DEVELOPMENTAL STAGES IN READING CHINESE AS A SECOND LANGUAGE

BY

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DISSERTATION

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Abstract

This dissertation investigated whether adult second language (L2) learners of Chinese go through stages when learning to read Chinese characters. A study conducted with preschoolers to 6th graders in China (Chen, 2004) had demonstrated that children whose native language (L1) is Chinese pass through three reading stages (i.e., visual, phonetic, and orthographic) when they learn to read Chinese. These stages are interpreted as analogous to the developmental stages of L1 English readers (i.e., logographic, alphabetic, and orthographic) posited by Ehri (1991).

The two research questions of this study are as follows: (a) Do adult L2 learners of Chinese undergo stages in learning to read Chinese? (b) If so, do the reading stages of adult L2 learners parallel those of L1 Chinese children? These questions were examined by conducting two computer-based experiments with 70 college students enrolled in beginning/intermediate Chinese classes in a major US university. In experiment 1, participants learned to read 18 novel Chinese characters divided into three levels of visual distinctiveness of characters: distinctive, normal, and similar sets. In the distinctive set, individual strokes of characters were enhanced to make the characters visually distinctive. The normal set consisted of normal characters, and the similar set consisted of character pairs whose members were visually similar to each other. Experiment 2 required participants to learn 18 new Chinese characters that belong to three different levels of phonetic family consistency: consistent, semi-consistent, and inconsistent.

Logit mixed modeling (Jaeger, 2008) analysis of the data revealed effects of individual participants’ working memory spans in experiment 1, such that subjects who had higher working memory spans were better able to learn characters. In experiment 2, an interaction effect between character knowledge and phonetic consistency was found, in which subjects who knew more characters learned the consistent families better than the semi-consistent or the inconsistent
The results suggest that adult L2 learners of Chinese go through reading stages in learning to read Chinese, but that the stages are different from those of Chinese children learning to read. It is proposed that when learning to read Chinese characters, adult L2 learners bypass the visual stage and start from the phonetic stage, and then proceed to the orthographic stage as their character knowledge base increases. The absence of a visual stage in the adult L2 learners of Chinese can be explained by positing different character knowledge and/or a cognitive difference between child L1 readers and adult L2 readers. The existence of the phonetic and the orthographic stages in adult L2 reading development dispels a long-held belief that written Chinese is processed as a whole, and confirms that the phonetic principle plays a significant role in learning to read Chinese. Pedagogical implications of these findings are (a) explicit instruction on the phonetic principle in reading Chinese would be beneficial to the learners, and (b) repetition of simple practice with seeing, hearing, and speaking aloud is effective in learning to read Chinese characters.
To my mother and father
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Chapter 1

Introduction

The Chinese language has one of the most phonologically opaque writing systems. Thus, it is intriguing that learners of Chinese are able to read novel characters after only a short period of learning Chinese despite relative lack of phonetic information. One recent study has investigated the reading development of young Chinese children and has reported that they pass through three reading stages (i.e., visual, phonetic, and orthographic) in learning to read Chinese (Chen, 2004). The finding from young first language (L1) readers of Chinese naturally leads to the question of how second language (L2) learners learn to read Chinese. Do L2 learners of Chinese undergo three reading stages just like L1 learners? Motivated by this simple question, this dissertation investigated how adult L2 learners of Chinese learn to read Chinese characters.

The concept of reading stages in L1 Chinese actually stems from research on the reading development of L1 English children. This body of research has supported the existence of a series of stages or phases in the acquisition of literacy skills among L1 English children (Chall, 1983; Ehri, 1991, 1992, 1998, 1999, 2005; Frith, 1985; Marsh, Friedman, Welch, & Desberg, 1981; Mason, 1980; Seymour & Elder, 1986). It has been reported that young beginning readers of L1 English pass through a succession of different stages, with each stage typically represented by one predominant reading strategy. Detailed characteristics and names for stages are slightly different depending on the researcher, but generally they have agreed upon a sequence of three stages of word reading: the logographic, alphabetic, and orthographic stages.

L1 English children start to read words by remembering salient visual features of the letters resulting in a stage called the logographic stage. For example, a four-year-old child may read the word yellow by remembering the tall posts in the middle, instead of matching the letters.
with the corresponding sounds (Ehri, 1998). After this stage, children start to connect some graphemes to phonemes using grapheme-phoneme correspondence (GPC) rules. This second stage is called the alphabetic stage, in which children read a written word *yellow* by mapping *y* to /j/, *e* to /ɛ/, *ll* to /l/, *o* to /o/, and *w* to /u/. Children then move to the next stage, as they repeatedly encounter words sharing repeated spelling patterns such as –*ing*, –*ment*, –*tion*, and thus can read these spelling patterns as wholes without having to decode each constituent letter. This is the final stage in word reading and is called the orthographic stage (Ehri, 1991; Frith, 1985) or consolidated alphabetic stage (Ehri, 1998, 1999, 2005). Processing larger orthographic units reduces working memory load, which enables readers to read more efficiently.

Reading stages in the acquisition of Chinese were likewise observed in a study by Chen (2004). Chen found that three stages also exist in L1 Chinese character reading development. She designated the three stages in Chinese character reading, which are equivalent to the logographic, alphabetic, and orthographic stages, as the visual, phonetic, and orthographic stages, respectively. This suggests that such stages in reading development may be inevitable within a language and may be universal across languages and writing systems.

**Statement of the Problem**

Stages of reading have been well documented in L1 literacy acquisition of English and confirmed by L1 reading development in Chinese. L1 literacy acquisition from the perspective of reading stages has been investigated in other languages, such as Brazilian Portuguese (Cardoso-Martins, Resende, & Rodrigues, 2002; Cardoso-Martins, Corrêa, Lemos, & Napoleão, 2006), French (Bastien-Tonialazzo & Jullien, 2001), German (Wimmer & Hummer, 1990), and Spanish (Sebastian-Galles & Vacchiano, 1995). However, this research area is still in its infancy in L2
reading studies. L2 reading research has concentrated on efficient comprehension of texts (i.e., top-down reading processes) rather than accurate decoding of words (i.e., bottom-up processes). As a result, as Koda (1996) noted, L2 reading at the word-level has received less attention than it deserves. Since then, many studies have examined L2 reading at the word-level (Akamatsu, 2002; Chikamatsu, 1996, 2006; Liu, Wang, & Perfetti, 2007; Wang, Koda, & Perfetti, 2003; Wang, Liu, & Perfetti, 2004; Wang, Perfetti, & Liu, 2003). Only two studies investigated L2 reading from the developmental perspective, but their focus was on the transfer of L1 reading strategies to L2 reading (Chikamatsu, 2006) or L2 word processing (Liu et al., 2007) rather than the developmental trajectory of a L2 reading.

Yin, Anderson, & Zhu (2007) was the first and as of yet only study to date to investigate reading stage models in L2 reading development. Yin et al. (2007) examined L1 Chinese children’s developmental stages in their L2 English word reading within Chinese elementary school students. The results showed that Chinese children follow a similar sequence of reading stages to L1 English children in learning to read L2 English words. Interestingly, the strategy of orthographic analogy, which was considered to be important in reading L1 Chinese characters (He, Wang, & Anderson, 2005; Ho, Wong, & Chan, 1999; Shu, Anderson, & Wu, 1999), yielded less influence on Chinese children’s reading of L2 English words. These results raise the possibility that L2 readers also pass through reading stages of the target language, but that the influence of readers’ reading strategies from the L1 is less significant when they learn to read a second language.

