described: narrative level, meta-narrative and para-narrative. The narrative level referred to any discourse directly related to the story line of events, meta-narrative referred to any discourse that refers to the story but is not actually part of the story line and para-narrative referred to any discourse concerning the speaker’s own experience as it relates to the story line. Adult ESL students (Japanese and Venezuelan Spanish speakers) performed two tasks, a recall task and an oral picture narration task. The findings revealed that in terms of object- and other–regulation, there was a high correspondence between private speech and gesture. Overall, Japanese students used more gestures with their private speech than the Venezuelans in six of the seven categories listed. Furthermore, in terms of other–regulation, the Venezuelans utilized this form of regulation more so than their Japanese counterparts. McCafferty (1998) concluded that this qualitative study provided evidence to support McNeill’s argument, chiefly that gestures, like language, play a role in the mediation of thought, and that thought, language and gesture are interrelated. As in McCafferty (1992), cross–cultural differences in private speech use were demonstrated.
There are strong parallels between Sasaki’s (1987) cross-cultural kusho study (see Chapter 1) and McCafferty’s (1998) cross-cultural study. In the kusho study, finger writing in space was used by participants in order to help solve language problems. This use of a non-verbal gesture constitutes a type of object-regulation, that is, use of the environment to help regulate internal behaviour. The fact that in Sasaki’s kusho study, the Chinese character culture members (Asians) utilized this type of object-regulation and the non-Asian (e.g., Greeks, Americans etc.) did not can be compared with McCafferty’s findings. Here, the L1 logographic participants used more non-verbal private speech gestures than the L1 alphabetic participants. This provides tentative support for a cross-cultural private speech difference. Therefore, differing language systems can impact on cognition, and private speech, as an important part of cognitive processing and problem solving, can reflect this difference.

However, not all studies have found differences in the use of private speech by different cultural groups. For example Al-Namlah, Fernyhough, and Meins (2006) investigated private speech and STM in relation to children from two diverse cultural groups (Saudi Arabia and Britain). Because of the strong contrast between Saudi and British culture, especially in terms of the interactions of family members, Al-Namlah et al. predicted that such differences would be reflected in the children’s use of private speech. For example, in Saudi culture, girls are encouraged to talk among themselves and express themselves, particularly when gathering with older female relations. In contrast, Saudi boys are prohibited from speaking when in the company of older male family members. On the contrary, British children of both genders are encouraged to express themselves in the company of family members regardless of sex or age. In accordance with the Vygotskyan (1986) notion that, as a form of self-regulation, children rely on the conventions of social speech to aid in problem solving, Al-Namlah et al. posited that the contrastive Saudi and British social speech patterns would influence children’s private speech use. Private speech was elicited through a problem-solving task (Tower of London; Shallice, 1982). The task involved the completion of a three-dimensional puzzle which required the placing of variously shaped pegs into appropriate holes. The children were video-taped during this task and their utterances were categorized as either social or private speech. Private speech utterances were
defined as any self-directed talk that did not involve another person. Private speech utterances were also graded on their degree of relevance to the task at hand (e.g., task relevant utterances – utterances that describe one’s activity and task irrelevant utterances – utterances that are directed to imaginary or absent others). No difference was found between the Saudi and British children’s use of private speech. This finding was not consistent with McCafferty’s (1992) pattern of results, which found that contrastive cultural groups used private speech differently. However, these two contradictory results can be explained by how the two researchers defined private speech. McCafferty defined private speech to include any questions directed at the experimenter by the participants. These questions were considered a form of other-regulation, whereby guidance from other people is sought to mediate inner processing. Recall that in McCafferty’s study, the main source of private speech difference between the two cultural groups (Japanese and Hispanics) was in their production of other-regulation. However, Al-Namlah et al. did not consider questions directed by the children to the experimenter as instances of private speech. Therefore, it is likely that the different findings attained by McCafferty and Al-Namlah et al. were a result of their different interpretations of what constitutes private speech phenomena per se. Frawley (1997) has argued that a major problem of comparing private speech studies is that there is no consensus on how the phenomenon is defined. This was certainly evident here.

Furthermore, Al-Namlah et al. compared two similar L1 orthographic background groups (alphabetic Arabic and alphabetic English), whereas McCafferty compared two contrastive L1 orthographic groups (logographic Japanese and alphabetic Spanish). In terms of orthography, the language distance between Arabic and English is not as great as the language distance between Japanese and Spanish. Recall that Sasaki (1987) found that L1 logographic background language users utilize different self-regulatory strategies (e.g., kusho) from L1 alphabetic background language users during linguistic problem-solving tasks. As suggested before, kusho can be considered a type of private speech because when participants write Chinese characters in space they utilize the surrounding environment to regulate their inner processing. The use of the surrounding environment to regulate inner processing is also known as object-regulation, which can be considered private speech (see Frawley & Lantolf, 1985).
Therefore, it is possible that specific differences in L1 orthographic background may impact on how private speech is used. Arguably, the similar L1 orthographic background shared by the Saudi and British children in Al-Namlah et al.’s study may have contributed to a uniformity of private speech production. However, this is highly speculative.

Al-Namlah et al. also investigated the relationship between private speech and STM performance. Phonological memory was assessed through the presentation of line drawings in an immediate recall task. The verbal associations of the objects in the drawings were either phonologically similar (e.g., cat, car, clown, cow) or phonologically dissimilar (e.g., house, dog, lamp, glass). The assumption here was that the phonologically dissimilar items would be easier to recall because they would be stored phonologically. In contrast, the phonologically similar items would require more visual processing. Therefore, the phonologically dissimilar items were assumed to be representative of phonological processing. Drawings were presented on cards. The children then had to repeat the names of the objects of the drawings on the card in their correct serial order. No differences were found between the Saudi and British children’s performance on these STM tasks. When the children’s private speech use on the Tower of London task was compared with their STM performance, private speech was found to be a strong predictor of the recall of phonologically dissimilar items. This was not the case for the phonologically similar items. Therefore, children who used more private speech were more likely to use phonological recoding strategies during STM recall. This suggests a positive link between private speech and STM. This finding is consistent with other children’s studies which have found that the use of private speech can enhance performance during cognitive tasks (e.g., Fernyhough & Fradley, 2005; Winsler, Diaz, McCarthy, Atencio, & Adams-Chabay, 1999). Even though some studies have found positive correlations between private speech and cognitive processing in adults (e.g., Duncan & Cheyne, 1999), little research (if at all) has been conducted on the relationship between private speech usage and memory performance in adults. One of the aims of the present study is to investigate the adult private speech of variant L1 orthographic background language learners during L2 WM tasks.
In summary, the studies by McCafferty demonstrate that approaches to linguistic problem solving, as evidenced by private speech utterances, differ between cultural members of language learners from diverse (Japanese and Venezuelan) linguistic backgrounds. However, this may not be the case for contrastive cultural groups who have a congruent L1 orthographic background (as in Al-Namlah et al., 2006). These studies provide further support for the notion that the cultural and linguistic background of language learners can impact on their cognitive processing. In addition, children’s private speech is a strong predictor of phonological recoding strategies in STM recall of visually presented items.

*Why Investigate Inner Speech from an L2 Logographic Perspective?*

Vygotsky (1986) posited that the sign system (such as language), once internalized, results in a transformation in thinking. Just as tools mediate a change in the physical environment, language and sign systems, as psychological tools, can mediate a change in the mental environment (Vygotsky, 1978, 1986). If this is true then it is conceivable that the internalization of differing sign systems, such as Chinese and English writing systems, may result in some cognitive processing differences (see Chapter 1). It is also conceivable that inner speech, as a phenomenon embedded in cognition, problem solving and language development, may also reflect a degree of cultural divergence. There is some empirical evidence to substantiate this claim. For example, in McCafferty’s (1992, 1998) cross-cultural studies involving L2 private speech, differences were identified between Japanese (who are readers of Kanji, a logographic writing system) and Hispanic (alphabetic) readers in terms of their private speech utterances.

In the present study, it was speculated that an inner speech investigation comparing logographic and alphabetic background language users during the acquisition and processing of an artificial logographic script might reveal cultural inner speech differences directly attributed to L1 orthographic background. This assumption was based on the findings of Experiment 1. In Experiment 1, the L1 logographic background Chinese outperformed their L1 alphabetic background counterparts. It was argued that the inculcation of an L1 logography equipped the Chinese with particular orthographic processing skills, which were transferable to processing a congruent L2 script. This
argument would be further strengthened if it could be shown that L1 logographic Chinese were utilizing different inner processing strategies, such as visual inner speech, from their L1 alphabetic counterparts during the previous experimental tasks of Chapter 2 and 3.

The main goal of the inner speech investigation reported here was to determine if orthographically variant language learners utilized different inner processing strategies when processing the artificial logographs during the acquisition of artificial logographs, syntactic decision tasks and WM experiments outlined in Chapter 2 and 3 (Experiment 1, 2a and 3a). In particular, the focus of the investigation of the inner speech of orthographically variant L1 language learners, when processing the L2 artificial logographs, was to determine whether or not any culturally determined differences could be established and to determine the extent to which inner speech (both verbal and visual) was utilized in the acquisition and use of a non-alphabetic L2. Therefore, two main research questions were arrived at:

1. Does inner speech vary among different L1 background language learners when processing an L2 logographic script?
2. Does a logographic L2 induce inner processing strategies more orientated toward visual processing than verbal processing?

**Acquiring the Artificial Logographs**

*Reading Studies Experiments 1 and 2a*

The data that form the basis of the inquiry were gathered from the participants of the reading experiments (Experiments 1 & 2a) and the WM experiments (Experiments 3a & 3b). Recall that, in Experiment 1 and 2a (Chapter 2), Chinese-English bilinguals, English-French bilinguals and English monolinguals were required to learn an artificial logographic script over two sessions. These participants then undertook two tasks processing this newly acquired script – a lexical decision task and a syntactic decision task. Upon conclusion of these tasks, a questionnaire was then administered to investigate participants’ cognitive strategies used when learning this artificial script. In Experiments 3a and 3b, the focus was on working memory ability when recalling a similar artificial logographic script in different groups of participants. The questionnaire data is reported separately below.
Method Experiments 1 and 2a

Participants
The same individuals from the reading experiments (Experiments 1 and 2a).

Materials
The questionnaire used to collect data was partly adapted from a mental rehearsal questionnaire by Anderson (1982) (see Appendix K and L for the respective English and Chinese versions). A five point Likert-scale was used for all surveyed items to indicate participants’ interpretations of cognitive phenomena related to the acquisition of the artificial logographs and their meanings, such as task difficulty, the use of private speech (defined as any self-directed utterances), the use of hieroglyphicity (the association of a real world shape to help remember a target logograph’s meaning), the type of mental rehearsal (naming vs. visualizing) as a strategy to aid recall and the quality of both inner naming and inner visualizing of items.12

Procedure
Recall that participants were presented with 12 artificial logographs with 12 corresponding meaning associations in their respective native languages. Participants were required to learn this script to a specific set of criteria, which involved drawing the artificial logographs accurately from memory and correctly identifying each artificial logograph’s meaning. This learning phase occurred in two sessions spaced one week apart. In the second session, at the end of all learning and testing phases, the questionnaire was administered to participants in their respective native languages.

Design and Analysis
Chinese-English bilingual, English-French bilingual and English monolingual data consisted of participants’ responses at each level on the Likert scale to items and a Kruskal-Wallis test for independent samples was used to identify any between-subjects (Chinese bilingual vs. English monolingual vs. English bilingual) differences. Calculations for all planned comparisons followed Siegel and Castellan’s (1988) procedures. In cases where a significant difference was attained between the three groups and planned comparisons revealed no difference between the two alphabetic L1

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12 These factors were identified from interviews with two Chinese-English bilinguals and two English native speakers who participated in the pilot study.
groups (English monolinguals and English-French bilinguals), further Kruskal-Wallis tests for independent samples were conducted to determine the impact of L1 orthographic background on group responses by contrasting the Chinese-English bilinguals with the alphabetic (French-English and English) language users. If no effect for L1 orthographic background was found, then a further Kruskal-Wallis test for independent samples was conducted based on bilingualism (collapsed across bilingual groups) as the between-subjects factor (bilinguals vs. monolinguals).

Results

Table 4.1 shows the mean ratings of participants who chose each statement as the best description of the cognitive processes they believed they engaged in when acquiring the artificial logographs and their meanings. Kruskal-Wallis tests for independent samples with Group (Chinese-English bilinguals vs. English-French bilinguals vs. English monolinguals) as the between-subjects factor were conducted on the following variables: task difficulty, private speech, hieroglyphicity, type of rehearsal (verbal vs. visual), quality of inner naming and quality of inner visualizing.

Task difficulty. The majority of participants in all three groups rated the learning of the target logographs and their meanings as “not difficult but not easy either”. There was no significant difference between the three groups in their interpretation of task difficulty, $\chi^2 (2) = 1.68, ns$.

Private speech. The majority of the English-French bilinguals (74%) and English monolinguals (65%) reported using no speech when learning the target logographs and their meanings. Only half of the Chinese-English bilinguals (50%) reported using no private speech. Overall, there was no difference between the three groups based on the amount of private speech uttered when learning the artificial logographs and their meaning associations, $\chi^2 (2) = 2.25, ns$.

Hieroglyphicity. When learning the artificial logographs and their meanings, associations of a real world object to aid in recall was a strategy used to varying degrees in all three groups. Overall 65% of English monolinguals used hieroglyphicity with all or most of the artificial logographs and their meanings, compared with 40% of the Chinese-English bilinguals and only 32% of the English-French bilinguals. A significant difference between the three groups was found, $\chi^2 (2) = 7.36, p < .03$, suggesting (as
can be seen from Table 4.1) that the bilinguals used this strategy less than the monolinguals. Comparing bilinguals overall with monolinguals supported this observation, $\chi^2 (1) = 7.34, p < .008$.

**Type of rehearsal.** The majority of the participants in all three groups both named and visualized artificial logographs and their meanings when memorizing them. There was no difference between the three groups, $\chi^2 (2) = 4.42, ns$.

**Quality of naming.** Ninety-four percent of English monolinguals and 75% of English-French bilinguals, compared with only 56% of Chinese-English bilinguals, chose the category “full name, well pronounced” when commenting on the quality of their naming of the artificial logographs in order to memorize them. A marginal difference between the three groups was found, $\chi^2 (2) = 5.03, p < .09$, and planned comparisons did not reveal any differences between the three groups. A further Kruskal-Wallis test for independent samples based on L1 orthographic background (Chinese-English bilinguals vs. alphabetic speakers) indicated that the L1 logographic Chinese-English bilinguals rated the quality of their inner speech as marginally lower than the L1 alphabetic (English monolinguals and English-French bilinguals) language learners, $\chi^2 (1) = 3.64, p < .06$.

**Quality of visualizing.** Sixty-four percent of the English-French bilinguals, 63% of the English monolinguals, and 50% of the Chinese-English bilinguals chose the category “clear, detailed, close-up image” when describing the quality of their mental visualization of artificial logographs in order to memorize them. Overall, there was no difference between the three groups in the quality of their mental visualizing as a strategy to recall the artificial logographs and their meanings, $\chi^2 (2) = 1.62, ns$. 
Table 4.1

Mean Ratings (with SE in parentheses) of Participants’ Reported Cognitive Strategies Used in the Acquisition of the Artificial Logographic Script during Experiment 1 and 2a

<table>
<thead>
<tr>
<th></th>
<th>Bilinguals</th>
<th></th>
<th>Monolinguals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Logographic</td>
<td>Alphabetic</td>
<td>Alphabetic</td>
</tr>
<tr>
<td></td>
<td>(Chinese-English)</td>
<td>(English-French)</td>
<td>(English)</td>
</tr>
<tr>
<td>Task Difficulty¹</td>
<td>3.3 (0.2)</td>
<td>3.1 (0.2)</td>
<td>3.0 (0.2)</td>
</tr>
<tr>
<td>Private Speech²</td>
<td>4.2 (0.3)</td>
<td>4.6 (0.2)</td>
<td>4.4 (0.2)</td>
</tr>
<tr>
<td>Hieroglyphicity²</td>
<td>2.8 (0.2)</td>
<td>2.8 (0.2)</td>
<td>2.1 (0.3)**</td>
</tr>
<tr>
<td>Quality of Naming³</td>
<td>1.7 (0.3)</td>
<td>1.3 (0.1)</td>
<td>1.1 (0.1)*</td>
</tr>
<tr>
<td>Quality of Visualizing³</td>
<td>2.0 (0.3)</td>
<td>1.6 (0.3)</td>
<td>1.6 (0.3)</td>
</tr>
<tr>
<td>Rehearsal Typeª</td>
<td>2.6 (0.2)</td>
<td>2.3 (0.2)</td>
<td>2.8 (0.2)</td>
</tr>
</tbody>
</table>

Note. All items were rated on a 5 point Likert-scale as indicated below.
¹ Difficult (1) to Easy (5).
² Most (1) to Least (5).
³ Highest (1) to Lowest (5).
ª Verbal (1) to Visual (5).