Since Yin et al.’s (2007) study confirmed the existence of stages in children’s L2 word reading, this raised the question of whether adult L2 readers would also follow reading stages similar to child L2 readers. The answer is not self-apparent, because of differences between
young L2 learners and adult L2 learners in terms of linguistic and cognitive abilities. Adult L2 learners generally possess fluency in speaking and reading their L1 when they start to learn an L2, whereas child L2 learners have to deal with acquisition of the L2 while simultaneously improving in their L1. In addition, most adult L2 learners possess fully developed cognitive abilities, while child L2 learners’ cognitive abilities are still developing along with their linguistic development. As of the beginning of this study, no known research involving adult L2 learners had yet addressed the development of L2 word reading.

**Goals of the Dissertation**

The purpose of this dissertation is to investigate the existence of reading stages in adult L2 learners’ reading development. I examine this question in the context of adult L2 learners learning the Chinese language. The Chinese writing system is an ideal candidate for ascertaining the existence of reading stages for adult L2 learners, due to two important characteristics of Chinese characters which differ from alphabetic systems: complexities in orthography and opaqueness in phonological decoding. If reading stages exist for adult L2 learners, then it is presumed that they would be manifested more clearly in learning to read a complex, opaque, difficult writing system rather than a simple, transparent system.

The specific research questions examined in this study are as follows: (a) Do adult L2 learners of Chinese also undergo stages in learning to read Chinese? (b) If so, do their reading stages parallel those of L1 Chinese children? One prediction is that adult L2 learners would not pass through any stages in literacy acquisition, because adult learners are cognitively fully developed, unlike young children, and because they have already gone through the reading stages in learning how to read their L1. This is plausible, based on the fact that decoding
problems have been reported less among adult L2 readers than among young L1 readers (Koda, 1996). On the other hand, it is also possible that adult L2 learners of Chinese would follow stages similar to L1 Chinese children regardless of their experience in L1 reading stages. This result would suggest that reading stages are universal and necessary in literacy acquisition of L2 as well as L1. In other words, if adult L2 readers show similar stages to L1 children, we can infer that human cognitive development involves stages whenever one learns to read in a new language.

**Significance of the Study**

The results of this study contribute to both L2 reading research and the teaching of L2 reading. First, this study is the first to investigate a reading stage model in literacy development of not only adult L2 learners, but also of Chinese as an L2. Adult readers’ decoding skills of L2 words have rarely received attention, compared to reading comprehension of L2 texts or L2 vocabulary learning, and thus reading progress at the word level has not yet been examined. This is not because L2 word reading is less important. Rather, L2 reading research has mostly concentrated on English as L2, but most adult L2 learners of English were exposed to the Latin alphabet before puberty and therefore already possess competent alphabetic reading skills. However, the majority of American L2 learners of Chinese are adults, and it is difficult for them to achieve decoding proficiency, since the non-alphabetic Chinese writing system is very different from the alphabetic writing system of their L1 (Everson, 1998). The Chinese writing system has thousands of visually complex characters and is phonologically opaque. L2 researchers have recently started investigating reading Chinese characters as an L2, and have examined the sensitivity of visuospatial characteristics of Chinese characters, the awareness and
use of semantic or phonetic components of compound characters, and the relationship between recognition and production of Chinese characters or words (Everson, 1998; Jackson, Everson, & Ke, 2003; Ke, 1996; Liu et al., 2007; Shen & Ke, 2007; Wang, Perfetti, et al., 2003; Wang et al., 2004). However, no study has yet empirically addressed L2 learners’ ability to derive a correct pronunciation from a written Chinese character from the perspective of developmental stages.

Second, in practice, this study will benefit both teachers and learners of Chinese as L2. Learning to read and write Chinese characters is a major obstacle for L2 learners of Chinese in the beginning level (Everson, 1998). Understanding how L2 beginning readers acquire decoding proficiency in Chinese characters and in which stage L2 learners are to be placed, teachers will be able to assess students’ decoding performance and interpret students’ reading errors more accurately and efficiently, which will allow them to offer appropriate and timely assistance to students in need (Hempenstall, 2004). Also, for L2 learners of Chinese, meta-knowledge of reading development in Chinese will be helpful for evaluating their own reading skills in the light of the general L2 Chinese reading development and identifying the sources of difficulty, thereby lessening the burden of learning to read Chinese characters.

The Chinese Writing System

Before closing this chapter, some concepts and terminology regarding the Chinese writing system that are relevant to better understand the rest of this dissertation will be introduced. Chinese characters have long been called “ideographs” or “logographs”, emphasizing their conveyance of some semantic content. It was once believed that Chinese characters are processed as visual wholes, and that little phonological analysis is used in reading Chinese (e.g., Baron & Strawson, 1976). The origin of Chinese scripts may be logographic, but they have
evolved into a morpho-syllabic system in which the characters map onto syllable units that are also usually morphemes (DeFrancis, 1984, 1989), and characters that contain the pronunciation component now make up about more than 80% of all Chinese characters (Hanley, 2005). This is consistent with the history of various writing systems in the world that have moved away from representing meaning toward representing sound (DeFrancis, 1989).

Each Chinese character has a visual form, a pronunciation, and a meaning. For example, the written character with the visual form 木 bears the meaning ‘tree’ and is read as mu4. In terms of structural complexity, Chinese characters are divided into simple and compound characters. Simple characters are those which cannot be separated into smaller components, such as 木 ‘tree’, 日 ‘sun’, 月 ‘moon’, and 人 ‘human’. On the other hand, a compound character consists of smaller components, such as a semantic radical, a phonetic radical or a combination thereof. A semantic radical is a component that generally conveys the semantic category of a character, which is often simply referred to as a radical, while a phonetic component, often called a phonetic, conveys some pronunciation cues for the character, such as an initial, a final, or a tone. There are approximately 200 radicals and about 1,000 phonetics in Chinese script (Hanley, 2005). The number of radicals is generally agreed upon, but the number of phonetics varies researcher to researcher from 800 (Taylor & Taylor, 1983) to 1499 (Perfetti & Tan, 1999). The number by Perfetti and Tan (1999) is based on their analysis of 9641 simplified characters listed in Modern Chinese Dictionary (現代漢語多功能詞典, 1995). Among them, 563 phonetics are taught during the first six years of formal schooling in China (Shu, Chen, Anderson, Wu, & Xuan, 2003).

The pronunciation of a Chinese character is marked using the Pinyin system, along with the number indicating the tone. Here, for example, the pronunciation of 木 is mu and has the fourth tone.
Compound characters can be divided into two categories: semantic compound characters and phonetic compound characters. A semantic compound consists of two or more semantic elements, and the meaning of the whole character is associated with the combination of its radicals. For example, the semantic compound character 明 \textit{ming2} consists of the two radicals 日 ‘sun’ and 月 ‘moon’; the meaning of the character as a whole is ‘bright’. Also, the semantic compounds 林 and 森 consist of two or three radicals of 木 ‘tree’. The character with two trees, 林, means ‘wood’, while the character with three trees, 森, means ‘forest’.

As for phonetic compound characters, they are comprised of a radical and a phonetic. For example, a phonetic compound, 油 \textit{you2} ‘oil’, is composed of a radical on the left side meaning ‘water’ and a phonetic on the right side, 由 \textit{you2}, which provides a pronunciation cue for the whole character. In most phonetic compounds, the radical typically appears on the left side of the character and the phonetic on the right. In 20% of characters, however, these positions are transposed (Hanley, 2005).

Phonetic compounds are the most prevalent type of characters in modern Chinese script, and their frequency in modern Chinese is generally considered to be more than 80% (Hanley, 2005), varying from 82% (Zhou, 1978) to 85% (Perfetti & Tan, 1999). Of the 2570 characters taught explicitly from Grade 1 to Grade 6 in elementary schools in China, phonetic compounds make up 72% (Shu et al., 2003). Note, however, that the phonetic of a character often does not exactly correspond to the pronunciation of the whole character, but corresponds to only either its initial, final or tone. There are even cases where the pronunciation of the phonetic is totally different from that of the whole character. In modern Chinese, the rate of phonetic compounds having the same pronunciation as their phonetics when tone is not considered is only around 40%, varying from 37% (Perfetti, Zhang, & Berent, 1992) to 39% (Zhou, 1978), but it declines...
to 26% when the tone of the phonetic is taken into account. For the characters taught in Chinese elementary schools, the percentage is similar to the above, i.e., 39% of the phonetic compounds share the same pronunciation with their phonetics when tone is disregarded (Shu et al., 2003).

This unreliability of phonetics in phonetic compounds in Chinese raises the issues of regularity and consistency. Regularity can be defined as to whether the pronunciation of a character is identical with that of its phonetic. Thus, a character is a regular character if it has the same pronunciation as its phonetic, whereas it is irregular if it has a different pronunciation from its phonetic. For example, 油 you2 is regular because its pronunciation is the same as its phonetic, 由 you2, while 袖 xiù4 is irregular since it is pronounced differently from its phonetic, 由 you2.

Consistency refers to whether the pronunciations of multiple characters sharing the same phonetic are consistent (Tzeng, 2002). A group of characters sharing the same phonetic is called a phonetic family, and phonetic consistency is how much the pronunciations of the member characters within the same phonetic family are congruent (Shu et al, 2003). A phonetic family is consistent if the character members in the phonetic family have the same pronunciation, whereas a phonetic family is inconsistent if its members all have different pronunciations. For instance, the family of 巨 ju4 is consistent because its character members (巨 ju4, 矩 ju4, 拒 ju4) all have the same pronunciation, while the 卑 bei1 family is inconsistent because its character members (卑 bei1, 牌 pai2, 脾 pi2) are all pronounced differently. The family of 泉 quan2 can be considered as semi-consistent because some of its members (線 xian4, 腺 xian4) share the same pronunciation, which is different from that of another of its members 鰁 quan2. In other words, regularity is an intra-character characteristic regarding the pronunciations of the
phonetic and the whole character, whereas consistency is an inter-character characteristic in terms of the pronunciations among the characters sharing the same phonetic.
Chapter 2

Stages of Reading

L1 children’s reading development has been observed and described as a sequence of stages or phases, each of which is represented by its own prominent and predominant reading strategy. At least ten stage models of alphabetic word reading have been proposed (Chall, 1983; Ehri, 1991, 1992, 1998, 1999, 2005; Ellis & Large, 1988; Frith, 1985; Gibson, 1965; Gough & Hillinger, 1980; Marsh, Friedman, Welch, & Desberg, 1981; Mason, 1980; Seymour & Duncan, 2001; Stuart & Coltheart, 1988), and a stage model of Chinese character reading was recently proposed by Chen (2004). Specific features and names for stages or phases slightly differ from model to model, but proposals for all reading stages generally converge on a similar trajectory of development.

First, children start to read by relying on a few salient but idiosyncratic visual features in a word or a character with a limited knowledge of letters or words. It is basically a paired-association in which a visually distinctive feature in the script to read is arbitrarily selected and associated with the word. In the next stage, children read words more accurately and consistently by employing a phonetic strategy, i.e., matching a grapheme with a phoneme in English or employing the phonetic of a phonetic compound in Chinese. Finally, as their reading ability and awareness of the orthographic structures increase, they reach the most advanced stage in which they read words by using an orthographic strategy, i.e., taking advantage of orthographic neighborhood information in English or phonetic family information in Chinese. This progress in reading can be represented as three consecutive stages: the visual, the phonetic, and the orthographic stages. The term for each stage is adopted from Chen (2004) in her reading stage model of L1 Chinese character reading acquisition.
It is notable that in reading stage models, since increased reading experience brings about the children’s transition to the next stage, there exits an intrinsic chronological order among these three stages. The visual stage is the first, then the phonetic, and the orthographic is the end-state. In the following sections, the characteristics of each stage will be described by first referring to L1 English word reading, and then referring to L1 Chinese character reading.

The Visual Stage

The first stage that children reach when learning to read is the visual stage. Because of the dependence on visually distinctive cues when reading, this stage is termed visual in the Chinese stage model (Chen, 2004), but it is designated logographic (Frith, 1985) or pre-alphabetic (Ehri, 1991, 1998, 1999, 2005) in English stage models. Interestingly, even L1 English children learning to read an alphabetic writing system start to read by depending on visually salient features in words, instead of relying on letter-sound connections.

L1 English children in this stage are generally unable to apply letter-sound correspondence rules to word reading. Most young children in the visual stage usually know some letters but often cannot read an entire word by itself. They recognize a word by remembering one or more salient but arbitrary (i.e., non-phonetic) visual features in the word. A child in the visual stage may be able to read look because he or she sees “two eyes” in the middle of the word, or another child may read camel by linking m in the middle of the word to two humps of a camel (Ehri, 1998).

Also, children in this stage are context-dependent readers. They identify a printed word by remembering the given context accompanying the word rather than by connecting its letters to their sounds. In a study by Mason (1980), four-year old context-dependent readers could read
signs or labels such as stop, exit, or milk only with the signs and the products. They could learn to identify three or four printed words on a ten-word list, but they forgot most or all of them in 15 minutes. The children also could not read the learned words when the case of the letter was altered, even when they could differentiate upper and lower case letters. Gough, Juel, and Griffith (1992) showed that children in the visual stage could not identify a word when the visual cue or the context accompanying the written word was removed. In Gough and colleagues’ study, children were taught four words, one of which had a thumbprint next to it. Children learned to read the ‘thumbprint’ word the fastest, but did not recognize the word when the thumbprint was removed. However, when the thumbprint was put back, they identified the ‘thumbprint’ word.

Reading words by relying on visually salient cues is unsystematic, arbitrary, and unreliable, so children using that strategy often fail to read words accurately and consistently. Children in the visual stage do not differentiate between Pepsi and Xeps or between COCA-COLA and LOCA-COLA, even when they are asked to find the errors (Masonheimer, Drum, & Ehri, 1984). Children employ visual cues to read by default since a priori they lack knowledge of the alphabetic principle. As children are exposed to more words and have mastered letter names or sounds, they can associate some letters to sounds and they move to the subsequent phonetic stage.

As with beginning English readers, L1 Chinese beginning readers also start to read their first words by relying on a few outstanding visual features in a character. In Chen’s (2004) first experiment, four-year old L1 Chinese children depended on a distinctive feature in a Chinese character when they learned to read their first characters, as L1 English children did in learning to read their first words. Chen compared the use of the visual reading strategy between L1 English and L1 Chinese children. Even though children of both language groups were of the
same age (four years), the L1 English children were all non-readers but the L1 Chinese children could read an average of eight characters, varying between zero and 20 characters. Both language groups learned three different types of words or characters of their native languages that were manipulated in terms of visual distinctiveness. Children of both language groups all read the distinctive type containing visually salient features better than the normal type, which in turn was read better than the similar type containing items that appeared similar to each other. For L1 Chinese children, according to their character knowledge, the children were divided into two groups of more experienced readers who knew an average of 15 characters and less experienced readers who knew an average of one character. When the reading performances of the two groups were compared, the performance pattern was the same in both groups regardless of their differences in character knowledge, indicating that more experienced L1 Chinese readers depended on the visual distinctive feature to read as much as less experienced readers.