* $p < 0.1$, for Logographic L1 vs. Alphabetic L1.
** $p < .05$, for Bilingual vs. Monolingual.

Discussion

The Chinese-English bilinguals, English-French bilinguals and English monolinguals demonstrated very little difference when learning the artificial logographs and their meanings and all three of the groups rated the learning of the artificial logography as equally easy (or difficult). Visual and verbal processes were found to be equally important for all three groups in the acquisition of the artificial script and no evidence to support a visually orientated acquisition trend for L2 logographic script was attained. Furthermore, both inner naming and inner visualizing ranked as important strategies that the majority of participants utilized to memorize the artificial logographs.
Private speech did not appear to play a major role in the acquisition of the artificial logographs.

Hieroglyphicity appeared to be a strategy relied on most by monolingual participants. Prior studies have found a bilingual advantage over monolinguals in the acquisition of new vocabulary items. For example, Thomas (1988) found that bilingual English-speaking students outperformed monolingual English-speaking students on the acquisition of French vocabulary items. Hence, it is possible that the monolingual English language learners, who might be less accomplished at retaining new vocabulary items than their bilingual counterparts, needed to rely more on hieroglyphicity as a compensatory strategy in order to recall the artificial logographs and their meaning associations.

Even though the L1 logographic and alphabetic language learners utilized the same strategies and cognitive techniques to learn the artificial script, a marginal difference was found in terms of the efficacy of these strategies, that is, the L1 logographic language learners rated the quality of their verbal inner speech as marginally lower than both the L1 alphabetic groups. This effect, though relatively weak, does suggest the possibility of an inner speech cultural effect based on L1 orthographic background and offers tentative support for studies which have found that phonological activations in L2 reading are less crucial for logographic background readers than for alphabetic background readers (e.g., Akamatsu, 2003; Koda, 1989,1990; Mori, 1998).

In sum, both verbal and visual inner speech played an important role in learning a set of artificial logographs and their semantic associations and no visually-orientated learning trend was attained in relation to participants’ L1 orthographic background. However, a visually-orientated learning trend was attained with monolinguals relying more on hieroglyphicity than their bilingual counterparts.

*WM Studies Experiments 3a and 3b*

In the WM studies, different groups of Chinese-English bilinguals, English-French bilinguals and English monolinguals learned a similar artificial logographic script. They did so under the same conditions except for three main differences. First, the artificial logographic script they acquired consisted of only 10 artificial logographs
and their meanings, compared with 12 in the reading experiments. Second, the meaning associations paired with the artificial logographs used in the WM studies consisted of nouns only, compared with the mixed noun and verbs of the artificial script used in the reading studies. Third, the acquisition phase consisted of only one learning session in the WM studies compared with the two learning sessions in the reading experiments.

In the previous investigation involving the participants of the reading experiments it was found that, when learning the artificial logographs, the Chinese language learners rated the quality of their inner naming as lower than their L1 alphabetic counterparts. It was also found that the monolingual English group relied more on hieroglyphicity than the bilingual groups (Chinese-English bilinguals and English-French bilinguals) as a strategy to learn the artificial logographs. It was predicted that these two trends would be repeated.

Method Experiments 3a and 3b

Participants
The same individuals from the WM experiments (Experiments 3a and 3b).

Materials
The same questionnaire as before.

Procedure
The questionnaire was administered in the participant’s native language on conclusion of all WM tasks.

Design and Analysis
As for the questionnaire data in Experiments 1 and 2a.

Results
Table 4.2 shows the mean ratings of participants who chose each statement as the best description of the cognitive processes they engaged in when acquiring the artificial logographs and their meanings. Kruskal-Wallis tests for independent samples with Group (Chinese-English bilinguals vs. English-French bilinguals vs. English monolinguals) as the between-subjects factor were conducted on the following variables: task difficulty, private speech, hieroglyphicity, type of rehearsal (verbal vs. visual), quality of inner naming and quality of inner visualizing.
Task difficulty. The majority of participants in all three groups rated this task as either “not difficult but not easy either” or “easy”. More than 40% of the Chinese-English bilinguals rate the task as “very easy” compared with 7% of the English-French bilinguals and 18% of the English monolinguals. However, as with Experiments 1 and 2a, the three groups were not significantly different, $\chi^2 (2) = 3.45, ns$.

Private speech. As with Experiments 1 and 2a, the majority of the participants in all three groups uttered little or no private speech. There was no difference between the three groups based on the amount of private speech uttered when learning the artificial logographs and their meaning associations, $\chi^2 (2) = 2.29, ns$.

Hieroglyphicity. The spread of ratings was fairly even among the three groups, with most participants associating at least some of the artificial logographs with real world objects to assist their memorization. Unlike the results of Experiments 1 and 2a, where the bilinguals used less hieroglyphicity than the monolinguals, no significant group differences were detected here, $\chi^2 (2) = 0.28, ns$.

Type of rehearsal. As with Experiments 1 and 2a, the majority of the participants in all three groups both named and visualized artificial logographs and their meanings when memorizing them. There was no difference between the three groups, $\chi^2 (2) = 0.58, ns$.

Quality of naming. The majority of the English monolinguals (73%) and English-French bilinguals (76%) chose the category “full name, well pronounced” when commenting on the quality of their inner naming of the artificial logographs. In contrast, only 20% of the Chinese-English bilinguals chose this category. A Kruskal-Wallis test for independent samples revealed significant group differences, $\chi^2 (2) = 11.4, p < .004$. Planned comparisons confirmed that the Chinese-English bilinguals rated the quality of their inner naming as being of significantly poorer quality than the English-French bilinguals and the English monolinguals, $p < .05$. The English-French bilinguals and English monolinguals did not differ on their inner naming ratings. This pattern of results indicates an L1 background effect, with L1 logographic participants rating the quality of their inner speech as lower than their L1 alphabetic counterparts.

Quality of visualizing. At least half of the participants in all three groups described the quality of their inner visualizing as either a “clear, detailed, close-up
image” or “clear, detailed, distant image”. No significant group differences were found, $\chi^2 (2) = 2.12, ns.$

Table 4.2
Mean Ratings (with SE in parentheses) of Participants’ Reported Cognitive Strategies Used in the Acquisition of the Artificial Logographic Script during the WM Experiments

<table>
<thead>
<tr>
<th></th>
<th>Bilinguals</th>
<th></th>
<th>Monolinguals</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Logographic</td>
<td>Alphabetic</td>
<td>Alphabetic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Chinese-English)</td>
<td>(English-French)</td>
<td>(English)</td>
<td></td>
</tr>
<tr>
<td>Task Difficulty¹</td>
<td>3.9 (0.2)</td>
<td>3.5 (0.2)</td>
<td>3.3 (0.2)</td>
<td></td>
</tr>
<tr>
<td>Private Speech²</td>
<td>3.9 (0.3)</td>
<td>4.2 (0.3)</td>
<td>4.5 (0.2)</td>
<td></td>
</tr>
<tr>
<td>Hieroglyphicity²</td>
<td>2.3 (0.2)</td>
<td>2.5 (0.4)</td>
<td>2.3 (0.3)</td>
<td></td>
</tr>
<tr>
<td>Quality of Naming³</td>
<td>2.9 (0.3)</td>
<td>1.6 (0.4)</td>
<td>1.6 (0.2)*</td>
<td></td>
</tr>
<tr>
<td>Quality of Visualizing³</td>
<td>2.5 (0.3)</td>
<td>1.9 (0.4)</td>
<td>2.4 (0.3)</td>
<td></td>
</tr>
<tr>
<td>Rehearsal Typeª</td>
<td>2.4 (0.1)</td>
<td>2.2 (0.2)</td>
<td>2.4 (0.2)</td>
<td></td>
</tr>
</tbody>
</table>

Note. All items were rated on a 5 point Likert-scale as indicated below.
¹ Difficult (1) to Easy (5).
² Most (1) to Least (5).
³ Highest (1) to Lowest (5).
ª Verbal (1) to Visual (5).

* $p < .05$. Logographic L1 vs. Alphabetic L1

Discussion

As with the previous investigation, there was very little difference between the Chinese-English bilinguals, English-French bilinguals and the English monolinguals. All three groups rated learning the artificial logographs as equally easy (or difficult). Again, an overall combination of visual and verbal processes was found to be equally important in learning the script for all participants indicating that no visual processing
orientation was found for the L1 logographic Chinese-English bilinguals. Most participants in all three groups utilized hieroglyphicity and private speech to some degree to facilitate learning the artificial logographs. Overall, participants in all three of the groups tended to rate their inner visualizing of the artificial logographs fairly highly. However, this was not the case when participants rated the quality of their inner naming.

As predicted, the Chinese-English bilinguals rated the quality of their inner speech as significantly lower than their English monolingual and English-French bilingual counterparts. That this effect held up with different participant groups is indicative of the robustness of the finding. Clearly, logographic background participants feel less confident than alphabetic language learners about the quality of their inner speech. Recall that inner speech is an important cognitive phenomenon closely related to language development and problem solving (Vygotsky, 1986). These cross-cultural differences in the qualitative nature of inner speech reflect a general difference in phonological processing. Based on the findings of studies like Hanley and Huang (1997), it was argued in earlier chapters that Chinese logographic processing may require more visually-oriented processing strategies whereas English alphabetic processing may require more phonologically oriented cognitive strategies. The lower quality inner speech of the logographic Chinese is consistent with this argument.

In the investigation involving the participants of the reading experiments, the English monolinguals relied more on hieroglyphicity than the bilingual groups. However, in the present investigation this was not the case. Contrary to predictions, all three groups relied equally on the strategy of hieroglyphicity to memorize the artificial logographs. A possible explanation for this result might be that the artificial script in the present investigation was easier to memorize than the one used in the prior reading experiments. For example, the artificial logographic script used in the reading experiments contained 12 artificial orthographic structures with grammatically mixed meaning associations (six nouns and six verbs) whereas in the WM studies, the script contained only 10 artificial logographic structures with 10 meaning associations (all nouns). Therefore, the less complicated script may have been easier to memorize than the more complicated one. This may have reduced participants’ dependence on mnemonic strategies such as hieroglyphicity.
In summary, all participants relied on a combination of visual and verbal strategies to acquire the artificial logographs. Even though the three groups utilized the same cognitive strategies, the Chinese-English bilinguals again rated the quality of their inner speech as lower than their L1 alphabetic counterparts. The repeated nature of this trend indicates that the finding is reliable. This L1 background effect supports the general argument that logographic Chinese adopt cognitive processing strategies less reliant on phonological processing than their alphabetic L1 counterparts. This provides general support for the main argument of the present study. It was also argued that the utilization of hieroglyphicity as a language acquisition strategy by monolinguals may be affected by the complexity of the script to be acquired.

*Processing the Artificial Logographs*

The next investigation involved an analysis of participants’ interpretations of cognitive phenomena related to their processing of the artificial logographs.

*Reading Studies*

In the previous two investigations, the focus was on the cognitive strategies deployed by language learners in the acquisition of an artificial logography. In the present analysis, the focus on cognitive strategies shifts from acquisition to syntactic processing of the artificial logography (Experiment 2a). As before, it was predicted that the L1 logographic Chinese language users would utilize more visually orientated cognitive strategies than their L1 alphabetic counterparts when processing artificial logograph strings. Based on the previous investigations, it was predicted that the L1 logographic language learners would rate the quality of their inner speech as lower than the L1 alphabetic language learners. Again, a questionnaire was utilized to investigate participants’ reported cognitive strategies, this time when processing artificial logograph strings during the syntactic decision task (Experiment 2a).

*Method Experiment 2a*

*Participants*

The same individuals from Experiments 1 and 2a.

*Materials*

As before.
**Procedure**

As before.

*Design and Analysis*

As before.

**Results**

Table 4.3 shows the mean ratings of participants who chose each statement as the best description of cognitive processes, which took place when making syntactic judgements on artificial logograph strings. Kruskal-Wallis tests for independent samples with Group (Chinese-English bilinguals vs. English-French bilinguals vs. English monolinguals) as the between-subjects factor were conducted to identify any trends during the syntactic processing of the artificial logograph strings.

**Task difficulty.** Only 20% of the Chinese-English bilinguals, and 23% of English-French bilinguals found the task difficult or very difficult compared to 60% of the English monolinguals. There was a significant difference between the perceived difficulty of processing the artificial logograph strings during the syntactic decision task by the Chinese-English bilingual, English-French bilingual and English monolingual groups, $\chi^2 (2) = 13.04, p < .002$. Planned comparisons supported the observation that the Chinese-English bilinguals considered the processing of the logograph strings significantly easier than the English monolinguals, $p < .05$. However, there were no significant differences between either the Chinese-English bilinguals and the English-French bilinguals or the English-French bilinguals and the English monolinguals.

**Private speech.** Private speech utterances were fairly evenly spread among the three groups and the majority of participants uttered private speech when processing the artificial logograph strings. There was no difference in the amount of private speech uttered by the three groups, $\chi^2 (2) = 2.34, ns$.

**Hieroglyphicity.** The majority of participants in all three groups utilized the associations of real world objects with the artificial logographs as a mnemonic strategy when processing the artificial logograph strings during the syntactic decision task. The group difference was marginally significant, $\chi^2 (2) = 5.92, p < .06$. A further Kruskal-Wallis test revealed no differences based on L1 orthographic background (Chinese-English bilinguals (logographic) vs. alphabetic), $\chi^2 (1) = .55, ns$. However, there was a
bilingual effect, with the bilinguals relying significantly less on hieroglyphicity than the monolinguals, $\chi^2 (1) = 5.62, p < .02$.

**Naming.** All participants named target logographs in their minds to some degree when making syntactic decisions. The spread of responses was evenly distributed among the three groups, $\chi^2 (2) = 2.77, \text{ns}$.

**Quality of naming.** Regarding participants’ commentary on the quality of their mental naming of logographs when making syntactic judgements, only 17% of Chinese-English bilinguals, compared to 61% of English-French bilinguals and 75% of English monolinguals, chose the category of “full name, well pronounced.” There was a significant difference between the three groups’ ratings on the quality of their inner naming, $\chi^2 (2) = 12.34, p < .003$. Planned comparisons revealed that the Chinese-English bilinguals rated the quality of their inner naming of artificial logographs as significantly lower than both the English monolinguals and the English-French bilinguals, all $ps < .05$, who did not differ on this factor. Hence, the L1 logographic background participants rated the quality of their inner speech as lower than their L1 alphabetic background counterparts.

**Visualizing.** Participants were also questioned on any inner visualization of the artificial logographs that occurred when undertaking the syntactic decision task. The majority of participants in all three groups visualized the artificial logographs when making syntactic decisions, and no significant group difference was attained, $\chi^2 (2) = 0.72, \text{ns}$.

**Quality of visualizing.** In regard to participants’ commentary on the quality of the visual imagery conjured in their minds when processing the artificial logograph strings, the Chinese-English bilinguals (67%) and the English-French bilinguals (58%) rated the quality of their visualizing of logographs as higher than the English monolinguals (36%) by choosing the category, “Clear, detailed, close-up image.” However, no overall significant difference was identified between groups, $\chi^2 (2) = 1.81, \text{ns}$. 
Table 4.3

*Mean Ratings (with SE in parentheses) of Participants’ Reported Cognitive Strategies Used when Processing Artificial Logograph Strings during Experiment 2a*

<table>
<thead>
<tr>
<th>Bilinguals (Chinese-English)</th>
<th>Monolinguals (English-French)</th>
<th>Monolinguals (English)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task Difficulty&lt;sup&gt;1&lt;/sup&gt;</td>
<td>3.5 (0.3)</td>
<td>3.0 (0.2)</td>
</tr>
<tr>
<td>Private Speech&lt;sup&gt;2&lt;/sup&gt;</td>
<td>3.2 (0.3)</td>
<td>3.8 (0.3)</td>
</tr>
<tr>
<td>Hieroglyphicity&lt;sup&gt;2&lt;/sup&gt;</td>
<td>3.0 (0.2)</td>
<td>3.2 (0.3)</td>
</tr>
<tr>
<td>Naming&lt;sup&gt;2&lt;/sup&gt;</td>
<td>2.7 (0.2)</td>
<td>2.4 (0.2)</td>
</tr>
<tr>
<td>Quality of Naming&lt;sup&gt;3&lt;/sup&gt;</td>
<td>2.5 (0.2)</td>
<td>1.6 (0.2)</td>
</tr>
<tr>
<td>Visualizing&lt;sup&gt;2&lt;/sup&gt;</td>
<td>2.9 (0.3)</td>
<td>3.3 (0.3)</td>
</tr>
<tr>
<td>Quality of Visualizing&lt;sup&gt;3&lt;/sup&gt;</td>
<td>1.6 (0.2)</td>
<td>1.8 (0.3)</td>
</tr>
</tbody>
</table>

*Note.* All items were rated on a 5 point Likert-scale as indicated below.