Chen (2004) argues that beginning L1 Chinese readers tend to remain longer in the visual stage than L1 English readers of an equivalent age, based on the fact that L1 English children who read about four words on average were found not to use the visual strategy and used the alphabetic strategy instead (Ehri & Wilce, 1985). In contrast, more experienced L1 Chinese readers who were able to read 15 characters were found to still use the visual strategy, which implies that L1 Chinese readers may stay in the visual stage longer than L1 English readers.

Despite of the clear existence of the visual stage in both English and Chinese, it has been reported that L1 children of some languages with shallow orthographic systems, such as German, Brazilian Portuguese, and Spanish, seem to stay in the visual stage very briefly and move to the next stage or skip the visual stage entirely (Cardoso-Martins, et al., 2002; Sebastian-Galles & Vacchiano, 1995; Wimmer & Hummer, 1990). This implies that the visual stage may be related
to the phonetic transparency of the writing system and that readers of orthographically deep writing systems, such as English and Chinese, may experience a longer visual stage than those of shallow writing systems, such as German, Portuguese, and Spanish.

The Phonetic Stage

L1 English children become aware of the alphabetic principle as they are exposed to an increasing number of written words and learn to name letters (Chall, 1983; Ehri, 1991, 1998, 1999, 2005; Frith, 1985; Marsh, Friedman, Welch, & Desberg, 1981). Alphabetic readers realize that the identical letter encountered in different words is pronounced similarly and attempt to sound out new words on the basis of their letter knowledge. In L1 English word reading, the dominant reading strategy used in this stage is reading a word according to the alphabetic principle, i.e., grapheme-phoneme correspondence (GPC) rules. Thus, in alphabetic stage models, this stage is usually called the alphabetic stage (Ehri, 1991; Frith, 1985), and is divided further into the partial-alphabetic and the full alphabetic phases in Ehri’s model (Ehri, 1998, 1999, 2005).

English readers who have passed the visual stage and entered the alphabetic stage take advantage of an alphabetic strategy rather than a visual one. In a study by Ehri and Wilce (1985), pre-readers who could read no words and beginning readers who could read from a few to several words learned to read two sets of words. One set was composed of visual spellings, such as WBC for “giraffe,” and the other set of words was in simplified phonetic spellings whose letters corresponds to sound, such as JRF for “giraffe.” Pre-readers who could not read any words read the visual spelling group more easily than the phonetic one, whereas beginning readers who could read some words read the phonetic spelling group more easily than the visual spellings.
In English, the alphabetic stage begins with the partial application of the alphabetic principle and develops toward the full decoding or phonological recoding skills later. Readers in the early alphabetic stage do not have enough knowledge of the alphabetic principle to discern the less distinctive sounds, e.g., vowels. Thus, they attempt to read by relying on more salient sounds in a word, such as the first and the final letters. Children might remember to read jail by linking the first and last letters J and L to their letter names “jay” and “el” (Ehri, 2005). As their reading experiences increase and improve, children become able to fully decode written words according to GPC rules. They can read jail correctly by connecting each consonant and vowel to the corresponding sound. Since children have obtained more complete control of the connections between graphemes and phonemes, they can read familiar words more accurately and can read unfamiliar words systematically with increased accuracy.

In Chinese, the principle mapping between speech and print is called the phonetic principle, which corresponds to the alphabetic principle in English (Anderson, Li, Ku, Shu, & Wu, 2003). The phonetic principle states that in written Chinese, the phonetic of a phonetic compound character provides is an indicator of the pronunciation of the character. The reading stage in which the main reading strategy is to utilize the phonetic principle, therefore, may be called the phonetic stage. Chinese characters are not represented by phonemes, but characters containing phonetics comprise more than 80% (Hanley, 2005), and around 37% to 39% of phonetic compounds have the same pronunciation as their phonetics if tone is not considered (Perfetti et al., 1992; Zhou, 1978). The phonetic principle in Chinese describes the mapping between characters and syllables, while the alphabetic principle in English illustrates the correspondence between letters and phonemes (Chen, Shu, Wu, & Anderson, 2003).

The use of the phonetic and analogy strategies characterizes the phonetic stage of
Chinese learning (Chen, 2004). The phonetic strategy refers to the reading of a character using its phonetic, and the analogy strategy refers to the reading of a character by making analogies to other characters sharing the same phonetic as the first character. For example, a phonetic strategy is used when a phonetic compound 柚 you4 is read by its phonetic 由 you2, while an analogy strategy is used when a character 柚 you4 is read by making an analogy to another character 油 you2 containing the same phonetic. According to Chen (2004), L1 Chinese kindergarteners who are aged five years and eight months on average with knowledge of about thirty characters have some awareness of the phonetic and analogy strategies. They can transfer learned phonetics to unknown characters containing the phonetics in reading, which indicates their use of the phonetic strategy. L1 Chinese phonetic readers can also make an analogy to new characters sharing the same phonetics with the compound characters known to them, which shows their use of the analogy strategy.

The Orthographic Stage

As their reading experience increases, L1 English children encounter different words sharing repeated letter sequences. They begin to consider a recurring letter pattern as one orthographic unit and read it as a whole. For example, children in this stage know that –ing is an orthographic unit because they have seen –ing in many other words, such as going, coming, eating, ring, and wing, so they read king, thing, bring, sing as k-ing, th-ing, br-ing, s-ing, instead of decoding each constituent letter separately, i.e., k-i-n-g. The reading strategy of finding the shared orthographic units (e.g., -ing) across many words (e.g., going, coming, eating, ring, and wing) and applying the unit to read new words (e.g., reading king, thing, bring, sing in a way of k-ing, th-ing, br-ing, s-ing) is called the orthographic strategy, and the reading stage where this
strategy is the primary and distinctive skill is designated the orthographic stage. This is the most advanced stage of word or character reading in both English and Chinese. The orthographic strategy is different from and more advanced than the visual, in that it enables the readers to analyze words in a systematic way, instead of picking up arbitrary visual cues. It also differs from and is more advanced than the alphabetic strategy, in that it enables readers to merge the recurring orthographic pattern into one larger unit beyond decoding each letter in a word (Frith, 1985).

In English, orthographic units that recur across words often coincide with morphemes, such as -ing, -ment, -tion, -ed, -est, but in fact the notion of orthographic neighborhood best captures the concept of orthographic unit. Words that share the same letter sequences are considered to be in the same orthographic neighborhood. For example, gaze, laze, and maze share the –aze pattern, and so are in the same orthographic neighborhood. Glushko (1979) proposed the concept of the orthographic neighborhood, and found that the pronunciation of nonwords is affected by the pronunciation of their orthographic neighbors. Orthographic neighborhoods can be categorized into consistent neighborhoods (e.g., made, wade, fade) and inconsistent neighborhoods (e.g., save-have, creak-steak, most-cost), based on the pronunciation consistency of the orthographic unit within the same neighborhood.

Children’s ability to use orthographic neighborhood information implies that they can expand their analogy skills to all the members of the orthographic neighborhood. Thus, the use of the consistency information within an orthographic neighborhood marks the onset of the orthographic stage. The advantage of the orthographic strategy is that it generally speeds up word reading and facilitates the decoding of unfamiliar words, because orthographic reading is faster than letter-sound conversion reading. Also, orthographic reading strategy is beneficial in that
processing larger units reduces the load on working memory and enables readers to read more efficiently. For example, when asked to read the word *interesting*, orthographic readers may read it as *in-ter-est-ing*, whereas phonetic readers may read it as *i-n-t-e-r-e-s-t-i-n-g* (Ehri, 1998). Certainly, orthographic reading is faster and requires less memory than GPC reading.

In Chinese, the phonetic family is equivalent to the orthographic neighborhood in English, and the awareness and the use of phonetic consistency marks the orthographic stage (Chen, 2004). To know and use how the phonetic is pronounced within the same phonetic family, i.e., the orthographic strategy, is not easy to learn but very advantageous to read unfamiliar characters. Phonetic family consistency is reported as a better index for character pronunciations than regularity (Chen et al. 2003; Tzeng, 2002). According to Shu et al. (2003), frequency-weighted consistency is more than 60% on average in the characters taught in the upper grades of elementary school, while the rate of regularity is 39% on average when tone is not counted for all characters taught from Grade 1 to Grade 6. This means that readers have a 60% chance of success when predicting the pronunciation of a new phonetic compound with the most frequent pronunciation of the phonetic family. On the other hand, readers have odds of 39% to be successful in guessing the pronunciation of an unfamiliar phonetic compound with the same pronunciation as its phonetic. According to Chen (2004), L1 Chinese fourth- and sixth-graders also use the orthographic strategy, i.e., they rely on the consistency information of a phonetic family, to read new characters containing the same phonetic. They read characters in consistent families more easily and better than those in semi-consistent families and read characters in the semi-consistent families better than those in inconsistent families throughout three learning trials.

To summarize, according to the L1 Chinese reading development model proposed by Chen (2004), L1 Chinese children first start to read by relying on an arbitrary visually salient cue.
in a character, indicative of the visual stage. Then as their reading progresses, they become able to use phonetics in reading phonetic compound characters containing the same phonetic and to make an analogy across compound characters sharing the same phonetic, which shows that they have moved to the phonetic stage. Finally, as children’s analogy skills become sophisticated, they use phonetic family consistency information to read unknown characters, which marks that they have reached the orthographic stage.
Chapter 3
Overview of the Experiments

In this chapter, the experiments conducted for the dissertation will be outlined, including the rationale for the design of the two experiments and other tasks, and a detailed description of the pre- and post-experiment tasks.

Rationale

The purpose of this dissertation is to answer the following two research questions: (a) Do adult L2 learners of Chinese undergo stages in learning to read in L2? (b) If so, do Chinese reading stages of adult L2 learners parallel the stages of L1 children, i.e., the visual, phonetic, and orthographic stages? To investigate these questions, two computer-based experiments to be conducted on L2 learners of Chinese of two different proficiency levels, beginning and intermediate levels, were designed.

Experiment 1 was designed to seek evidence for the visual stage of L2 Chinese character reading. To test participants’ use of the visual strategy, L2 learners first learned simple Chinese characters that belong to three different levels of visual distinctiveness and then were asked to name the learned characters. If L2 learners use a visual strategy in learning to read Chinese characters, then they were expected to perform best on the characters with visually salient features, worst on the characters that are similar to each other, and at intermediate levels with the normal characters.

Experiment 2 was designed to seek evidence for the presence of the phonetic and the orthographic stages of L2 Chinese reading. To test the reading strategies that determine the phonetic stage, i.e., the phonetic and the analogy strategies, in the test phase of Experiment 2, L2
learners were asked to read unknown phonetic compound characters containing learned
independent phonetics (i.e., a test of the phonetic strategy) or characters sharing the same
phonetics with the characters that they had learned (i.e., a test of the analogy strategy). If L2
learners can read new characters using the learned phonetics or the phonetics of the characters
that they have learned, then they are considered to be using strategies that constitute the phonetic
stage. On the other hand, if they cannot read novel characters using phonetic information of the
known characters, it would suggest that they cannot utilize the phonetic and the analogy
strategies that characterize the phonetic stage.

To test for the use of the orthographic strategy, in the training phase of Experiment 2, L2
learners learned phonetic compound characters, as well as the simple characters serving as the
phonetics of the phonetic compounds, which belong to three different levels of phonetic family
consistency: consistent, semi-consistent, and inconsistent. If L2 learners use an orthographic
strategy, i.e., they use phonetic family consistency information, as is used in the orthographic
stage, then they would show better learning of characters from a consistent family than those
from a semi-consistent or inconsistent family. Table 1 summarizes how the various stages are
examined within the experimental design.

Table 1

<table>
<thead>
<tr>
<th>Method of Examining Stages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reading Strategy on Test</strong></td>
</tr>
<tr>
<td>Visual strategy:</td>
</tr>
<tr>
<td>Phonetic and analogy</td>
</tr>
<tr>
<td>Orthographic strategy:</td>
</tr>
</tbody>
</table>

Table 1
Table 1 (Continued)

<table>
<thead>
<tr>
<th>Materials &amp; Test Method</th>
<th>Visual Stage</th>
<th>Phonetic Stage</th>
<th>Orthographic Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Simple characters</td>
<td>• Phonetic compound characters</td>
<td>• Simple and phonetic compound characters</td>
</tr>
<tr>
<td></td>
<td>• Participants read characters with distinctiveness manipulated</td>
<td>• Participants read characters containing the same phonetics as the known characters</td>
<td>• Participants read characters with consistency manipulated</td>
</tr>
</tbody>
</table>

Overview of the Experiments

In addition to the two main experiments described above, participants also participated in five other short tasks in the study: three off-line surveys and two online working memory tasks. All seven measures were individually carried out in one day, and it took on average of about one and a half hour altogether per participant. Since Experiment 1 and Experiment 2 are explained in detail in the next chapters, the details of the other five tasks are described here with an overview of an experimental session provided in Table 2.

Table 2

Overview of a Typical Experimental Session

<table>
<thead>
<tr>
<th>Order</th>
<th>Task Category</th>
<th>Task Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Survey</td>
<td>Language Background Questionnaire</td>
<td>Participant Profile Questionnaire</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Chinese Character Test</td>
<td>Test of Chinese character knowledge</td>
</tr>
<tr>
<td>3</td>
<td>Main Experiment</td>
<td>Experiment 1</td>
<td>Experiment Examining the Visual Stage</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Experiment 2</td>
<td>Experiment Examining the Phonetic and Orthographic Stages</td>
</tr>
<tr>
<td>5</td>
<td>Working Memory</td>
<td>Letter Rotation Task</td>
<td>Test of Visuospatial Working Memory</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Reading Span Task</td>
<td>Test of Verbal Working Memory</td>
</tr>
<tr>
<td>7</td>
<td>Survey</td>
<td>Post-experiment Questionnaire</td>
<td>Post-experiment Survey</td>
</tr>
</tbody>
</table>
**Language background questionnaire.** At the beginning of the experimental session, participants were asked to fill out a Language Background Questionnaire. The Language Background Questionnaire is designed to obtain a detailed linguistic profile of the participants, such as their native language, foreign languages, and the length and the setting of Chinese language learning. The Language Background Questionnaire is listed in Appendix A.