<sup>1</sup> Difficult (1) to Easy (5).

<sup>2</sup> Most (1) to Least (5).

<sup>3</sup> Highest (1) to Lowest (5).

* *<sup>p</sup> < .05, for Logographic L1 vs. Alphabetic L1.*

** *<sup>p</sup> < .05, for Bilingual vs. Monolingual.*

*** *<sup>p</sup> < .05, for Chinese-English Bilingual vs. English Monolingual.*

**Discussion Reading Studies**

Overall, all three groups relied on a combination of visual processing strategies (e.g., hieroglyphicity, inner visualizing) and verbal processing strategies (e.g., inner naming, private speech) when making grammatical judgements on artificial logograph strings. No evidence was attained to suggest a visually-orientated inner speech bias when processing the artificial script, nor was any evidence found to support the idea that L1 logographic language learners utilized more visually-orientated cognitive strategies than verbal ones when processing the artificial script. However, consistent with the
learning phase, monolinguals were again found to rely more on the visually-orientated strategy of hieroglyphicity than their bilingual counterparts when processing the artificial script.

Even though private speech did not appear to play a major role during the acquisition phase of the artificial logography, it came to the fore when processing the artificial script during grammatical judgement decision making. This suggests that the role of private speech, in terms of SLA of logographic script, is one of a linguistic problem-solver rather than an acquisition tool utilized for learning new vocabulary items. This provides tentative support for Vygotsky’s (1986) role of private speech as a speech function that manifests only when cognition is especially challenged and supports prior L2 inner speech reading studies (e.g., Sokolov, 1972) which have found that inner speech increases when reading difficult L2 text.

As before, the Chinese-English bilinguals rated the quality of their inner naming as less than that of both the English-French bilinguals and the English monolinguals. The reduced quality of the L1 logographic Chinese language users’ inner speech compared with the L1 alphabetic language users’ inner speech suggests that phonological activations may have been stronger with L1 alphabetic language users than with the L1 logographic language users. In the reading experiments, where the focus was on acquisition, the difference was a marginal one between the L1 logographic and the L1 alphabetic language learners. However, the difference was reliably stronger when processing the script in a reading-related task (grammatical judgements of symbol strings). In the reading-related grammatical judgement task, the reduced level of verbal (or phonological) inner speech by the Chinese-English bilinguals suggests that they may have been more reliant on orthographic (visual) or semantic factors when processing the artificial logograph strings. The present findings provide support for an inner speech cultural effect resulting from participants’ L1 orthographic background.

In summary, the Chinese-English bilinguals, English-French bilinguals and English monolinguals mostly utilized the same cognitive strategies and techniques to deal with the task demands of making grammatical judgements on logograph strings. However, the results suggest that, even though the same cognitive strategies were engaged by all three language-learning groups to deal with the challenge of processing
the artificial script, participants’ L1 orthographic background, as well as their bilingualism, may have influenced the efficacy of these cognitive strategies, as in the case of the reduced quality of the Chinese-English bilinguals’ inner speech and the monolinguals’ greater reliance on hieroglyphicity.

**WM Studies**

Participants were also questioned on their interpretations of cognitive phenomena activated during the recall of the 10 artificial logographs during the WM tasks of Experiment 3a. Borrowing heavily from the questionnaire used in Experiment 2a (relating to the syntactic decision experiment), participants were questioned on cognitive phenomena related to their WM recall of the acquired artificial logographs. Based on the findings of the previous investigations, it was predicted that the L1 logographic Chinese would again rate the quality of their inner speech as lower than the L1 alphabetic background participants.

**Method Experiments 3a and 3b**

**Participants**

The same individuals from the WM experiments (Experiments 3a and 3b).

**Materials**

The questionnaire of Experiment 2a was adapted and a number of minor changes were introduced making it more relevant to the WM tasks (see Appendix M and N). Two new questions were included relating to the task difficulty of WM recall of artificial logographs under the conditions of concurrent auditory and visuo-spatial suppression. The rest of the questionnaire related only to the WM normal task (recall of artificial logographs without concurrent interference). As with Experiment 2a, participants responded to questions through a five point Likert-scale. Cognitive phenomena such as task difficulty, private speech, hieroglyphicity, naming, the quality of inner naming, visualizing, and the quality of inner visualizing was investigated.

**Procedure**

As before.

**Design and Analysis**

As before.
Results

Table 4.4 shows the mean ratings of participants who chose each statement as the best description of their cognitive processes, which took place when recalling the artificial logographs. Kruskal-Wallis tests for independent samples with Group (Chinese-English bilinguals vs. English-French bilinguals vs. English monolinguals) as the between-subjects factor were conducted to determine any differences in reported subjective experience and processes engaged in when recalling artificial logographs in WM.

Task difficulty (WM normal task). Thirty-eight percent of the English-French bilinguals and 27% of the English monolinguals found recalling the artificial logographs on the WM normal task “difficult”, compared with only 18% of the Chinese-English bilinguals, reflecting a significant group difference, $\chi^2 (2) = 6.37, p < .05$. A further analysis focusing on L1 orthographic background (Chinese-English bilingual (logographic) vs. alphabetic) as the between-subjects factor revealed that the L1 logographic background Chinese-English bilinguals found the task significantly easier than their L1 alphabetic counterparts, $\chi^2 (1) = 6.37, p < .02$.

Private speech (WM Normal task). The majority of the English monolinguals (68%) uttered no private speech when recalling the artificial logographs. In contrast, only 29% of the Chinese-English bilinguals and 24% of the English-French bilinguals uttered no private speech. Again, the participants who uttered private speech chose only responses with the category “short phrases and/or words” and not “full sentences”. These group differences were significant, $\chi^2 (2) = 6.59, p < .04$. Further exploration of the bilingualism effect revealed that overall the bilinguals used significantly more private speech than the monolinguals, $\chi^2 (1) = 6.01, p < .02$.

Hieroglyphicity (WM Normal task). Most of the participants associated at least some of the artificial logographs with real world objects when recalling them. The spread of responses was fairly even across the three groups and no significant group differences were found, $\chi^2 (2) = 1.12, ns$.

Naming (WM Normal task). The majority of the participants in all three groups named most of the artificial logographs in their minds when recalling them in WM. The
spread of responses was fairly even across all three groups and no significant group differences were found, $\chi^2 (2) = 2.16$, ns.

**Quality of naming (WM Normal task).** The majority of English-French bilinguals (76%) and English monolinguals (62%) chose either the category “full name, well pronounced” or “full name, slurred pronunciation” compared with only 36% of the Chinese-English bilinguals, $\chi^2 (2) = 6.12$, $p < .05$. Further exploration of the L1 orthographic background revealed that the L1 logographic Chinese-English bilinguals rated the quality of their inner speech as significantly lower than the L1 alphabetic language learners, $\chi^2 (1) = 5.91$, $p < .02$.

**Visualizing (WM Normal task).** The majority of participants in all three groups visualized at least some of the artificial logographs when recalling them in WM. The spread of responses was fairly even and no significant group trend was attained, $\chi^2 (2) = 0.62$, ns.

**Quality of visualizing (WM Normal task).** The majority of English-French bilinguals (62%) chose the category “clear, detailed, close-up image” when describing the quality of their inner visualizing when recalling the artificial logographs. In contrast, only 13% of the English monolinguals and 29% of the Chinese-English bilinguals chose this category. However, no significant group differences were found, $\chi^2 (2) = 3.03$, ns.

**Task difficulty (WM Auditory Suppression task).** The spread of responses across all three groups was fairly even with most of the participants either choosing the category “very difficult” or “difficult” when describing their recall of artificial logographs under the condition of concurrent auditory suppression. No significant group differences were found, $\chi^2 (2) = 3.11$, ns.

**Task difficulty (WM Visuo-Spatial Suppression task).** The majority of the English monolinguals (55%) chose the category “very difficult” to describe their recall of artificial logographs under the condition of concurrent visuo-spatial suppression. In contrast, only a small percentage of Chinese-English bilinguals (12%) and English-French bilinguals (15%) chose this category. A significant group difference was found, $\chi^2 (2) = 13.1$, $p < .003$. Planned comparisons revealed that the Chinese-English bilinguals and the English-French bilinguals (who did not differ) rated the task as significantly easier than the English monolinguals, ps < .05.
Table 4.4
Mean Ratings (with SE in parentheses) of Participants’ Reported Cognitive Strategies Used when Recalling the Artificial Logographs during Experiment 3a

<table>
<thead>
<tr>
<th></th>
<th>Bilinguals</th>
<th></th>
<th>Monolinguals</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Logographic (Chinese-English)</td>
<td>Alphabetic (English-French)</td>
<td>Alphabetic (English)</td>
<td></td>
</tr>
<tr>
<td><strong>WM tasks</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task Difficulty¹</td>
<td>3.3 (0.3)</td>
<td>2.6 (0.1)</td>
<td>2.6 (0.2)*</td>
<td></td>
</tr>
<tr>
<td>Private Speech²</td>
<td>3.6 (0.3)</td>
<td>3.9 (0.3)</td>
<td>4.4 (0.2)**</td>
<td></td>
</tr>
<tr>
<td>Hieroglyphicity²</td>
<td>2.8 (0.2)</td>
<td>2.4 (0.3)</td>
<td>2.7 (0.3)</td>
<td></td>
</tr>
<tr>
<td>Naming²</td>
<td>2.4 (0.3)</td>
<td>2.1 (0.3)</td>
<td>1.9 (0.2)</td>
<td></td>
</tr>
<tr>
<td>Quality of Naming³</td>
<td>2.9 (0.3)</td>
<td>1.9 (0.4)</td>
<td>2.0 (0.2)*</td>
<td></td>
</tr>
<tr>
<td>Visualizing²</td>
<td>2.8 (0.3)</td>
<td>3.2 (0.4)</td>
<td>3.2 (0.3)</td>
<td></td>
</tr>
<tr>
<td>Quality of Visualizing³</td>
<td>2.5 (0.3)</td>
<td>1.8 (0.4)</td>
<td>2.6 (0.3)</td>
<td></td>
</tr>
<tr>
<td><strong>Auditory Suppression</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task Difficulty¹</td>
<td>1.9 (0.2)</td>
<td>1.4 (0.2)</td>
<td>1.5 (0.1)</td>
<td></td>
</tr>
<tr>
<td><strong>Visuo-Spatial Suppression</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task difficulty¹</td>
<td>2.4 (0.2)</td>
<td>2.2 (0.2)</td>
<td>1.5 (0.1)**</td>
<td></td>
</tr>
</tbody>
</table>

*Note. All items were rated on a 5 point Likert-scale as indicated below.  
¹ Difficult (1) to Easy (5).  
² Most (1) to Least (5).  
³ Highest (1) to Lowest (5).  
* p < .05, for Logographic L1 vs. Alphabetic L1.  
** p < .05, for Bilingual vs. Monolingual.*
Discussion WM Studies

Overall, the present findings indicated that the three groups of participants utilized similar cognitive strategies when processing the artificial logographs during the WM Normal task. The participants of all three groups relied on a combination of verbal processing (e.g., inner naming, private speech) and visual processing (e.g., inner visualizing, hieroglyphicity) when recalling the artificial logographs in WM. In terms of the quality of these processes, the majority of participants in all three groups rated their inner visualizing highly and evenly across groups. However, this was not the case when participants rated the quality of their inner speech.

As predicted, the L1 logographic Chinese rated the quality of their inner speech as lower than the combined L1 alphabetic group of English-French bilinguals and English monolinguals. The recurring pattern of this L1 background trend again indicates its robustness. The cognitive functions of inner speech as a phenomenon crucial to language development, planning and problem solving have been well documented (e.g., De Guerrero, 1994, 1999; Ushakova, 1994; Vygotsky, 1986). Therefore, an inner speech difference between language learners of different L1 orthographic backgrounds constitutes evidence for a difference in cognition. As with the previous investigation, the nature of this difference supports the general argument made in earlier chapters that L1 logographic Chinese may be less capable at phonological processing than their L1 alphabetic counterparts. Furthermore, the logographic Chinese-English bilinguals rated the WM Normal task as significantly easier than the L1 alphabetic language learners. This finding provides evidence that the inculcation of an L1 logographic background facilitates the ease in which orthographically congruent logographic items are processed in WM, which directly supports the language transfer hypothesis outlined in Chapter 1 of this study.

In terms of private speech, the bilinguals produced more utterances than the English monolingual group on the WM Normal task. According to Vygotsky (1986), private speech is a psycho-linguistic tool that is utilized by adults to solve particularly challenging problems. However, the WM Normal task of Experiment 3a did not involve problem solving in any way. Therefore, it is likely that the uttering of private speech during this task had a specific memory function. The uttering of private speech would
automatically trigger phonological associations in the mind and it seems probable that the uttering of private speech during the recall of artificial logographs was facilitating rehearsal in the phonological loop. For example, the participants who used private speech only chose the category “short phrases and/or words” and not “full sentences”. Because the phonological loop is a limited capacity store (Baddeley, 1986), it seems likely that only the phonological associations of the artificial logographs would have been rehearsed. Hence, participants would have uttered the single meanings aloud to themselves. Therefore, the private speech utterances in this context were probably an externalized form of rehearsal in the phonological loop. Because prior research has found that the use of private speech can positively impact on WM processing (e.g., Al-Namlah et al., 2006) it is conceivable that the use of private speech contributed to the superior WM performance of the bilinguals over the monolinguals.

If the uttering of private speech facilitated the ease of recall of artificial logographs, how then was this achieved? Recall that the bilinguals outperformed the monolinguals on the WM Visuo-spatial suppression task in which processing in the VSSP was replaced with processing in the phonological loop. The bilinguals also found this task easier than the monolinguals. It may have been that the bilinguals were uttering private speech as a means to focus their attention on rehearsing the artificial logographs in the phonological loop. Prior research (e.g., Bialystok, 1992, 1997, 1999; Bialystok et al., 2004) has found bilingual processing advantages over monolinguals that were related to higher levels of attention and control during cognitive processing tasks. Therefore, it was possible that the bilinguals’ superiority over the monolinguals may have been a result of their greater ability to switch between the two WM subsystems (the VSSP and the phonological loop). That is, the bilinguals used private speech as a strategy to focus their attention on rehearsing in the phonological loop when deprived of a visuo-spatial processing capability. However, this is highly speculative.

In summary, a significant group difference relating to inner speech provided further evidence for cross-cultural differences in cognitive processing. Furthermore, the L1 logographic background Chinese-English bilinguals rated the WM Normal task as easier than their L1 alphabetic background counterparts, which was consistent with the idea that L1 logographic processing skills were being transferred to a congruent L2
orthography. It was also found that the bilinguals uttered more private speech than the monolinguals, which may have contributed to their superior performance.

**General Discussion**

The primary objectives of the exploration of the cognitive strategies utilized by participants who undertook the reading and WM experiments of the present study, were to determine whether (1) inner speech varies among different L1 background language users when processing an artificial logographic script and (2) whether or not a logographic L2 induces inner processing strategies more orientated toward visual processing than verbal processing. In relation to the first objective, this study provides support for the argument that inner speech does vary among orthographically variant L1 background language users. In terms of both acquiring and processing the artificial logographs, the L1 logographic background language learners consistently rated the quality of their verbal inner speech as lower than the alphabetic L1 background language learners. This effect held across two different groups of participants.

The finding that the L1 logographic language learners consistently rated the quality of their inner speech as lower than the L1 alphabetic language learners suggests that they were less capable at phonological processing. This finding provides converging evidence for the general argument posited in this study concerning the visual/verbal processing orientations of L1 logographic and alphabetic language learners. It was posited in earlier chapters that the inculcation of an L1 logographic writing system may lead to the development of specific L1 visually-related skills. Some evidence was found to support this contention. In the reading study (Experiment 1), the logographic Chinese-English bilinguals outperformed the L1 alphabetic language learners on a lexical decision task that required a high degree of visual processing. This finding was explained as a result of the L1 logographic language learners transferring their specialist L1 reading skills to processing an orthographically congruent logographic writing system. The finding from the questionnaire data that the L1 logographic language learners were less capable at phonological processing than their L1 alphabetic counterparts is consistent with the general argument put forward in this study. That is, the inculcation of a logographic orthography may enhance some specific visual processing skills while similarly, the inculcation of an alphabetic orthography may
enhance some specific phonological processing skills, and that such enhanced skills can be transferred to the processing of a congruent L2 orthography.