**Chinese character test.** The Chinese Character Test, a measure of participants’ Chinese character knowledge, was administered next. This test was created by the experimenter, based on the Chinese textbooks used at the research site, the University of Illinois at Urbana-Champaign, for the first- and second-year Chinese classes, *Chinese Link: Beginning* (Wu, Yu, Zhang & Tian, 2006) and *Chinese Link: Intermediate* (Wu, Yu, & Zhang, 2007). The test consisted of 60 Chinese words and asked for the pronunciation (*pinyin*) and meaning (English translation) of each given word. Twenty words were selected from the characters learned in the textbook for the first semester, another 20 were from the second semester, and the last 20 drawn from both the third and fourth semesters. Words that are taught in the fourth semester were included in the test to measure Chinese character reading proficiency of higher level learners. Out of the 60 words, 34 are one-syllable and 26 are two-syllable words, which comprised 86 characters altogether. The Chinese Character Test is displayed in Appendix B.

In the character test, participants were asked to write down the pronunciation of the word in *pinyin* and its meaning in English on the test sheet. The test was scored by assigning one point to the correct pronunciation of the entire syllable in *pinyin* and one point for the correct English definition. Since the test had 60 words consisting of 86 characters, the maximum score for the *pinyin* was 86 points, and the maximum for the English meaning was 60. Partial points were given for the *pinyin* portion of the test, with 0.3 point given respectively for the correct
initial, final, and tone. However, no partial point was given for the meaning portion. The maximum score of the character test was 146, and the mean score was 60.92 (SD = 27.1; range 24.5-129.0).

**Working memory tasks.** Working memory is the immediate and temporary storage in memory of information while performing a task. According to the best-known view of working memory (Baddeley & Hitch, 1974), working memory consists of two sub-systems called the phonological loop and the visuospatial sketch pad, with a higher-level system called the central executive. The phonological loop concerns verbal information, while the visuospatial sketch pad deals with visual and spatial information. The central executive plays a role in coordinating and supervising information taken through the phonological loop and the visuospatial sketch pad. This indicates that a working memory has two main domains: the verbal and the visuospatial (or non-verbal). In the literature on working memory, one of the most common measures for verbal working memory is the reading span task (Conway, Kane, Bunting, Hambrick, Wilhelm, & Engle, 2005; Daneman and Carpenter, 1980; Shah & Miyake, 1996; Swets, Desmet, Hambrick & Ferreira, 2007), and a common measure of visuospatial working memory is the letter rotation task (Gupta, 2003; Miyake et al., 2001; Shah & Miyake, 1996).

In the current study, both a reading span task and a letter rotation task were used to assess an individual participant’s verbal and visuospatial working memory capacity, respectively. Since both tasks measure working memory, which involves not only information storage but also concurrent processing of additional information, the tasks consisted of two components: the presentation of to-be-remembered target stimuli, such as a letter at the end of the sentence or the spatial orientation of the top of a letter, and the presentation of a secondary processing task, such as judging semantic plausibility of the sentence or answering whether the image is normal or
The reading span and letter rotation tasks had the same overall structure. Each task consisted of 42 items divided into 12 sets with a single set consisting of 2, 3, 4, or 5 items. Each set size, (i.e., set size of 2, 3, 4, and 5) appeared three times in each working memory task. Each participant viewed the same items in the same order. Working memory tasks assess individual participants’ differences in their working memory capacity, so tasks need to be implemented for participants under the exact same condition. For this reason, it is desirable that the order of item presentation in working memory tasks be the same across participants, instead of random order presentation. In each working memory task, participants were told to answer a question about each item while retaining another piece of information about the item in memory at the same time, and then to write down the remembered information on the answer sheet.

**Letter rotation task.** The letter rotation task used in the current study was modified from the task of the same name by Miyake et al. (2001) and was implemented using E-Prime software by the experimenter. The version used in this study had half the items that Miyake and colleagues used. Capital letters of F, J, L, P, or R were used as items in this task. Two manipulations were made of the position of the letters. In the first manipulation, the letters either remained as normal or were flipped along their vertical axis, making them either normal or mirror images. In the second manipulation, both normal and mirror images of each letter were rotated at multiples of 45 degrees, yielding the 8 possible positions of 45, 90, 135, 180, 225, 270, 315, and 360 degrees of rotation. Table 3 shows all possible images of “F” used in the letter rotation task. Each letter had 16 possible normal or mirrored-image orientations in total, and there were 80 possible images for all five upper case letters.
Table 3

Materials Example of Letter Rotation Task Using the Letter “F”

<table>
<thead>
<tr>
<th>Normal Images</th>
<th>Mirror Images</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotation at multiples of 45 degrees</td>
<td></td>
</tr>
<tr>
<td>45° 90° 135° 180°</td>
<td>45° 90° 135° 180°</td>
</tr>
<tr>
<td>225° 270° 315° 360°</td>
<td>225° 270° 315° 360°</td>
</tr>
</tbody>
</table>

This task contained 42 random items among 80 possibilities, which was assigned into one of 12 sets. Each set contained sizes of 2, 3, 4, or 5 items and appeared three times in the entire task. The set started with the two-item presentation, and the same number of items was presented three times. Then the number of letters per set was increased stepwise to 3, 4, and then to 5 letters per set, which yielded 12 sets in total. All the items in the Letter Rotation Task are listed in Appendix C.

Participants were instructed to say aloud “Regular” for normal letters or “Flipped” for mirrored letters immediately after seeing each letter on the computer screen and to remember the spatial orientation of the letter (i.e., where the top of the letter was pointing) simultaneously. After each set of items, participants were asked to report the orientation of each letter’s top in the correct serial order of presentation by writing numbers on a paper answer sheet containing a grid representing the eight possible positions of the letter’s top. Participants started with a practice trial with three sets of two items and continued the practice trials until they became comfortable with the task. The task was designed to be fast-paced by making the experimenter move to the
next difficulty level as soon as participants answered or reached the maximum time interval of three seconds between each item. However, after each set when participants reported the orientation of the letters, they could have as much time as they wanted. This took around 10 to 15 minutes, including instruction, practice, and the main task.

![Diagram](image)

**Figure 1.** Example of a letter rotation task with a two-item set

Scoring the data collected from the letter rotation task followed the methods used by Gupta (2003), Miyake et al. (2001), and Shah & Miyake (1996). The memory portion of the test consisted of participants’ recalled report of the letter’s head orientation. Participants’ vocal judgments on normal or mirrored-images were recorded by the experimenter but were not included in the data analysis. In the working memory tasks, the processing performance (in our case, image report) usually serves to ensure that participants pay attention to the secondary task and correlates positively with performance on the storage component, which indicates there is no trade-off between processing and recall accuracy (Conway et al. 2005; Kane et al. 2004; Shah & Miyake, 1996).

Individual written reports on the orientation of the top of the letter were collected, scored by the experimenter, and included in the data analysis as a measure of participants’ visuospatial
working memory capacity. The items which were correctly recalled in the correct serial position were counted as correct and given one point. The maximum score was 42 points, and the mean was 19.86 points (SD = 6.85; range 6-33).