One limitation of the present study was the nature of self-report data as an indication of cognitive processing. When quantifying these types of data, there was always the possibility that the participants’ responses may not have accurately reflected what was happening in their minds at the time. However, the lower verbal inner speech ratings of the L1 logographic language learners was considered to be an accurate indication of their mental processing because the present findings converge with evidence taken from a variety of L1 and L2 research fields. For example, a number of L1 word identification studies have demonstrated that phonological activations are crucial for English readers (e.g., Jared & Seidenberg, 1991; Gottlob, Goldinger, Stone, & Van Orden, 1999; Lesch & Pollatsek, 1993; Lukatela & Turvey, 1991, 1994; Van Orden, Johnston, & Hale, 1988), yet less important for Chinese readers (e.g., Chen, Flores d’Arcais, & Cheung, 1995; Ju & Jackson, 1995; Shen & Forster, 1999; Tan, Hoosain, & Peng, 1995; Wong & Chen, 1999). In addition, a number of L2 reading studies have shown that L1 logographic background readers, when deprived of phonology, can process L2 text with less interference than alphabetic L1 background readers (e.g., Koda, 1989, 1990). Furthermore, some L2 reading studies have shown that the reverse of this is also true. For example, when orthographic/visual factors of L2 text are interfered with, L1 logographic background readers perform less well than alphabetic L1 background readers (e.g., Akamatsu, 2003). The finding that L1 logographic language learners’ had poorer quality verbal inner speech than their L1 alphabetic counterparts is consistent with this body of prior research.

In relation to objective (2), the acquisition and processing of artificial logographic script did not result in an overall visually-orientated cognitive processing trend. Instead, the Chinese-English bilinguals, English-French bilinguals and the English monolinguals all used a combination of visual and verbal cognitive strategies in order to acquire the artificial logographs and to use them during the reading and WM tasks. Clearly, visual and verbal strategies play an important role in the acquisition and processing of an L2 logographic script. However, it is possible that the crucial role of inner speech and private speech during the acquisition and processing of the artificial
logographs may have been more a reflection of the task demands than representative of an authentic logographic learning and reading context. For example, the acquisition period of the artificial logographs was limited to two learning sessions spread across a one-week time span for participants who took part in the reading studies and only one session for participants who undertook the WM studies. Therefore, the artificial logographs could be considered low frequency linguistic items. Prior research has indicated that with low frequency words, phonological processing is crucial for lexical retrieval. For example, in a series of six experiments on adult readers, Jared, Levy, and Rayner (1999) found that phonological processes were only activated during the reading of low frequency words. The findings of the present study indicated that when language learners acquire and process an artificial logographic script, they rely on a combination of both verbal and visual inner speech and despite the stylized, highly visual structure of the logographic script, inner visual processing did not predominate. However, it was demonstrated that the quality of the generated verbal inner speech could vary depending on the participants’ L1 orthographic background. Furthermore, the L2 background (or lack thereof) of language learners could also directly impact on the type of inner processing deployed in both acquiring and using an artificial logographic L2 script.

Summary

In this chapter, the cognitive strategies that were deployed by the Chinese-English bilinguals, English-French bilinguals and English monolinguals, when processing the artificial logographs, was investigated. Overall, all three language learner groups relied on a combination of verbal and visual cognitive strategies to process the artificial logographic script. However, in terms of WM processing, the L1 logographic Chinese found the processing of the artificial logographs easier than the L1 alphabetic language learners. This finding indicated that the L1 logographic background of the Chinese-English bilinguals had positively impacted on their processing of a congruent logographic writing system. Furthermore, it was found that the L1 logographic language learners consistently rated the quality of their verbal inner speech as lower than the L1 alphabetic language learners. This finding provided evidence for the argument that L1 logographic language learners have a lesser phonological processing capability than L1 alphabetic language learners due to L1 orthographic background differences. This
provides general support for the argument that the L1 logographic and alphabetic language learners were transferring different phonologically based skill sets to their processing of L2 logographic items. It was also found that bilinguals were more flexible than the monolinguals in their range of cognitive processing strategies, such as utilizing private speech to aid the recall of artificial logographs in WM.

Chapter 5 will summarize briefly the purpose of the study, the findings of the study, the key issues which arose from the discussion, and the study’s contribution to and implications for theory. It will also recommend directions for future research.
CHAPTER 5

The present study explored the language transfer hypothesis from a previously ignored research perspective: the transfer of specific L1 logographic reading skills to L2 logographic processing. Prior research found that alphabetic and syllabic background language learners transfer their L1 orthographic processing skills to L2 alphabetic reading (e.g., Akamatsu, 2003; Chikamatsu, 1996; Koda, 1999, 2000; Muljani et al., 1998). However, little research (if any) had investigated the possibility of L1 to L2 logographic transfer. Therefore, this exploratory study focused on the effects of an L1 logographic background on language learners’ cognitive processing of L2 logographic script.

The main argument of this study was that the inculcation of an L1 logographic orthography (Chinese) could result in the enhancement of visually orientated reading skills which facilitate the ease of processing logographic script. Evidence to support this assumption was found in L1 word identification studies where visual processing was found to be more important to logographic reading (e.g., Chen et al., 1995; Ju & Jackson, 1995; Shen & Forster, 1999; Tan et al., 1995; Wong & Chen, 1999; Zhou & Marslen-Wilson, 2000) than to alphabetic reading (e.g., Gottlob et al., 1999; Lesch & Pollatsek, 1993; Lukatela & Turvey, 1991, 1994; Pollatsek et al., 1992; Van Orden et al., 1988). These orthographic processing differences have been confirmed by recent neurophysiological evidence, indicating that logographic and alphabetic script is processed in different brain regions (e.g., Chen et al., 2002; Nakada et al., 2001; Tan et al., 2001; Yamaguchi et al., 2002). Furthermore, there is evidence that the inculcation of a logographic script may enhance visuo-spatial processing and visual memory skills. For example, studies have found that L1 logographic background participants are better than L1 alphabetic background participants at visual memory tasks (e.g., Demetriou et al., 2005; Flaherty, 2000; Mann, 1985), spatial memory tasks (e.g., Tavasolli, 2002) and on spatial processing tests (e.g., Stevenson et al., 1985; Stevenson & Ying-Lee, 1990; Tamaoka et al., 1993). On the basis of these findings, it was hypothesized that specific L1 logographic (visually-related) reading skills could be transferred to L2 logographic processing, providing significant benefit effects. By contrast, readers lacking an L1 logographic background (i.e., L1 alphabetic English readers) would be disadvantaged.
when processing L2 logographic script. This idea was explored empirically from three main theoretical perspectives: L2 reading, L2 working memory, and language learners’ inner processing strategies.

In order to investigate L2 reading, three experiments were conducted (Experiments 1, 2a, and 2b). In Experiment 1, L1 logographic background language learners (Chinese-English bilinguals) and L1 alphabetic background language learners (English-French bilinguals and English monolinguals) acquired a small set of target artificial logographs and their semantic associations in an artificial script. A lexical decision task tested their ability to identify the targets from a set of structurally similar and dissimilar items. This lexical decision task was constructed to mimic a crucial process involved in reading saccades of Chinese characters, i.e., the repeated fast identification of a complex visual orthographic structure from a combination of different orthographic structures. In reading Chinese text, readers rapidly need to identify highly complex visual orthographic structures, many of which have an unreliable phonological association (Shu et al., 2003). It was found that the Chinese-English bilinguals outperformed the L1 alphabetic background language learners. This finding indicated that the Chinese-English bilinguals had transferred their L1 orthographic (visual) processing skills to an orthographically congruent L2, supporting the main hypothesis in this study. Importantly, the English-French bilinguals and English monolinguals performed the same, indicating that a bilingual background per se did not facilitate the ease of processing an artificial logographic script. Hence, the superior performance by the Chinese-English bilinguals was not attributed to their bilingual history. However, a monolingual Chinese comparison group was not tested here so the full effects of bilingualism on this task are yet to be explored.

To test whether the logographic transfer effect attained in Experiment 1 held at a deeper level of analysis (i.e., grammatical and semantic processing), a syntactic decision task was conducted. The artificial logographs were arranged into a combination of legal and illegal strings. The task was to identify whether or not the presented strings were of the target syntactic form (NVN strings). In Experiment 1, the L1 logographic background language learners outperformed the L1 alphabetic background language learners, thus it was predicted that this trend would be repeated. However, the Chinese-
English bilinguals did not outperform the L1 alphabetic background language learners, indicating that at the sentence level, an L1 logographic background did not facilitate the syntactic processing of L2 artificial logograph strings. No bilingual performance advantage was found here either. However, when carrying out the same task in the native language (Experiment 2b) the bilinguals outperformed the monolinguals, indicating an L1 processing advantage.

In Experiment 1, it was argued that the Chinese-English bilinguals’ superior performance was a result of their enhanced visual processing skills. However, the degree to which phonological processing was playing a part in the processing of the artificial logographs was not fully known. Hence, in order to investigate the visual processing of the artificial logographic script independently of the confounding influence of phonological processing, a series of WM experiments (Experiments 3a and 3b) were conducted.

In Experiment 3a, artificial logographs were recalled with and without concurrent interference. This interference consisted of auditory and visuo-spatial suppression to disrupt phonological and visual processing, respectively. Again, based on the results of Experiment 1, it was predicted that L1 logographic background language learners would outperform the L1 alphabetic background language learners. However, this was not found to be the case. On the auditory suppression task (which required a high degree of visual processing), the Chinese-English bilinguals outperformed the English monolinguals, but not the English-French bilinguals. Hence, it was concluded that an L1 logographic history did not facilitate the ease of visually processing artificial logographs in WM. However, the Chinese-English bilinguals rated the recall of the artificial logographs (without concurrent interference) as easier than the L1 alphabetic background language learners, indicating that, at least on some level, L1 – L2 logographic transfer had taken place. It was also found that the bilinguals outperformed the monolinguals when processing the artificial logographs under concurrent visuo-spatial suppression. This finding indicated that a bilingual background per se provides cognitive processing benefits when recalling L2 logographs.

In Experiment 3b, the recall of a set of artificial logographs without any meaning associations was tested. The assumption here was that artificial logographs lacking
meaning associations would be difficult to verbalize, and consequently, participants would have to rely on their visual processing skills. Therefore, it was predicted that the L1 logographic background language learners would outperform the L1 alphabetic background language learners. However, the Chinese-English bilinguals did not outperform the L1 alphabetic background language learners indicating no L1 – L2 logographic transfer effects. In addition, L1 WM was also tested. Here, items were displayed in the participants’ respective native language (either Chinese characters or English words). It was found that the Chinese-English bilinguals outperformed the L1 alphabetic background language learners, indicating a language-specific WM processing differential.

Finally, all participants were questioned on the cognitive strategies that they deployed when acquiring and processing the artificial logographic script. Overall, it was found that the language learners used the same cognitive strategies when learning and processing the artificial script. However, the Chinese-English bilinguals consistently rated the quality of their verbal inner speech as lower than the L1 alphabetic background language learners. This finding suggested that the Chinese-English bilinguals were transferring their L1 phonological skills (or lack thereof) to the processing of the artificial logographs. It was also found that the bilinguals used more private speech when processing the artificial logographs in WM than the monolinguals, indicating a greater range of cognitive processing strategies. In the next section, the implications of these findings and recommendations for future research will be discussed from the theoretical perspective of language transfer.

Language Transfer Patterns

In the present study, ‘L2’ signified the acquisition of any language (or languages) other than L1. However, when the Chinese-English and English-French bilinguals acquired the artificial logography they were technically acquiring an L3, not an L2. Therefore, the finding that L1 logographic background language learners outperformed L1 alphabetic background language learners on a logographic lexical decision task indicated that L1 to L3 logographic transfer had taken place. Here, the Chinese-English bilinguals were transferring their L1 logographic processing skills to a newly acquired and orthographically congruent script. However, this was not the only
pattern of language transfer found. For example, the finding that a bilingual background benefited L3 WM processing signified L2 to L3 transfer. Furthermore, the finding that a language learner’s L2 experience benefited L1 syntactic processing indicated that backwards L2 to L1 transfer had occurred. These language transfer patterns are illustrated below (see Figure 5.1) and will be discussed in turn.

![Diagram](image)

**Figure 5.1.** The direction of language transfer found in this study. The transfer of L1 logographic processing skills to L3 logographic reading is depicted in (a), the transfer of bilingual (L2) cognitive processing skills to L3 logographic WM recall is depicted in (b) and, in (c) the transfer of bilingual language processing skills to L1 syntactic processing is depicted. Broken and unbroken arrows represent L1 alphabetic and L1 logographic background language learners, respectively.

In Experiment 1, Chinese-English bilinguals outperformed English-French bilinguals and English monolinguals on a lexical decision task using an acquired logographic script (see (a) in Figure 5.1). The virtually identical performance of the English-French bilinguals and English monolinguals indicated that a bilingual language learning history was not providing any cognitive processing benefit effects on this task. Therefore, it was argued that the Chinese-English bilinguals were transferring their L1 logographic reading skills to processing an artificial logographic script. However, a Chinese monolingual group was not tested here. Therefore, it was conceivable that the Chinese participants’ bilingual experience might have positively impacted on their
performance. Hence, further research with a monolingual Chinese group should be conducted. If it is found that the Chinese bilinguals and monolinguals are equally proficient at processing the artificial logographic script, then the argument for an L1 logographic transfer effect can be strengthened.

In addition, because the Chinese-English bilinguals were from Beijing, they would have learnt Hanyu pinyin before they were introduced to Chinese characters. This is significant because Hanyu pinyin is a phonemic representation of the Chinese language using the English alphabet. Essentially, Hanyu pinyin is taught to children in the first two months of school to facilitate the reading of Chinese characters (Siok & Fletcher, 2001). There is evidence to suggest that the acquisition of Hanyu pinyin facilitates the phonological processing ability of Chinese school children (e.g., Siok & Fletcher, 2001; Wang, Perfetti, & Liu, 2005). Therefore, in the present study, it was possible that the Chinese-English bilinguals’ exposure to Hanyu pinyin might have equipped them with a phonological awareness not related to their L1 logographic history. Future research might avoid this situation through the testing of Chinese participants from Hong Kong, where it is common for children to learn to read Chinese characters from rote memory without any help from a phonetic script (Siok & Fletcher).

Nonetheless, the present finding indicated that L1–L3 logographic transfer had taken place. The key implication of this finding is that L1 orthographic transfer effects are not limited to alphabetic or syllabic languages. Just as an L1 alphabetic and syllabic background can result in the development of skills which aid in processing L2 alphabetic and or syllabic text (e.g., Akamatsu, 2003; Chikamatsu, 1996; Koda, 1999, 2000; Muljani et al., 1998), so too can the inculcation of an L1 logography provide significant performance benefits when processing L3 logographic script.

However, evidence for the transfer of L1 logographic processing skills on deeper level processing tasks (such as L2 syntactic processing (Experiment 2a) and L2 WM (Experiment 3a)) was less conclusive. On these tasks, the Chinese-English bilinguals performed the same as the English-French bilinguals. The implication here is that the Chinese-English bilinguals’ specialist L1 logographic processing skills may be limited to the visual identification of complex orthographic structures (as in Experiment 1). That is, when deeper level processing skills are required, such as syntactic and WM
processing, the L1 logographic and L1 alphabetic background language learners process artificial logographic script similarly. Hence, logographic transfer effects may be limited to perceptual skills related only to Chinese orthographic processing and that, when tasks require deeper level processing skills, an L1 logographic background advantage dissipates. Hence, it is recommended that future research investigating logographic transfer effects focus on perceptual processes closely related to logographic reading. That is, research should explore how L1 orthographically variant readers recognize the intricate structural permutations of L2 logographic orthography.

Even though the Chinese-English bilinguals’ performance on deeper level processing tasks did not indicate an L1 logographic background advantage, the questionnaire data (Chapter 4) revealed that some L1 – L3 logographic transfer had occurred. For example, the Chinese-English bilinguals rated the recall of the artificial logographs in WM (Experiment 3a) as easier than the English-French bilinguals and English monolinguals (who found the task equally difficult). This finding indicated that an L1 logographic background facilitated the ease of processing the artificial logographic script, but not to the extent that significant performance benefits were found. The main implication here for future research is that L2 WM paradigms involving artificial logographic scripts may not be sensitive enough to detect any performance-based logographic transfer effects. Hence, it is again recommended that future research seeking to explore logographic transfer effects concentrate on perceptual processing rather than deeper level L2 WM investigations.

In addition, the questionnaire data also revealed that the L1 logographic background language learners consistently rated the quality of their verbal inner speech as lower than the L1 alphabetic background language learners. This finding suggested that the L1 logographic background language learners were less capable at phonological processing than their L1 alphabetic counterparts, which supports the idea that the inculcation of a logographic writing system orients readers toward less of a dependence on phonological processing than L1 alphabetic language learners. This finding provides support for the language transfer hypothesis, in that the L1 logographic Chinese-English bilinguals were transferring their L1 phonological processing skills (or lack thereof) to the acquisition and processing of L2 logographic script.
Furthermore, the finding of a differential between variant L1 orthographic background language learners’ inner speech has an important theoretical implication for psycholinguistic research. Inner speech is a unique phenomenon, which is both social (or cultural) and cognitive at the same time (Vygotsky, 1986). For example, language and sign systems are psychological tools, which are internalized through a long process of social and cultural behaviour. This inculcation of language results in a transformation of consciousness, such as the development of the higher mental functions, (e.g., memory, attention, and problem solving (Vygotsky, 1978)). Therefore, a finding indicating an inner speech difference related to the L1 orthographic background of language learners provides support for Vygotskyan sociocultural theory (1978, 1986). That is, different psychological tools, such as logographic Chinese and alphabetic English writing systems, once internalized, result in different processing orientations. Arguably, these different processing orientations manifested in terms of lower quality verbal inner speech generation by L1 logographic background language learners. Consequently, this area warrants future research, particularly in terms of the impact of L1 orthography on the generation of inner speech during complex L2 processing and language acquisition tasks. Moreover, a cross-cultural inner speech investigation of participants processing an artificial logographic script constitutes a novel approach to psycholinguistic research. While some studies have investigated cross-cultural private speech (e.g., McCafferty, 1992, 1998), cross-cultural inner speech has been largely ignored in the literature. The key issue here is that research that investigates cognitive processing through an experimental psychology methodological framework may also benefit from the incorporation of a constructivist perspective into their research paradigms. Language transfer research has not investigated Vygotskyan psycholinguistic perspectives and it is posited here that such an approach may provide further insight into the complex processes involved in acquiring and using an L2 (or an L3).

Even though the Chinese-English bilinguals’ performance on deeper level L2 logographic processing tasks (e.g., Experiments 2a and 3a) did not indicate any L1 logographic background performance advantages, the findings of the L1 WM task (Experiment 3b) did provide evidence for a language-specific processing differential.
For example, Chinese-English bilinguals’ spans for Chinese words were longer than the English-French bilinguals and English monolinguals’ spans for English words. Because the Chinese and English language items were carefully balanced in terms of temporal word length, this word span advantage of the Chinese speakers could not be explained by a faster rehearsal rate of items in the phonological loop. Therefore, it was likely that some other process was involved which enabled the Chinese-English bilinguals to retain more L1 language items in WM. This finding is significant, because it satisfies a basic condition necessary for language transfer to occur. That is, logographic and alphabetic writing systems are not the same and, consequently, are processed differently.

Conceivably, this L1 WM processing differential may be related to visuo-spatial processing. For example, prior research has found that visual processing does not play a critical role in the recall of L1 alphabetic English words (e.g., Baddeley, 1966; Cheung & Kemper, 1994; Cimbalo & Laughery, 1967), but is important in the recall of L1 logographic Chinese characters (e.g., Hue & Erickson, 1988; Mou & Anderson, 1981; Zhang & Simon, 1985). Furthermore, the findings of the present study (Experiment 3a) indicated that visuo-spatial processing played a significant role in the recall of structurally complex L2 logographic language items. Hence, considering the critical role that visual processing plays in the WM recall of both L1 and L2 logographic items, and the relatively autonomous role of phonological processing in L1 alphabetic language items, it is conceivable that the L1 WM processing differential found in the present study (Experiment 3b) is related to visual processing. However, this is highly speculative. Even though some research has been conducted in this area (e.g., Cheung & Kemper, 1993, 1994; Cheung et al., 2000; Kimura, 1984), further investigation is needed to determine the precise nature of this L1 WM difference.

In summary, evidence was found to support the idea that L1 logographic background language learners transfer their specific orthographic processing skills to processing an orthographically congruent L3. However, the nature of such transfer may be (mostly) limited to perceptual processes involved in the recognition of orthographic structures. Consequently, it was recommended that future research should focus on investigating logographic transfer from this perspective. Even though L1 logographic background language learners found processing an artificial logographic script in WM
easier than the L1 alphabetic background language learners, they did not outperform them. The implication here was that the L2 WM paradigm in the present study was not sensitive enough to detect an L1 – L3 logographic transfer effect. An inner speech differential was also found suggesting that the L1 logographic background language learners were transferring their L1 phonological processing skills (or lack thereof) to L3 logographic processing. It was recommended that future research incorporate psycholinguistic perspectives into experimental language research designs to further understand the complex processes involved in language acquisition. It was also found that Chinese characters and English words were processed differently in L1 WM. It was recommended that future research explore the nature of this difference. In the next section, the transfer of bilingual-related skills to L3 and L1 processing will be discussed.

Even though bilinguality was not the major focus of this study, strong L2 effects were found, particularly regarding the processing of artificial logographs in WM (see (b) in Figure 5.1). Because few (if any) studies have investigated bilingual effects on processing artificial logographs, these findings were considered important and warrant discussion here. In Experiments 1 and 2a, it was found that a language learner’s bilingual background had no impact on performance when reading an L3 artificial logography. However, in Experiment 3a, it was found that bilinguality provided significant performance benefits when processing an L3 artificial logography in WM. The bilinguals outperformed the monolinguals on the Visuo-Spatial Suppression task, whereby participants were deprived of processing in the visual subsystem. The bilinguals also found this task easier than the monolinguals. These findings indicated that the bilinguals were able to substitute phonological processing for visual processing when denied access to the visual subsystem, indicating a superior ability to focus their attention and control while processing the artificial logographs. Furthermore, on the L1 WM (Experiment 3b) and the WM Normal Tasks (Experiment 3a), which did not require high levels of attention and control, the English-French bilinguals performed equally with the English monolinguals. Therefore, it was likely that the bilinguals’ superior performance on the Visuo-Spatial Suppression Task (Experiment 3a) was the result of an increased ability to control executive functions. This finding supports the work of Bialystok and colleagues (1992, 1997, 1999; Bialystok et al., 2004) who have
found that bilinguals outperform monolinguals on tasks requiring high levels of executive control. The main implication of this finding is that acquisition of a second language can result in the development of skills pertaining to higher levels of attention and control and that these skills can be transferred to L3 cognitive processing. It is recommended that further research explore the effects of a bilingual background on L3 WM processes. In particular, tasks that require high levels of executive control (e.g., concurrent auditory and visuo-spatial suppression) should be incorporated into future research paradigms to consolidate the findings of this study. The important take-home message here is that the acquisition of an L2 has the ability to profoundly impact on a language learner’s cognitive processing skills.

Additionally, the questionnaire data revealed that the bilinguals used more private speech than the monolinguals when recalling L2 logographic items in WM. Arguably, the use of private speech facilitated the ease of recall of the artificial logographs for the bilinguals. Recall that studies have found positive links between children’s private speech and their STM performance (e.g., Al-Namlah et al., 2006). However, in the present study it was not known for certain whether the use of private speech was facilitating L2 WM processing. Therefore, future research should determine if this was, in fact, the case. It may have been that the bilinguals were uttering private speech as a way to focus attention on recalling L2 logographic items in WM. Thus, future investigations should explore the relationship between private speech and the exercise of executive control in L2 WM.

A bilingual history was also found to benefit L1 processing (see (c) in Figure 5.1). In Experiment 2b of this study, syntactic judgements were made on native language word/character strings. It was found that the Chinese-English bilinguals and the English-French bilinguals outperformed the English monolinguals on this task. This result was explained by the likelihood that the bilinguals were more familiar with explicit grammatical knowledge than the English monolingual group. Consequently, this awareness would have facilitated the faster identification of syntactic strings. Hence, it was argued that a bilingual background can positively impact on a language learner’s metalinguistic awareness. This finding is in line with numerous studies which have found that bilingualism increases the metalinguistic awareness of language learners.
The key implication here is that language transfer is not unidirectional. That is, a language learner’s L2 background can significantly affect L1 processing and vice versa. Recently, research into the effects of an L2 on native language processing has been gaining ground (see Cook, 2003) and the present finding is a modest contribution to this emerging research field.

In summary, evidence for a bilingual advantage when processing artificial logographs in WM was found. Because this processing advantage was detected under the condition of concurrent visuo-spatial interference, it was argued that the bilinguals had exercised higher levels of executive control than the monolinguals. It was conjectured that the use of private speech might have facilitated the bilinguals’ performance. It was recommended that future research explore L2 WM processing and the use of private speech through tasks requiring high levels of executive control. Finally, it was found that a bilingual background facilitated L1 syntactic processing. The main implication here is that language transfer is not unidirectional and that the acquisition of a second language has the ability to profoundly affect cognitive processing in L1, as well as L3.

Future Directions

This study approached the investigation of language transfer from a number of unorthodox perspectives. For example, the use of an artificial logographic orthography provided a way to investigate logographic transfer from the perspective of logographic and alphabetic background language learners. Up until now, research has mostly focused on L1 alphabetic, syllabic and logographic background language learners processing L2 alphabetic or syllabic script. Even though some studies (e.g., Wang et al., 2006) have investigated L2 logographic processing, it has been from the perspective of L1 alphabetic background language learners only. The use of an artificial logographic orthography constitutes a new research paradigm to the fields of SLA, L2 reading, L2 WM, and L2 psycholinguistic research. Furthermore, the incorporation of these research perspectives into a singular research design is, in itself, unorthodox and has revealed the interrelatedness of a number of cognitive processes across different domains. For example, it was found that the ontogenetic phenomenon of private speech was used as a
bilingual strategy during the WM processing of L2 logographs. This finding is, in effect, a conglomerate of sociocultural theory, experimental and cognitive psychology, and SLA. The interdisciplinary approach adopted here has provided a broad lens from which to view a number of cognitive processes from a variety of theoretical perspectives. Furthermore, in this study the methods were quite contrastive, that is, the use of paradigms from experimental psychology with the integration of a constructivist theoretical perspective constitute two research extremes. The more contrastive the methodologies, the more confident the researcher can be when data correspond (Cohen & Manion, 1994). Hence, the findings of this research, through cross-validation from a variety of methodological approaches, lent greater currency to the findings. Therefore, it is recommended that future research investigating L1 orthographic background effects on L2 logographic processing incorporate an interdisciplinary approach that combines the theoretical perspectives and methodological paradigms of SLA, experimental psychology (reading and WM) and Vygotskian sociocultural theory (inner and private speech). In this way, both the intrapsychological and the interpsychological aspects of language processing can be investigated.

Conclusion

This study investigated cross-linguistic variation and the transfer of L1 orthographic processing skills to logographic reading and WM contexts. Evidence was found to indicate that language learners transfer specific L1 orthographic processing skills to L3 logographic processing. In addition, evidence was also found indicating that a bilingual history enhances cognitive performance in both L1 and L3. However, the study also revealed a uniformity of cognitive processing that cut across linguistic and cultural backgrounds.
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Appendix A
Definition of terms as used in this study

Inner speech: In this proposal inner speech is a generic term involving any speech for oneself. This includes covert mental language related to processes involving problem solving, mental rehearsal or practice, memory storage/retention, language learning and development, and any speech codes utilized in silent reading. It is generally assumed that this speech of the mind has a multitude of functions and forms.

Graphophonnic processes: The processes involved in the translation of the grapheme to the phoneme, that is, from the written symbol to the sound equivalent.

Hieroglyphicity: The subjective association of an abstract shape with a real world object.

Kana script: Japanese syllabaries of hiragana and katakana.

Kanji: Chinese characters used in the Japanese writing system.

Kusho: A non-verbal private gesture specific to Chinese character learning cultural members like Chinese and Japanese.

Lexical decision: A common experimental technique of cognitive psychology which involves the making of a judgement response based on lexical stimuli.

Logograms: The structural forms of logographic script (e.g., Chinese characters, Sanskrit symbols, Akkadian cuneiform characters).

Logography: A writing system that utilizes symbols and morphemes as representative of semantic and phonetic information.
Morpheme: Units of language in their smallest form with meaning.

Morphograph: A member of a writing culture that utilizes the morpheme as the basic unit of sound representation (e.g., Chinese language users).

Orthography: The words ‘orthography’ and ‘writing system’ overlap in meaning (Cook & Bassetti, 2005). The word ‘script’ refers to the graphic form of the writing system and the word ‘orthography’ refers to the set of rules associated with the writing system (e.g., spelling etc.). Because of the interrelatedness of a writing system’s graphic form and corresponding set of rules for use, the terms ‘orthography’ and ‘script’ are used interchangeably in the thesis unless otherwise indicated. That is, when ‘orthography’ is used, it refers to both the graphic form and the corresponding set of rules associated with the particular writing system under discussion.

Pinyin: The use of the English alphabetic system to represent Chinese words.

Phonograph: A member of a writing culture that utilizes the phoneme as the basic unit of sound representation (e.g., alphabetic script users, e.g., English, Italian etc. and syllabic script users, e.g., Korean Hangul).

Phonological loop: A mechanism associated with the rehearsal of verbal information in working memory.

Phonological store: A storage facility for verbal information in working memory.

Private speech: Also known as egocentric speech. Self-regulatory utterances which fulfill no communicative function (used in this proposal as an overt form of inner speech).

Prosody: the features of rhyme, intonation and stress that give spoken English expression.
Saccade: The movement of the eye from one word to the next during the act of reading.

Speech recoding: The transference of written information into a sound equivalent.

Subvocalization: Silent speech, a term used mostly by cognitive psychologists to describe inner speech in a STM or working memory context.

Subvocal rehearsal: The covert rehearsal of verbal information to prevent decay or memory loss in short-term memory.

Syntactic decision: An experimental technique which requires the making of a judgement response based on grammatical stimuli.

Tachistoscope: A device that resembles a slide projector which is used to present images at precisely timed intervals.

Visual cache: A storage facility for visual and spatial information in working memory.

Working memory: The memory associated with temporary storage and manipulation of information.
Appendix B

_Age of L2 Acquisition and Time Spent in an L2 Environment (in years) of Chinese-English and English-French Bilinguals (Experiment 1, 2a & 2b)_

<table>
<thead>
<tr>
<th>Bilinguals</th>
<th>Chinese-English</th>
<th>English-French</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age of L2 Acquisition</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1–3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>3–6</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>7–12</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>13–18</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td>&gt; 18</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>20</td>
<td>19</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Time spent in L2 Environment</strong></th>
<th>Chinese-English</th>
<th>English-French</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1*</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>1–3</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>3–6</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>6–10</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>&gt; 10</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>20</td>
<td>19</td>
</tr>
</tbody>
</table>

*Participants in this category had spent at least 6 months in an L2 environment but less than 1 full year.*
Appendix C

*Total Mean Word Frequency for Chinese and English Nouns and Verbs - A Comparison of Chinese Nouns and Verbs with English Equivalents from the Set A and Set B Symbol Strings (t tests, two-tailed)*

<table>
<thead>
<tr>
<th></th>
<th>Chinese</th>
<th></th>
<th>English</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td></td>
<td>M (SD)</td>
<td></td>
</tr>
<tr>
<td>Nouns</td>
<td>0.25 (0.2)</td>
<td></td>
<td>0.3 (0.31)</td>
<td>-0.33</td>
</tr>
<tr>
<td>(A)</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Verbs</td>
<td>0.28 (0.2)</td>
<td></td>
<td>0.59 (0.43)</td>
<td>-1.6</td>
</tr>
<tr>
<td>(A)</td>
<td></td>
<td></td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>Nouns</td>
<td>0.17 (0.1)</td>
<td></td>
<td>0.14 (0.1)</td>
<td>0.58</td>
</tr>
<tr>
<td>(B)</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Verbs</td>
<td>0.26 (0.27)</td>
<td></td>
<td>0.53 (0.45)</td>
<td>-1.26</td>
</tr>
<tr>
<td>(B)</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>0.24 (0.19)</td>
<td></td>
<td>0.39 (0.37)</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>46</td>
</tr>
</tbody>
</table>

*Note.* Set A and Set B depicted in parenthesis.

* Equal variances not assumed.

All *p* > .05
Appendix C (continued)

*Total Mean Word Frequency for Chinese and English Nouns and Verbs – A Comparison of the Set A with the Set B Symbol Strings for Chinese and English Nouns and Verbs (t tests, two-tailed)*

<table>
<thead>
<tr>
<th>Symbol String</th>
<th>List A</th>
<th>List B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$(SD)$</td>
</tr>
<tr>
<td>Chinese</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nouns</td>
<td>0.25</td>
<td>(0.2)</td>
</tr>
<tr>
<td>Verbs</td>
<td>0.28</td>
<td>(0.2)</td>
</tr>
<tr>
<td>English</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nouns</td>
<td>0.3</td>
<td>(0.31)</td>
</tr>
<tr>
<td>Verbs</td>
<td>0.59</td>
<td>(0.43)</td>
</tr>
</tbody>
</table>

* Equal variances not assumed.

All $ps > .1$
Appendix D
The Experimental Task Created to Determine Temporal Word Length in English and Chinese.