**Reading span task.** After completing the letter rotation task, participants read instructions for the reading span task. The reading span task required participants to memorize the letter at the end of the sentence while judging the semantic plausibility of the sentences. Inefficient comprehension of the sentences can influence holding the memorized letters in the correct order, so conducting the reading span task on participants’ native language is the ideal. Among the total of 70 participants, the majority of the participants in the current study were native speakers of English (45) and native speakers of Korean (14). Native languages of the rest of the 11 participants were dialects of Chinese (6), Thai (2), German (1), Russian (1), and Spanish (1). Since not every language version of the reading span task could accommodate each participant’s native language at the time of conducting the study, only two language versions of the reading span tasks, English and Korean, were used because native speakers of English and of Korean comprised the major population of the participants, i.e., 64.3% and 20%, respectively. For the participants whose native languages were not Korean, the English version was used.

The English version of the task used in this study was the task taken from Kane, Hambrick, Tuholski, Wilhelm, Payne, and Engle (2004) developed by the study authors. Each sentence consisted of 10-15 English words and was either semantically plausible or implausible. The total number of sentences in the task was 42. Out of 42 sentences, 19 sentences were semantically plausible, and the other 23 were implausible. At the end of each sentence, an alphabetic letter was presented. A sentence and a letter comprised a single item for the task, and a set consisted of 2, 3, 4, or 5 items. Each set size occurred three times in the entire task, which
yielded 12 trials total. The set size did not progressively increase but was randomly assigned to prevent the participants from strategically focusing on the to-be-remembered final letters. All the items in the Reading Span Task are listed in Appendix D.

Participants were required to read aloud the presented sentence, answer “Yes” or “No” to the question marked by a single question mark (?) about whether the sentence was semantically plausible, say aloud the letter after the question mark, and remember the letters until they were told to write them down. Immediately after a set of two to five items ended, three question marks (???) appeared, which signaled the participant to recall the letters and write them down in serial order on the answer sheet. After that, participants moved to the next set by pressing the spacebar. Figure 2 displays the procedure of a set size of two.

Figure 2. Example of the English reading span task with a set size of two

The Korean reading span task used in this study was one that Kim (2008) developed and programmed in E-Prime. The Korean version was created by matching the total number of items, the number of items in each set, and the order of the 12 sets appearing in the task. The sentences and recall-syllable at the end of the items were in Korean, but the Korean sentences were not direct translations of English original sentences. However, the items were matched for the order and number of ‘yes’ and ‘no’ answers to the semantic plausibility judgment subtask. The Korean
task was shown to be comparable with the English version, by Kim (2008), who conducted both the English and Korean reading span tasks on 32 Korean-English late bilinguals and found a significant correlation of .71 (p < .01). It took around 10 to 15 minutes for participants to complete the task.

Both the English and Korean versions were scored in the same manner by using “All-or-nothing Unit Scoring”, one of the four most commonly used scoring methods in the literature (Conway et al., 2005). Each item of the set received one point, but only if all the items of the set were correct and in the correct serial order. If any item of the set was incorrect, then no credit was given. The maximum score for the reading span task was 42, and the mean was 18.24 (SD = 9.66; range 2-42).

**Post-experiment questionnaire.** At the end of the experimental session after the two working memory tests, a Post-experiment Questionnaire was administered. It contained questions to ask whether there were any characters in the experiments that the participants already knew and what kind of strategies they used to memorize the characters in the experiments. The main purpose of this survey was to confirm that it was the first time for the participants to learn the characters provided in the experimental session and to collect any qualitative data regarding their reading strategies. No participant reported that there was a known character. The questionnaire is listed in Appendix G.
Chapter 4

Experiment 1

The purpose of Experiment 1 was to test whether adult L2 learners of Chinese are aided in remembering new characters by making one of the strokes visually distinctive, allowing us to determine whether they use a visual strategy in learning to read novel Chinese characters. This was achieved by having participants learn new character sets divided into three hierarchical levels of visual distinctiveness: distinctive, normal, and similar character set types. Characters in the distinctive set type were created by making one stroke of each character extraordinarily thick, whereas characters in the normal and the similar set types were regular characters without any visual enhancement. The bold strokes in the distinctive type function as a thumbprint in the literature of English L1 children’s reading development and play the same role as the lengthened strokes in the experiment with Chinese L1 children. Characters in the similar set type were regular but consisted of pairs of characters that were visually similar to each other. Each character set type contained six Chinese characters.

Participants were trained to read aloud characters in the training phase and were tested in the testing phase. In the training phase, they learned novel characters of three character set types over three learning trials. Then, in the testing phase, they were asked to name all the learned characters presented randomly along with other filler characters that were unknown to them. Two changes were made in the characters for the testing phase. The bold strokes of the characters of the distinctive type in the training phase were made normal, and some filler characters containing the bold strokes were inserted. The purpose of these changes in the testing phase was to see whether L2 Chinese learners could read the characters whose bold strokes were rendered in normal font in the context where other characters had the bold features.
It was hypothesized that participants utilize a visual strategy to learn characters and are therefore considered to exhibit visual stage characteristics if they meet the following two conditions. First, in the training phase, participants would use visual distinctiveness as an effective strategy to learn to read by learning the characters of the distinctive type the best, followed by the normal type, and then the similar type as the worst. Second, in the testing phase, participants would name and recognize significantly worse the characters whose bold strokes were removed when compared with the characters in the normal or similar types remaining the same as in the training phase.

**Method**

**Participants.** Seventy students enrolled in Chinese language classes at the University of Illinois at Urbana-Champaign participated and received $20 for their participation for both Experiment 1 and Experiment 2. Forty three students were enrolled in first semester Chinese language classes and 27 in third semester classes. Forty-five students were native speakers of English, and 25 were non-native speakers of English, but their second language was in all cases English. Native languages of non-native English participants were Korean (14), Thai (2), Spanish (1), German (1), Russian (1), and Chinese dialects such as Taishanese (2), Cantonese (3), and Fuzhouese (1). There were 42 males and 28 females, and their mean age was 20.14 (range: 18-27).

Each level of the beginning and intermediate Chinese classes at the University of Illinois at Urbana-Champaign usually consists of two semesters of training in the four language skills, i.e., speaking, listening, reading and writing. Each semester consists of 16 weeks, and each week consists of five 50-minute class periods. In the beginning level, i.e., the first-year, only
traditional characters are introduced and taught, but in the intermediate level, i.e., the second-year, simplified characters are taught.

Materials. A total of 36 characters were used as stimuli in Experiment 1. Only structurally simple characters without any phonological component were selected in order to test for visual strategies exclusively. Also, all the characters used in Experiment 1 were chosen from ancient or uncommon variant forms of current regular characters to ensure that all are real characters, and that it would be in this experiment that they would first encounter and learn them. The fact that the characters were unknown to the participants was confirmed by the questionnaire that the participants filled in at the end of the experimental session. Participants all answered that the experiment did not have any character that they knew or had seen before. All the stimuli have identical forms in the traditional and simplified character types, and were selected from the Comprehensive Chinese Character Dictionary (漢語大字典, 1993), one of the most reputable reference works on Chinese characters, containing 54,678 main character entries. Out of 36 characters used in Experiment 1, 18 characters were target stimuli in the experiment, and they were learned in the training phase. The other 18 characters served as fillers, added only to the testing phase. The complete set of the stimuli for Experiment 1 is shown in Appendix E. The pronunciations of the characters were recorded by a female native speaker of Chinese.