Native Mandarin speakers (People’s Republic of China) and native English speakers (Australians) were asked to say aloud Set A and Set B nouns and verbs (in their native language). These words were digitally recorded and entered into a computer software programme (SoundForge 7) to determine the temporal word length of each utterance in milliseconds. The aim here was to determine whether or not there was a significant difference in the temporal word length between the English word list and the Chinese word list in Set A and Set B.

Method

Participants
Six Mandarin native speakers from the People’s Republic of China and five Australian English native speakers participated in this experiment (N = 11). All were aged between 19 and 40 years and either had a university degree or were in the process of acquiring one. They were recruited from Queensland University of Technology and were paid a small fee for their participation.

Materials
For both the English and the Chinese items, the nouns and verbs of Set A and Set B were combined into a single set of 21 items consisting of 12 nouns and 9 verbs. These 21 items were randomized five times to create five word/character lists with varying serial orders. Each list was presented as a PowerPoint presentation. English words were presented in Times New Roman font, size 94, and Chinese characters were presented in SimSun font, size 94. In addition, a practice set of 25 English words and 25 corresponding Chinese characters was created. These items were randomly selected from the Australian Oxford Dictionary (1988) and were translated accordingly into Chinese (ABC Chinese-English Dictionary, 1996).

Procedure
Each participant was seated comfortably in a sound-proofed room in front of a computer screen. A head-worn microphone was used to maintain equal distance between
the mouth of the speaker and the microphone. Speech samples were recorded onto
digital audiotape using a JNC digital voice recorder. All participants were told that this
research was aimed at finding out how long it normally takes people to say certain
words in their dominant language and that it was important to pronounce words at their
normal speaking voice. Participants were asked to remain relatively still and make as
little noise as possible during testing. They were presented with word/character lists in
their native language only.

At the beginning of each set, a cross-shaped fixation point appeared at the centre
of the screen for three seconds. Each word/character was then displayed individually at
this location for three seconds. Participants were required to say each presented
word/character aloud at their normal speaking voice upon recognition of each item.
Short breaks were taken after each set. In all, each item from Set A and Set B was
uttered five times by every participant in their native language. One practice trial
preceded the experiment proper. The experiment was conducted in one 20-minute
session per participant.

*Design and Analysis*

All audio data were fed into a computer and saved as a WAV file. These WAV
files were then opened in sound editing software (SoundForge 7) where each utterance
was represented visually as a waveform and measured in ms (see Figure 1). Averaged
data were subjected to *t* tests (two-tailed).

*Figure 1.* An example of a participant’s utterance presented as a visual waveform in
SoundForge 7 software.
Results

For Set A, the temporal word length of the English ($M = 579$, $SD = 93$) and Chinese nouns ($M = 590$, $SD = 50$) was virtually identical, $t(10) = -.26$, ns, as were the temporal word lengths of the English ($M = 557$, $SD = 104$) and Chinese ($M = 568$, $SD = 35$) verb meanings, $t(6) = -.24$, ns. Similarly, for Set B no differences in temporal word length were found between English ($M = 531$, $SD = 78$) and Chinese nouns ($M = 572$, $SD = 42$), $t(10) = -1.1$, ns, and neither were there any differences in temporal word length between the English ($M = 602$, $SD = 169$) and Chinese verbs ($M = 582$, $SD = 48$), $t(6) = 0.3$, ns.

Conclusion

On the basis of this small study, the temporal word length of the English and Chinese nouns and verbs were not different for both Set A and Set B.
Appendix E

Total Mean Temporal Word Length in Milliseconds for Chinese and English Nouns and Verbs - A Comparison of Chinese versus English Temporal Word Length Measures taken from the Set A and Set B Symbol Strings (t tests, two-tailed)

<table>
<thead>
<tr>
<th></th>
<th>Chinese</th>
<th>English</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>t</td>
<td>df</td>
<td>p</td>
</tr>
<tr>
<td>Nouns</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(A)</td>
<td>11133 (752)</td>
<td>10957 (1836)</td>
<td>0.22</td>
<td>7</td>
<td>0.8*</td>
</tr>
<tr>
<td>Verbs</td>
<td>9643 (1544)</td>
<td>9580 (2709)</td>
<td>0.05</td>
<td>10</td>
<td>0.9</td>
</tr>
<tr>
<td>(B)</td>
<td>11045 (4263)</td>
<td>9971 (3571)</td>
<td>0.47</td>
<td>10</td>
<td>0.7</td>
</tr>
<tr>
<td>Verbs</td>
<td>9877 (2281)</td>
<td>9814 (1664)</td>
<td>0.05</td>
<td>10</td>
<td>0.9</td>
</tr>
<tr>
<td>Total</td>
<td>10424 (2488)</td>
<td>10080 (2448)</td>
<td>-0.48</td>
<td>46</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Note. Set A and Set B symbol strings depicted in parenthesis.

* Equal variances not assumed.

All ps > .1
### Total Mean Temporal Word Length in Milliseconds for Chinese and English Nouns and Verbs - A Comparison of the Set A with the Set B Symbol Strings (t tests, two-tailed)

<table>
<thead>
<tr>
<th>Symbol String</th>
<th>List A</th>
<th>List B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>(SD)</td>
</tr>
<tr>
<td><strong>Chinese</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nouns</td>
<td>11133</td>
<td>(752)</td>
</tr>
<tr>
<td>Verbs</td>
<td>9643</td>
<td>(1544)</td>
</tr>
<tr>
<td><strong>English</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nouns</td>
<td>10957</td>
<td>(1836)</td>
</tr>
<tr>
<td>Verbs</td>
<td>9580</td>
<td>(2709)</td>
</tr>
</tbody>
</table>

* Equal variances not assumed.

All $ps > .1$
Appendix F
Analysis of the Learning Criteria Data of Experiment 1 (Chapter 2)

In order to meet the learning criteria, participants had to recall successfully (1) the meaning of each target logograph and (2) the shape of each target logograph structure. The following experiment examines the performance on these tasks.

Method

Participants
The same individuals from Experiment 1, 2a and 2b.

Materials
As in Experiment 1, 2a and 2b.

Procedure
As outlined in the learning phases of Experiment 1 and 2a.

Design and Analysis
Incorrect responses only were subjected to a mixed ANOVA with Group (Chinese bilinguals vs. English bilinguals vs. English monolinguals), Session (Week 1 vs. Week 2), and Set (Set A vs. Set B) as the between-subjects factors and Recall (structure vs. meaning) as the within-subjects factor.

Results
Table 1 shows the mean of incorrect responses associated with recalling the structure and meaning of target logographs. A 3 x 2 x 2 x 2 mixed ANOVA, with Group (Chinese bilinguals vs. English bilinguals vs. English monolinguals), Session (Week 1 vs. Week 2), and Set (Set A vs. Set B) as the between-subjects variables and Recall (structure vs. meaning) as the within-subjects variables revealed no Group x Session x Set x Recall interaction, $F(2, 106) = 3.01, MSE = 3.15, ns$. Neither were there any three-way interactions, all $Fs < 1$. There was no Recall x Set interaction, $F < 1$, however there was a Recall x Session interaction, $F(1, 106) = 5.26, MSE = 5.5, p < .03$. Planned comparisons revealed that fewer meaning recall errors were committed in Week 2 than in Week 1, $p < .001$ and that similarly, fewer structure recall errors were committed in Week 2 than in Week 1, $p < .009$. This indicates a long-term memory effect in that the language learners had retained some of the target logographs’ semantic and structural
information from Week 1. No significant Recall x Group interaction was attained, $F(2, 106) = 2.93, MSE = 3.06$, $ns$. There was no significant Recall main effect, $F < 1$, indicating that overall the structures of target logographs were as easy (or difficult) to recall as their meanings. There was no Group main effect, $F < 1$, indicating that overall the three groups found the recall task equally easy (or difficult). There was no Set main effect, $F < 1$, indicating that overall Set A was no easier (or difficult) to recall than Set B.

**Table 1**

*Mean Number of Errors Made when Trying to Achieve the Learning Criteria (with SE in parentheses)*

<table>
<thead>
<tr>
<th></th>
<th>Bilinguals</th>
<th></th>
<th>Monolinguals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chinese-English</td>
<td>English-French</td>
<td>English</td>
</tr>
<tr>
<td><strong>Meaning Recall</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 1</td>
<td>2.0 (0.3)</td>
<td>1.4 (0.3)</td>
<td>1.1 (0.3)</td>
</tr>
<tr>
<td>Week 2</td>
<td>0.5 (0.2)</td>
<td>0.3 (0.3)</td>
<td>0.2 (0.3)</td>
</tr>
<tr>
<td>Mean</td>
<td>1.3 (0.3)</td>
<td>0.9 (0.3)</td>
<td>0.7 (0.3)</td>
</tr>
<tr>
<td><strong>Structure Recall</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 1</td>
<td>1.3 (0.3)</td>
<td>1.2 (0.3)</td>
<td>1.4 (0.3)</td>
</tr>
<tr>
<td>Week 2</td>
<td>0.6 (0.3)</td>
<td>0.9 (0.3)</td>
<td>0.8 (0.3)</td>
</tr>
<tr>
<td>Mean</td>
<td>1.0 (0.3)</td>
<td>1.1 (0.3)</td>
<td>1.1 (0.3)</td>
</tr>
</tbody>
</table>

**Discussion**

A logographic background did not benefit L1 Chinese learners in acquiring an artificial L2 logography. Equal performance by the English monolinguals and bilinguals indicated that a bilingual background did not aid the acquisition of L2 artificial
logographic script. Again this finding provides some support for Nayak et. al.’s (1990) study which found no overall performance advantages favouring multilingual learners over monolingual learners when acquiring an artificial linguistic system.

Improved performance by the language learners in Week 2 indicated that they had retained some information regarding the semantic and structural aspects of the artificial logographs. This suggests that the language learners were able to retain the logographs in their long term memory and is evidence that they had at least (partially) acquired the items.
## Appendix G

### The Set A Symbol Strings in English (top) and Chinese (underneath) Used in the Syntactic Processing Tasks (Experiment 2a and 2b)

#### Legal Targets

<table>
<thead>
<tr>
<th>Meaningless</th>
<th>Meaningful</th>
<th>Meaningless</th>
<th>Meaningful</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insect remember movie</td>
<td>Student remember movie</td>
<td>Movie insect student</td>
<td>Remember avoid student</td>
</tr>
<tr>
<td>昆虫 记得 电影</td>
<td>学生 记得 电影</td>
<td>电影 昆虫 学生</td>
<td>记得 避免 学生</td>
</tr>
<tr>
<td>Insect remember vehicle</td>
<td>Policeman remember vehicle</td>
<td>Insect student vehicle</td>
<td>Remember avoid policeman</td>
</tr>
<tr>
<td>昆虫 记得 车辆</td>
<td>警察 记得 车辆</td>
<td>昆虫 学生 车辆</td>
<td>记得 避免 警察</td>
</tr>
<tr>
<td>Movie remember vehicle</td>
<td>Policeman remember student</td>
<td>Vehicle policeman woman</td>
<td>Remember accept movie</td>
</tr>
<tr>
<td>电影 记得 车辆</td>
<td>警察 记得 学生</td>
<td>车辆 警察 妇女</td>
<td>记得 接受 电影</td>
</tr>
<tr>
<td>Insect tell movie</td>
<td>Woman tell policeman</td>
<td>Vehicle movie insect</td>
<td>Remember allow woman</td>
</tr>
<tr>
<td>昆虫 告诉 警察</td>
<td>女警 告诉 警察</td>
<td>车辆 电影 昆虫</td>
<td>记得 允许 妇女</td>
</tr>
<tr>
<td>Vehicle tell movie</td>
<td>Policeman tell student</td>
<td>Policeman vehicle insect</td>
<td>Remember avoid vehicle</td>
</tr>
<tr>
<td>车辆 告诉 警察</td>
<td>学生 告诉 警察</td>
<td>警察 车辆 昆虫</td>
<td>记得 避免 车辆</td>
</tr>
<tr>
<td>Vehicle tell woman</td>
<td>Policeman tell woman</td>
<td>Student movie woman</td>
<td>Avoid accept movie</td>
</tr>
<tr>
<td>车辆 告诉 妇女</td>
<td>学生 告诉 妇女</td>
<td>学生 电影 妇女</td>
<td>避免 接受 电影</td>
</tr>
<tr>
<td>Movie avoid vehicle</td>
<td>Policeman avoid vehicle</td>
<td>Remember become tell</td>
<td>Avoid accept vehicle</td>
</tr>
<tr>
<td>电影 避免 车辆</td>
<td>警察 避免 车辆</td>
<td>警察 避免 车辆</td>
<td>记得 避免 车辆</td>
</tr>
<tr>
<td>Movie avoid insect</td>
<td>Vehicle avoid student</td>
<td>Tell avoid remember</td>
<td>避免 接受 车辆</td>
</tr>
<tr>
<td>电影 避免 昆虫</td>
<td>车辆 避免 学生</td>
<td>告诉 避免 记得</td>
<td>避免 允许 电影</td>
</tr>
<tr>
<td>Movie avoid policeman</td>
<td>Insect avoid vehicle</td>
<td>Accept remember allow</td>
<td>Accept become woman</td>
</tr>
<tr>
<td>电影 避免 警察</td>
<td>警察 避免 车辆</td>
<td>接受 记得 记得</td>
<td>接受 成为 妇女</td>
</tr>
<tr>
<td>Insect accept movie</td>
<td>Student accept vehicle</td>
<td>Accept become policeman</td>
<td>允许 成为 警察</td>
</tr>
<tr>
<td>昆虫 接受 车辆</td>
<td>学生 接受 车辆</td>
<td>允许 警察</td>
<td>记得 避免 车辆</td>
</tr>
<tr>
<td>Vehicle accept insect</td>
<td>Woman accept movie</td>
<td>Tell become accept</td>
<td>记得 避免 车辆</td>
</tr>
<tr>
<td>车辆 接受 昆虫</td>
<td>女警 接受 电影</td>
<td>告诉 成为 接受</td>
<td>记得 避免 车辆</td>
</tr>
<tr>
<td>Insect accept woman</td>
<td>Policeman accept movie</td>
<td>Tell avoid allow</td>
<td>避免 避免 车辆</td>
</tr>
<tr>
<td>昆虫 接受 妇女</td>
<td>警察 接受 电影</td>
<td>告诉 避免 记得</td>
<td>避免 告诉 警察</td>
</tr>
<tr>
<td>Vehicle allow insect</td>
<td>Policeman accept movie</td>
<td>Become accept avoid</td>
<td>避免 告诉 妇女</td>
</tr>
<tr>
<td>车辆 允许 昆虫</td>
<td>警察 允许 电影</td>
<td>成为 避免 妇女</td>
<td>避免 告诉 妇女</td>
</tr>
<tr>
<td>Movie allow insect</td>
<td>Policeman allow movie</td>
<td>表达 女性 电影</td>
<td>记得 女性</td>
</tr>
<tr>
<td>电影 允许 昆虫</td>
<td>警察 允许 学生</td>
<td>表达 女性 车辆</td>
<td>记得 女性</td>
</tr>
<tr>
<td>Insect allow student</td>
<td>Policeman allow woman</td>
<td>允许 学生 虫</td>
<td>记得 女性</td>
</tr>
<tr>
<td>昆虫 允许 学生</td>
<td>警察 允许 妇女</td>
<td>表达 女性 看电影</td>
<td>记得 女性</td>
</tr>
<tr>
<td>Woman become insect</td>
<td>Student become policeman</td>
<td>Become movie remember</td>
<td>避免 学生 成为</td>
</tr>
<tr>
<td>妇女 成为 昆虫</td>
<td>学生 成为 警察</td>
<td>成为 电影 记得</td>
<td>避免 学生 成为</td>
</tr>
<tr>
<td>Vehicle become woman</td>
<td>Woman become policeman</td>
<td>Avoid vehicle tell</td>
<td>避免 车辆 女警</td>
</tr>
<tr>
<td>车辆 成为 妇女</td>
<td>表达 警察</td>
<td>避免 车辆 记得</td>
<td>避免 车辆 女警</td>
</tr>
<tr>
<td>Insect become student</td>
<td>Woman become student</td>
<td>Avoid movie remember</td>
<td>避免 电影 记得</td>
</tr>
<tr>
<td>昆虫 成为 学生</td>
<td>表达 学生</td>
<td>允许 学生 虫</td>
<td>避免 女性 记得</td>
</tr>
<tr>
<td>妇女 成为 虫</td>
<td>妇女 成为 警察</td>
<td>允许 学生 虫</td>
<td>避免 女性 记得</td>
</tr>
</tbody>
</table>

Note. Each string consists solely of noun and verb combinations arranged to be either meaningful or meaningless.
Appendix G

The Set B Symbol Strings in English (top) and Chinese (underneath) Used in the Syntactic Processing Tasks (Experiment 2a and 2b)

<table>
<thead>
<tr>
<th>Meaningless</th>
<th>Meaningful</th>
<th>Meaningless</th>
<th>Meaningful</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ocean understand village</td>
<td>Teacher remember village</td>
<td>Actor village reporter</td>
<td>Remember allow actor</td>
</tr>
<tr>
<td>海洋 懂得 村子</td>
<td>教师 记得 村子</td>
<td>演员 村子 记者</td>
<td>记得 允许 演员</td>
</tr>
<tr>
<td>Ocean understand reporter</td>
<td>Actor remember weapon</td>
<td>Weapon actor ocean</td>
<td>Remember allow reporter</td>
</tr>
<tr>
<td>海洋 记得 记者</td>
<td>演员 记得 武器</td>
<td>武器 演员 海洋</td>
<td>记得 允许 记者</td>
</tr>
<tr>
<td>Weapon understand ocean</td>
<td>Actor understand reporter</td>
<td>Village weapon teacher</td>
<td>Remember allow teacher</td>
</tr>
<tr>
<td>武器 记得 演员</td>
<td>演员 记得 记者</td>
<td>村子 武器 教师</td>
<td>记得 允许 教师</td>
</tr>
<tr>
<td>Ocean remember actor</td>
<td>Reporter understand actor</td>
<td>Teacher reporter ocean</td>
<td>Remember tell reporter</td>
</tr>
<tr>
<td>海洋 记得 记者</td>
<td>记者 记得 记者</td>
<td>教师 记者 海洋</td>
<td>记得 告诉 记者</td>
</tr>
<tr>
<td>Weapon remember reporter</td>
<td>Actor understand teacher</td>
<td>Ocean village teacher</td>
<td>Remember tell actor</td>
</tr>
<tr>
<td>武器 记得 记者</td>
<td>记者 记得 教师</td>
<td>海洋 村子 教师</td>
<td>记得 告诉 演员</td>
</tr>
<tr>
<td>Weapon understand ocean</td>
<td>Actor understand reporter</td>
<td>Reporter village ocean</td>
<td>Remember tell teacher</td>
</tr>
<tr>
<td>武器 记得 记者</td>
<td>记者 记得 武器</td>
<td>记者 村子 海洋</td>
<td>记得 告诉 教师</td>
</tr>
<tr>
<td>Weapon allow ocean</td>
<td>Actor tell reporter</td>
<td>Understand prevent include</td>
<td>Remember include teacher</td>
</tr>
<tr>
<td>武器 允许 海洋</td>
<td>演员 告诉 记者</td>
<td>懂得 防止 包括</td>
<td>记得 包括 教师</td>
</tr>
<tr>
<td>Actor allow ocean</td>
<td>Teacher tell actor</td>
<td>Remember include allow</td>
<td>Remember include actor</td>
</tr>
<tr>
<td>演员 允许 海洋</td>
<td>教师 告诉 演员</td>
<td>记得 包括 允许</td>
<td>记得 包括 演员</td>
</tr>
<tr>
<td>Village allow ocean</td>
<td>Reporter tell teacher</td>
<td>Tell include understand</td>
<td>Remember include reporter</td>
</tr>
<tr>
<td>村子 允许 海洋</td>
<td>记者 告诉 教师</td>
<td>告诉 包括 懂得</td>
<td>记得 包括 记者</td>
</tr>
<tr>
<td>Reporter include ocean</td>
<td>Teacher include reporter</td>
<td>Remember prevent include</td>
<td>Allow tell actor</td>
</tr>
<tr>
<td>记者 包括 海洋</td>
<td>教师 包括 记者</td>
<td>记得 防止 包括</td>
<td>允许 告诉 演员</td>
</tr>
<tr>
<td>Ocean include teacher</td>
<td>Teacher include actor</td>
<td>允许 告诉 防止</td>
<td>允许 告诉 教师</td>
</tr>
<tr>
<td>海洋 包括 教师</td>
<td>教师 包括 演员</td>
<td>Include prevent allow</td>
<td>Allow tell teacher</td>
</tr>
<tr>
<td>Ocean include weapon</td>
<td>Teacher remember actor</td>
<td>允许 告诉 防止</td>
<td>允许 告诉 记者</td>
</tr>
<tr>
<td>海洋 包括 武器</td>
<td>教师 记得 演员</td>
<td>Include prevent allow</td>
<td>Prevent tell teacher</td>
</tr>
<tr>
<td>Weapon tell actor</td>
<td>Actor prevent reporter</td>
<td>Prevent ocean tell</td>
<td>防止 海洋 告诉</td>
</tr>
<tr>
<td>武器 告诉 演员</td>
<td>演员 防止 记者</td>
<td>防止 海洋 告诉</td>
<td>防止 告诉 教师</td>
</tr>
<tr>
<td>Ocean tell reporter</td>
<td>Teacher prevent actor</td>
<td>Include ocean prevent</td>
<td>Prevent tell actor</td>
</tr>
<tr>
<td>海洋 告诉 记者</td>
<td>教师 防止 演员</td>
<td>包括 海洋 防止</td>
<td>防止 告诉 演员</td>
</tr>
<tr>
<td>Ocean tell weapon</td>
<td>Teacher prevent reporter</td>
<td>Prevent village allow</td>
<td>Prevent tell reporter</td>
</tr>
<tr>
<td>海洋 告诉 武器</td>
<td>教师 防止 记者</td>
<td>防止 村子 允许</td>
<td>防止 告诉 记者</td>
</tr>
<tr>
<td>Actor prevent ocean</td>
<td>Actor allow reporter</td>
<td>允许 海洋 记得</td>
<td>防止 懂得 记者</td>
</tr>
<tr>
<td>演员 防止 海洋</td>
<td>演员 允许 记者</td>
<td>允许 海洋 记得</td>
<td>防止 懂得 记者</td>
</tr>
<tr>
<td>Village prevent ocean</td>
<td>Teacher allow actor</td>
<td>允许 武器 记得</td>
<td>防止 懂得 教师</td>
</tr>
<tr>
<td>村子 防止 海洋</td>
<td>教师 允许 演员</td>
<td>Tell ocean remember</td>
<td>防止 懂得 教师</td>
</tr>
<tr>
<td>Weapon prevent ocean</td>
<td>Teacher allow reporter</td>
<td>告诉 海洋 记得</td>
<td>防止 懂得 教师</td>
</tr>
<tr>
<td>武器 防止 海洋</td>
<td>教师 允许 记者</td>
<td>允许 武器 记得</td>
<td>防止 懂得 教师</td>
</tr>
</tbody>
</table>

Note. Each string consists solely of noun and verb combinations arranged to be either meaningful or meaningless.
### Appendix H

**Age of L2 Acquisition and Time Spent in an L2 Environment (in years) of Chinese-English and English-French Bilinguals (Experiments 3a & 3b)**

<table>
<thead>
<tr>
<th>Bilinguals</th>
<th>Chinese-English</th>
<th>English-French</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age of L2 Acquisition</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 – 3</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>3 - 6</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>7 – 12</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>13 – 18</td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td>&gt; 18</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>17</td>
<td>13</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Time spent in L2 Environment</strong></th>
<th>Chinese-English</th>
<th>English-French</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1*</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>1 – 3</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>3 – 6</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>6 – 10</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>&gt; 10</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>17</td>
<td>13</td>
</tr>
</tbody>
</table>

*Note.* *Participants in this category had spent at least 6 months in an L2 environment but less than 1 full year.*
Appendix I

*English and Chinese Word/Character Frequency Information (SDs in parentheses) (Experiments 3a & 3b)*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Village</td>
<td>84 (.00828)</td>
<td>村子</td>
<td>107 (.00814)</td>
</tr>
<tr>
<td>Policeman</td>
<td>36 (.00355)</td>
<td>警察</td>
<td>81 (.00616)</td>
</tr>
<tr>
<td>Reporter</td>
<td>54 (.00533)</td>
<td>记者</td>
<td>65 (.00495)</td>
</tr>
<tr>
<td>Insect</td>
<td>37 (.00365)</td>
<td>昆虫</td>
<td>72 (.00548)</td>
</tr>
<tr>
<td>Movie</td>
<td>60 (.00592)</td>
<td>电影</td>
<td>262 (.01993)</td>
</tr>
<tr>
<td>Ocean</td>
<td>37 (.00365)</td>
<td>海洋</td>
<td>104 (.00791)</td>
</tr>
<tr>
<td>Vehicle</td>
<td>88 (.00868)</td>
<td>车辆</td>
<td>42 (.00320)</td>
</tr>
<tr>
<td>Weapon</td>
<td>103 (.01016)</td>
<td>武器</td>
<td>129 (.00981)</td>
</tr>
<tr>
<td>Student</td>
<td>351 (.03461)</td>
<td>学生</td>
<td>424 (.03226)</td>
</tr>
<tr>
<td>Teacher</td>
<td>152 (.01499)</td>
<td>教师</td>
<td>208 (.01582)</td>
</tr>
<tr>
<td>Mean</td>
<td>.009 (.009)</td>
<td>.011 (.009)</td>
<td></td>
</tr>
</tbody>
</table>
Appendix J

*English and Chinese Temporal Word Length in Milliseconds (SDs in parentheses)* *(Experiments 3a & 3b)*

<table>
<thead>
<tr>
<th>English</th>
<th>Temporal Word length</th>
<th>Chinese</th>
<th>Temporal word length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Village</td>
<td>637</td>
<td>村子</td>
<td>503</td>
</tr>
<tr>
<td>Policeman</td>
<td>633</td>
<td>警察</td>
<td>646</td>
</tr>
<tr>
<td>Reporter</td>
<td>624</td>
<td>记者</td>
<td>557</td>
</tr>
<tr>
<td>Insect</td>
<td>692</td>
<td>昆虫</td>
<td>616</td>
</tr>
<tr>
<td>Movie</td>
<td>525</td>
<td>电影</td>
<td>538</td>
</tr>
<tr>
<td>Ocean</td>
<td>486</td>
<td>海洋</td>
<td>595</td>
</tr>
<tr>
<td>Vehicle</td>
<td>551</td>
<td>车辆</td>
<td>536</td>
</tr>
<tr>
<td>Weapon</td>
<td>458</td>
<td>武器</td>
<td>565</td>
</tr>
<tr>
<td>Student</td>
<td>637</td>
<td>学生</td>
<td>601</td>
</tr>
<tr>
<td>Teacher</td>
<td>493</td>
<td>教师</td>
<td>624</td>
</tr>
<tr>
<td>Mean</td>
<td>574 (81)</td>
<td></td>
<td>578 (46)</td>
</tr>
</tbody>
</table>
Appendix K
Questionnaire on Participants’ Cognitive Strategies Involved in Acquiring and Reading the Artificial Logographic Script (English Language Version)

QUESTIONNAIRE
[To be completed only at the end of ALL experimental trials]

This questionnaire consists of two sections. In Section One, the questions relate to when you were learning the 12 symbols. In Section Two, the questions relate to when you were using the symbols during the NOUN VERB NOUN judgement task. Please circle the appropriate response.

Name: _______________________
Date: _______________________

SECTION ONE: Learning the symbols

NOTE: This part of the questionnaire refers only to when you were learning the symbols

(1.1) How difficult was it to learn 12 symbols?
A Very difficult
B Difficult
C Not difficult but not easy either
D Easy
E Very easy

(1.2) How did you learn the 12 symbols?
A I used the cards
B I used the pencil and paper
C I used the cards most of the time and the pencil and paper sometimes
D I used the pencil and paper most of the time and the cards sometimes
E Other – please specify

_____________________________________________________________________
_______________________________________________________________________
(1.3) If you used the pencil and paper to help learn the symbols, which statement best describes this process? (Ignore this question if you did not use pencil and paper to learn the symbols)

A I only drew the symbols
B I drew the symbols then wrote their names
C I wrote the names of the symbols then drew them
D I only wrote the names of the symbols
E Other – please specify

(1.4) When you were learning the 12 symbols did you say things aloud to yourself?

A I used a lot of speech, full sentences
B I used a lot of speech, short phrases and/or words
C I used some speech, full sentences
D I used some speech, short phrases and/or words
E I used no speech

(1.5) To help you remember the symbols did you associate any real world objects with the shape of the symbols?

A I associated all of the symbols with a shape from the real world to help me remember them
B I associated most symbols with a shape from the real world to help me remember them
C I associated some symbols with a shape from the real world to help me remember them
D I associated just one symbol with a shape from the real world to help me remember them
E Other – please specify

(1.6) Which statement best describes the way in which you rehearsed the 12 symbols in your mind to learn them? (If you did not rehearse the symbols in your mind ignore this question).

A I only named them
B I named then visualized them
C I visualized then named them
D I only visualized them
E Other – please specify
(1.7) If you rehearsed the names of the symbols in your mind to remember them which statement best describes the quality of this rehearsal? (If you did not name the symbols in your mind ignore this question).

A Full name, well pronounced
B Full name, slurred pronunciation
C Partial name, well pronounced
D Partial name, slurred pronunciation
E Other – please specify

(1.8) If you visualised the symbols in your mind to remember them which statement best describes the quality of this visual rehearsal? (If you did not visualise the symbols in your mind ignore this question).

A Clear, detailed, close-up image
B Clear detailed, distant image
C Fuzzy, close-up image
D Fuzzy, distant image
E Other – please specify

SECTION TWO: Using the symbols

During the NOUN VERB NOUN judgement task, you were required to decide if the symbols presented to you were in “legal” (NOUN VERB NOUN) combinations. This part of the questionnaire refers only to the use of the symbols. Please circle the appropriate response.

(2.1) How difficult was it to decide which symbol strings were legal?

A Very difficult
B Difficult
C Not difficult but not easy either
D Easy
E Very easy
(2.2) When you were deciding the legality of the symbol strings did you say things aloud to yourself?

A I used a lot of speech, full sentences  
B I used a lot of speech, short phrases and/or words  
C I used some speech, full sentences  
D I used some speech, short phrases and/or words  
E I used no speech

(2.3) When you were deciding the legality of the symbol strings did you remember the shapes of symbols by their association with real world objects?

A I associated all of the symbols with a shape from the real world to help me decide  
B I associated most symbols with a shape from the real world to help me decide  
C I associated some symbols with a shape from the real world to help me decide  
D I associated just one symbol with a shape from the real world to help me decide  
E Other – please specify

(2.4) When you were deciding the legality of the symbol strings did you

A Name all of the symbols in your mind before deciding  
B Name most of the symbols in your mind before deciding  
C Name some of the symbols in your mind before deciding  
D Name just one of the symbols in your mind before deciding  
E Not name any symbols in your mind before deciding

(2.5) If you did name symbols in the strings in your mind before deciding their legality, which statement best describes the quality of this naming? (Ignore this question if you chose E in question (2.4))

A Full name, well pronounced  
B Full name, slurred pronunciation  
C Partial name, well pronounced  
D Partial name, slurred pronunciation  
E Other – please specify
(2.6) When you were deciding the legality of the symbol strings did you

A Visualize all of the symbols in your mind before deciding
B Visualize most of the symbols in your mind before deciding
C Visualize some of the symbols in your mind before deciding
D Visualize just one of the symbols in your mind before deciding
E Not visualize any symbols in your mind before deciding

(2.7) If you visualised the symbol strings in your mind before deciding their legality, which statement best describes the quality of this visualisation? (Ignore this question if you chose E in question (2.6))

A Clear, detailed, close-up image
B Clear detailed, distant image
C Fuzzy, close-up image
D Fuzzy, distant image
E Other – please specify
Appendix L
Questionnaire on Participants’ Cognitive Strategies Involved in Acquiring and Reading the Artificial Logographic Script (Chinese Language Version)

问卷表
QUESTIONNAIRE

(请于所有测验完成时回答)
[To be completed only at the end of ALL experimental trials]

这个问卷表有两个部分。第一部分是问您如何学会这些十二个标记。
第二部分是关于您如何用这些十二个标记来分析名词/动词的定义。
请在适当的选择打圈圈。

This questionnaire consists of two sections. In Section One, the questions relate to when you were learning the 12 symbols. In Section Two, the questions relate to when you were using the symbols during the NOUN/VERB judgement task. Please circle the appropriate response.

名字:
Name:
日期:
Date:

第一部分：学习的过程

(注意：这个部分只问您学习的过程)

1.1 学会这些十二个标记艰不艰？

A 非常艰
B 艰
C 还好
D 容易
E 非常容易
1.2 您是如何学会这些十二个标记？

A 我用了卡片
B 我用了纸跟笔
C 我大部分用了卡片，有时候用纸跟笔
D 我大部分用了纸跟笔，有时候用卡片
E 其他。请详细：

______________________________  ________________________________

1.3 如果您用了纸跟笔来学会这些标记，哪下列选择描述您的学习过程是最正确的？（如果您没有用纸跟笔来学会这些标记，请不要回答）

A 我只有把标记画出来
B 我先把标记画出来然后把标记的定名写下来。
C 我先把标记的定名写下来然后在把标记画出来。
D. 我只有把标记的定名写下来
E 其他。请详细：

______________________________  ________________________________

1.4 在您的学习过程中，您有没有用念或者朗读的方法？

A 用了非常多，大部分是完整的句子。
B 用了非常多，大部分是片语或者单字。
C 用了一些完整的句子。
D 用了一些片语或者单字。
E 完全不用。
1.5 在您的学习过程中，您有没有用日常生活的事物来帮助您记住标记的形状？

A 我把所有的标记以及日常生活的事物联想在一起。
B 我把大部分的标记以及日常生活的事物联想在一起。
C 我把一部分的标记以及日常生活的事物联想在一起。
D 我只有把一样标记以及日常生活的事物联想在一起。
E 其它。请详细：

________________________________________________________________________
________________________________________________________________________

1.6 如果您用默念的方法来学会这些标记，哪下列选择描述您的学习过程是最正确的？（如果您没有用默念的方法来学会这些标记，请不要回答）

A 我只有把标记的定名念出来
B 我把标记的定名念出来然后想起标记的形式。
C 我想起标记的形式然后把标记的定名念出来。
D 我只有想起标记的形式
E 其它。请详细：

________________________________________________________________________
________________________________________________________________________
1.7 如果您把标记的全名念出来 来学会这些标记，
哪下列选择描述您的学习过程是最正确的？
(如果您没有用这个方法来学会这些标记，请不要回答)

A 我把标记的全名清楚的念出来
B 我把标记的全名大概的念出来
C 我把标记一部分的定名清楚的念出来
D 我把标记一部分的定名大概的念出来
E 其它. 请详细:

____________________________________________________________________________

1.8 如果您想起标记的形式来学会这些标记，
哪下列选择描述您的学习过程是最正确的？
(如果您没有用这个方法来学会这些标记，请不要回答)

A 清楚,详细，近的影像。
B 清楚,详细，迢的影像。
C 模糊, 近的影像
D.模糊, 迢的影像
E 其它. 请详细:

____________________________________________________________________________
第二部分: 标记的使用

(注意: 这个部分只问您如何用这些十二个标记来分析 名词/动词 的定义)

2.1 分析 名词/动词 的定义艰不艰?

A 非常艰
B 艰
C 还好
D 容易
E 非常容易

2.2 当您分析 名词/动词 的定义是否正确时, 您有没有用默念的方法?

A 用了非常多, 大部分是完整的句子.
B 用了非常多, 大部分是片语或者单字.
C 用了一些 完整的句子.
D 用了一些 片语或者单字.
E 完全不用.

2.3 当您分析 名词/动词 的定义是否正确时, 您有没有想起标记的形状?

A 我把所有的标记以及日常生活的事物联想在一起来帮助我决定
B 我把大部分的标记以及日常生活的事物联想在一起来帮助我决定
C 我把一部分的标记以及日常生活的事物联想在一起来帮助我决定
D 我只有把一样标记以及日常生活的事物联想在一起来帮助我决定
E 其它, 请详细:

____________________________________________________________________
____________________________________________________________________
2.4 当您分析名词/动词的定义是否正确时，您有没有？

A 先把所有的标记的定名想起来，然后在决定
B 先把大部分的标记的定名想起来，然后在决定
C 先把一部分的标记的定名想起来，然后在决定
D 先把一样标记的定名想起来，然后在决定
E 都没有，直接决定

2.5 如果您把标记的定名念出来用来决定这些标记是否正确，
哪下列选择描述您的回想过程是最正确的？(如果您2.4答E，请不要回答)

A 我把标记的全名清楚的念出来
B 我把标记的全名大概的念出来
C 我把标记一部分的定名清楚的念出来
D 我把标记一部分的定名大概的念出来
E 其它，请详细：

_______________________________________________________________
_______________________________________________________________

2.6 当您分析名词/动词的定义是否正确时，您有没有？

A 先把所有的标记的影像想起来，然后在决定
B 先把大部分的标记的影像想起来，然后在决定
C 先把一部分的标记的影像想起来，然后在决定
D 先把一样标记的影像想起来，然后在决定
E 都没有，直接决定
2.7 如果您把标记的影像想起来来决定这些标记是否正确，
哪下列选择描述您的回想过程是最正确的？(如果您2.6 答 E，请不要回答)

A 清楚,详细, 近的影像.
B 清楚,详细, 远的影像.
C 模糊, 近的影像
D 模糊, 远的影像
E 其它. 请详细:

_______________________________________________________________

_______________________________________________________________

_______________________________________________________________
Appendix M
Questionnaire on Participants’ Cognitive Strategies Involved in Acquiring and Processing the Artificial Logographic Script in WM (English Language Version)

QUESTIONNAIRE
[To be completed only at the end of ALL experimental trials]

This questionnaire consists of two sections. In Section One, the questions relate to when you were LEARNING the 10 symbols. In Section Two, the questions relate to when you were RECALLING the 10 symbols. Please circle the appropriate response.

Name: __________________________
Date: __________________________

SECTION ONE: Learning the symbols

NOTE: This part of the questionnaire refers only to when you were learning the symbols

(1.1) How difficult was it to learn 10 symbols?
A Very difficult
B Difficult
C Not difficult but not easy either
D Easy
E Very easy

(1.2) How did you learn the 10 symbols?
A I used the cards
B I used the pencil and paper
C I used the cards most of the time and the pencil and paper sometimes
D I used the pencil and paper most of the time and the cards sometimes
E Other – please specify
(1.3) **If you used the pencil and paper to help learn the symbols, which statement best describes this process? (Ignore this question if you did not use pencil and paper to learn the symbols)**

A I only drew the symbols  
B I drew the symbols then wrote their names  
C I wrote the names of the symbols then drew them  
D I only wrote the names of the symbols  
E Other – please specify

(1.4) **When you were learning the 10 symbols did you say things aloud to yourself?**

A I used a lot of speech, full sentences  
B I used a lot of speech, short phrases and/or words  
C I used some speech, full sentences  
D I used some speech, short phrases and/or words  
E I used no speech

(1.5) **To help you remember the symbols did you associate any real world objects with the shape of the symbols?**

A I associated all of the symbols with a shape from the real world to help me remember them  
B I associated most symbols with a shape from the real world to help me remember them  
C I associated some symbols with a shape from the real world to help me remember them  
D I associated just one symbol with a shape from the real world to help me remember them  
E Other – please specify

(1.6) **Which statement best describes the way in which you rehearsed the 10 symbols in your mind to learn them? (If you did not rehearse the symbols in your mind ignore this question).**

A I only named them  
B I named then visualized them  
C I visualized then named them  
D I only visualized them  
E Other – please specify
(1.7) If you rehearsed the names of the symbols in your mind to remember them which statement best describes the quality of this rehearsal? (If you did not name the symbols in your mind ignore this question).

A Full name, well pronounced
B Full name, slurred pronunciation
C Partial name, well pronounced
D Partial name, slurred pronunciation
E Other – please specify

(1.8) If you visualised the symbols in your mind to remember them which statement best describes the quality of this visual rehearsal? (If you did not visualise the symbols in your mind ignore this question).

A Clear, detailed, close-up image
B Clear detailed, distant image
C Fuzzy, close-up image
D Fuzzy, distant image
E Other – please specify

SECTION TWO: Recalling the symbols (without repeating words (Coca Cola) aloud or finger tapping)

During the symbol recall tasks you were required to recall sequences of previously learnt symbols. Two of these recall tasks involved the use of interference effects (i.e., finger tapping and repeating words aloud). THIS PART OF THE QUESTIONNAIRE REFERS ONLY TO THE RECALL TASK THAT DID NOT INVOLVE INTERFERENCE EFFECTS. Please circle the appropriate response.

(2.1) How difficult was it to recall the symbols in order?

A Very difficult
B Difficult
C Not difficult but not easy either
D Easy
E Very easy

(2.2) When you were recalling the symbols in order did you say things aloud to yourself?
A I used a lot of speech, full sentences  
B I used a lot of speech, short phrases and/or words  
C I used some speech, full sentences  
D I used some speech, short phrases and/or words  
E I used no speech  

(2.3) **When you were recalling the symbols in order did you remember the shapes of symbols by their association with real world objects?**  
A I associated all of the symbols with a shape from the real world to help me decide  
B I associated most symbols with a shape from the real world to help me decide  
C I associated some symbols with a shape from the real world to help me decide  
D I associated just one symbol with a shape from the real world to help me decide  
E Other – please specify  

(2.4) **When you were recalling the symbols in order did you?**  
A Name all of the symbols in your mind before deciding  
B Name most of the symbols in your mind before deciding  
C Name some of the symbols in your mind before deciding  
D Name just one of the symbols in your mind before deciding  
E Not name any symbols in your mind before deciding  

(2.5) **If you did name symbols in your mind when you were recalling them in order, which statement best describes the quality of this naming?**  (Ignore this question if you chose E in question (2.4))  
A Full name, well pronounced  
B Full name, slurred pronunciation  
C Partial name, well pronounced  
D Partial name, slurred pronunciation  
E Other – please specify  

(2.6) **When you were recalling the symbols in order did you?**  
A Visualize all of the symbols in your mind before deciding  
B Visualize most of the symbols in your mind before deciding  
C Visualize some of the symbols in your mind before deciding  
D Visualize just one of the symbols in your mind before deciding  
E Not visualize any symbols in your mind before deciding
(2.7) If you visualised the symbols in your mind when you were recalling them in order, which statement best describes the quality of this visualisation? (Ignore this question if you chose E in question (2.6))

A Clear, detailed, close-up image
B Clear detailed, distant image
C Fuzzy, close-up image
D Fuzzy, distant image
E Other – please specify

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SECTION THREE: Recalling the symbols (when repeating words (Coca Cola) aloud)

This part of the questionnaire refers only to the symbol recall task that involved saying words (Coca Cola) aloud when the symbol sequences were displayed. Please circle the appropriate response.

(3.1) How difficult was it to recall the symbols in order when you had to repeat words aloud?

A Very difficult
B Difficult
C Not difficult but not easy either
D Easy
E Very easy

-------

SECTION FOUR: Recalling the symbols (when finger tapping)

This part of the questionnaire refers only to the symbol recall task that involved finger tapping when the symbol sequences were displayed. Please circle the appropriate response.

(4.1) How difficult was it to recall the symbols in order when you had to tap your fingers?

A Very difficult
B Difficult
C Not difficult but not easy either
D Easy
E Very easy
问卷表
（请于所有测验完成时回答）

此问卷由四个部分组成。
第一部分是关于您对这十个符号的学习过程。第二部分是关于您对这十个符号的记忆过程。请在适合的选项上打圈。

名字:
日期:

第一部分: 符号学习过程
（注:这个部分仅涉及您学习这十个符号的过程）

1.1 您学习这十个符号感觉困难吗？

A 非常困难；
B 困难；
C 还好；
D 容易；
E 非常容易。

1.2 您是如何学习这十个符号的？
A 我使用卡片；
B 我使用纸和笔；
C 大多数时候我用卡片，有时候用纸和笔；
D 大多数时候我用纸和笔，有时候用卡片；
E 其它。请详述：______________________________________________________
_______________________________________________________________________

1.3 如果您用了纸和笔辅助学习这些符号，
下列哪个选择最能准确描述您的学习过程？
(如果您没有用纸和笔辅助学习这些符号，请不必回答此问题。)

A 我仅仅把符号画出来；
B 我先把符号画出来然后写出它们的名称；
C 我先写下符号的名称之后把它们画出来；
D. 我仅仅写下符号的名称；
E 其它。请详述：
_______________________________________________________________________
_______________________________________________________________________

1.4 在您学习这十个符号的过程中，您是否使用大声自我诵读的方式？

A 用了非常多这种方式，且大部分是完整的句子；
B 用了非常多这种方式，大部分是短语或者单字；
C 用了一些这种方式，大部分是完整的句子；
D 用了一些这种方式，大部分是短语或者单字；
E 完全不用。

1.5 为了帮助您记忆这十个符号，
您是否将这十个符号的形状与日常生活的事物联系？
我把所有的符号与日常生活的事物联想在一起；
B 我把大部分的符号与日常生活的事物联想在一起；
C 我把一部分的符号与日常生活的事物联想在一起；
D 我仅仅把一个符号与日常生活的事物联想在一起；
E 其它。 请详述：
_______________________________________________________________________
_______________________________________________________________________

1.6 如果您用默念的方法来学习这些符号，
下列哪个选择最准确地描述您的学习过程？(如果您没有用默念的方法，请不要回答此题。)

A 我只默念符号的名称；
B 我先默念符号的名称，之后把在大脑中浮现符号的图像；
C 我先在大脑中浮现符号的图像，之后默念符号的名称；
D 我仅仅在大脑中浮现符号的图像；
E 其它。 请详述：
_______________________________________________________________________
_______________________________________________________________________

1.7 如果您在大脑中默念这些符号的名称，以下哪个选项能最准确地描述这个过程？
(如果您没有使用这种方法，请不要回答此题。)
A 我把符号的名称完整地并清楚地默念出来；
B 我含糊地默念出符号的完整名称；
C 我清晰地默念出符号的部分名称；
D 我含糊地默念出符号的部分名称；
E 其它。请详述：

_______________________________________________________________________
_______________________________________________________________________

1.8 如果您通过在大脑中浮现符号的图像来学习这些符号，
下列哪个选项最准确地描述了您的学习过程？(如果您没有使用这种方法，
请不要回答此题。)

A 清楚,详细, 近距离的图像；
B 清楚,详细, 远距离的图像；
C 模糊, 近距离的图像；
D.模糊, 远距离的图像；
E 其它。请详述：

_______________________________________________________________________
_______________________________________________________________________

第二部分: 记忆符号（没有使用大声重复或者敲击手指的方式）
(在完成符号记忆任务时，您将被要求回忆之前学习的十个符号。其中两项符号记
忆任务涉及到使用干预影响帮助记忆符号，例如敲击手指和大声重复字符。此部
分是关于不使用干预影响时的符号记忆活动。请在适当的选项上打圈。)
2.1 记忆这十个符号困难吗？

A 非常难；
B 难；
C 还好；
D 容易；
E 非常容易。

2.2 当您记忆这十个符号时，您有没有使用自我颂读的方式？

A 用了非常多，大部分是完整的句子；
B 用了非常多，大部分是短语或者单字；
C 用了一些，大部分是完整的句子；
D 用了一些，大部分是短语或者单字；
E 完全不用。

2.3 当您记忆这十个符号时，您是否将它们的词形与现实生活中的具体事物联系？

A 我把所有的符号与日常生活的事物联想在一起帮助我决定；
B 我把大部分的符号与日常生活的事物联想在一起帮助我决定；
C 我把一部分的符号与日常生活的事物联想在一起帮助我决定；
D 我仅仅把一个符号与日常生活的事物联想在一起来帮助我决定；
E 其它。请详述：

2.4 当您记忆这十个符号的时候，您是否？

A 先想起所有符号的名称，然后决定；
B 先想起大部分符号的名称，然后决定；
C 先想起一部分符号的名称，然后决定；
D 先想起一个符号的名称，然后决定；
E 没有想符号的名称，直接决定。

2.5 如果您是通过回忆符号的名称来记忆这些符号，下列哪个选项最能准确描述这一过程？（如果您2.4 选 E，请不要回答此题。）

A 我把符号的全名清楚地念出来；
B 我把符号的全名含糊地念出来；
C 我把符号一部分名称清楚地念出来；
D 我把符号一部分名称含糊地念出来；
E 其它。请详述：

2.6 当您记忆这十个符号的时候，您是否？

A 先想起所有符号的图像，然后决定；
B 先想起大部分符号的图像，然后决定；
C 先想起一部分符号的图像，然后决定；
D 仅仅想起一个符号的图像，然后决定；
E 都没有，直接决定。

2.7 如果您通过回想符号的图像来记忆符号，下列哪个选项最准确地描述这一过程？
(如果您2.6 选 E，请不要回答此题。)

A 清楚,详细, 近距离的图像；
B 清楚,详细, 远距离的图像；
C 模糊, 近距离的图像；
D.模糊, 远距离的图像；
E 其它。请详述：


第三部分：记忆符号（通过大声重复）
（此部分仅涉及在呈现符号顺序时，使用大声重复字符完成符号记忆活动的问题。请圈注适当的选项。）

3.1 当您使用大声重复符号来帮助记忆符号时，您认为有多困难？
A 非常难；
B 难；
C 还好；
D 容易；
E 非常容易。

第四部分：记忆符号（通过手指敲击）
（此部分仅涉及在呈现符号顺序时，使用手指敲击方式完成符号记忆活动的问题。请圈注适当的选项。）

4.1 当您使用手指敲击的方式来帮助记忆符号时，您认为有多困难？

A 非常难；
B 难；
C 还好；
D 容易；
E 非常容易。