Characters for the training phase. The 18 target characters consisted of three character types with six characters in each set. The three types were visually distinctive, normal, and similar. The mean number of character strokes in each type was 4.8, 4.8, and 5, respectively. The distinctive set contained characters with a visually salient feature, created by exaggerating the width of one stroke of a normal character. Bolding is one common means of textual enhancement to make learners pay attention to specific forms in written input (Wong, 2005). It is along the
same lines as the methods used by the previous studies, such as varying the height and the size of
the alphabetic components within an English word (Ehri & Wilce, 1985) and elongating one
stroke of a character (Chen, 2004). For example, a stroke in the center of 伞 was exaggerated,
and 伞 was thus created and included in the distinctive type. The normal set consisted of six
regular Chinese characters without any artificial exaggeration in their strokes, e.g., 土. The
similar type consisted of three pairs of characters that were visually similar to each other, but
were different only in one or two components of the character, e.g., 无 -- 无. The characters
used in the distinctive type and the normal type were counter-balanced by participant by
constructing two lists of the stimuli, List 1 and List 2. The visually distinctive features of the
characters in the distinctive type of List 1 were eliminated and served as the normal type in List 2,
whereas the normal type in List 1 were changed to the distinctive type in List 2 by making one
stroke of each character with exaggerated thickness. In other words, the characters of the
distinctive type in List 1 corresponded to those of the normal type in List 2, while the characters
of the normal type in List 1 corresponded to those of the distinctive type in List 2. For example,
in List 1, 伞, 伞, 伞, 伞, 伞, 伞 were characters of the distinctive set, and
伞, 伞, 伞, 伞, 伞, 伞 belonged to the normal type. On the other hand, in
List 2, the bold stroke in the distinctive characters of List 1 was deleted and the character served
as the normal type, e.g., 伞, 伞, 伞, 伞, 伞, 伞, while a stroke of the
characters in the normal type were made much thicker, with these characters belonging to the
distinctive set, e.g., 伞, 伞, 伞, 伞, 伞, 伞. The distinctive and the normal
types were counter-balanced in this way to ensure that it was the effect of distinctive strokes that was being tested. For the similar set, counter-balancing was not applied.

**Characters for the testing phase.** Altogether, 36 characters were used in the testing phase. In addition to the 18 target characters used in the training phase, another 18 characters were added to the testing phase as fillers. The added filler characters were also low frequency and unknown to participants. In the testing phase, among 18 target stimuli, all 6 characters of the distinctive type were changed by removing the visual enhancement, which is referred to as the *changed distinctive type* hereafter. The purpose of this change was to test whether participants could still recognize and name the characters that had been previously enhanced, when that enhancement was subsequently removed. To reduce the likelihood of participants’ noticing the removed enhancement, another 18 new characters were added to the test as distracters, 12 of which had enhanced strokes, and the other six characters were composed of three pairs of visually similar characters. This enabled all 36 characters of the testing phase to have the same proportion of distinctive, normal, and similar characters with 12 characters for each set as the characters in the training phase.

**Procedure.** Participants were tested individually, seated in front of a laptop computer in a lab and wearing a headset. After completing the language background survey and the Chinese character test, they were assigned to one of two lists of Experiment 1. The characters were presented in random order using the E-Prime presentation software. Participants were instructed that they would learn 18 novel Chinese characters one at a time by seeing the character and hearing its pronunciation, and that they would be tested to name the learned characters at the end of the learning session. The experimenter was present in the lab behind the participant to monitor, record, and score the participants’ performance.
The experiment consisted of a training phase and a testing phase. The training phase was intended to teach participants the target characters by showing the character and providing its pronunciation. Participants were asked to read aloud the characters immediately after they heard the pronunciation. The testing phase consisted of a final test to ask participants to name the characters that they had learned in the training phase in the presence of added unfamiliar characters.

**Training phase.** The training phase was composed of a practice trial and three learning trials. The practice trial had the same structure as the training phase with participants learning to read three characters, which took about 5 minutes. Immediately after the practice trial, participants moved to the learning trials which were repeated three times. Each learning trial consisted of a learning section and a test section. A learning section aimed to train participants to learn to read the 18 stimulus characters, and a test section aimed to measure how many and what types of characters they had actually learned in the learning section.

In the learning section, each character appeared on a computer screen in random order one at a time with its pronunciation simultaneously presented over the headset. The entire set of 18 characters was presented by the E-Prime software, starting with a fixation point displayed for 700 ms. After the fixation point, a character was presented for 5000 ms and played twice over the headphones. Participants were instructed that they would see the character and hear its pronunciation. As soon as participants heard the pronunciation, they were asked to repeat aloud what they heard, which was done two times for each character. The detailed procedure for a learning section is presented in Figure 3.
Immediately after the learning section, participants moved to the test section and were asked to name by themselves all 18 characters that were presented randomly. The purpose of the test part was to measure participants’ character learning and to ensure that participants were alert and motivated to learn characters in the next learning section. Specifically, for the test section, the following instruction was given: “If you can recall the characters, then name its pronunciation. However, if you cannot recall, then say ‘I don’t remember.’” A pair of a learning and a test section comprised a learning trial, and participants had three learning trials in the training phase. In each learning trial, the presentation of the 18 target characters was in a random order.

**Testing phase.** The testing phase immediately followed the third learning trial of the training phase. The structure of the testing phase was the same as the test section of the learning trial, except for two changes. First, the characters of the distinctive type no longer had a visually distinctive feature. Second, 18 additional unknown characters were added to the test as distracters. To mask these changes, the following instruction was given for the testing phase:
“The next task is very similar to what you did in the past learning trials. You will be asked to name characters. Some are the characters that you have learned, but some are totally new to you. If you can recall the character, then name it. If you know that the character is what you have learned but you cannot recall its pronunciation, then say ‘I don’t remember’. However, if the character is totally new to you, then say ‘I don’t know.’” When a character appeared on the screen after a fixation point for 700 ms, participants answered it and pressed the spacebar to move to the next character. If participants did not answer or press the spacebar within 10 seconds, the next character came up automatically. The presentation of the test characters was in random order. The detailed procedure of the testing phase is shown in Figure 4.

![Figure 4. Example of a testing phase](image)

**Figure 4.** Example of a testing phase

**Scoring.** For character naming in the training phase and in the testing phase, each character was scored as **correct** if they named an entire syllable (excluding tone) correctly, and as **incorrect** otherwise. For scoring the characters in the testing phase, in particular, only 18 target characters were scored, and the other 18 filler characters were excluded from further analysis.
For character recognition in the testing phase, it was scored as *correct* if participants either responded with correct or incorrect pronunciation or said “I don’t remember”. The correct naming of the character indicated they recognized and remembered the pronunciation. Even incorrect naming or an answer with “I don’t remember” were counted as correct answers, because participants at least recognized the character and could provide even an incorrect name for the character or indicate they knew that they had seen it before but could not recall. However, “I don’t know” was scored *incorrect*, because the answer indicated that they did not recognize the character and considered it unknown to them. When participants responded to a character with more than two different answers, the last response was taken as their final answer.

**Statistical analysis.** Since the results from the experiment were dichotomous data, statistical analyses were carried out using a mixed logit model (Jaeger, 2008) in R (R Core Development Team, 2009). Mixed logit models are a generalization of logistic regression for binomially distributed outcomes with an ability to account for random subject and item effects in a single analysis. Recent studies report that the most widely-used Analysis of Variances (ANOVAs) is inappropriate to analyze categorical data, to which the binary outcomes from this experiment belong (Dixon, 2008; Jaeger, 2008). Categorical outcomes violate the primary assumption of ANOVAs, that the analyzed data are normally distributed. Also, ANOVAs use the means, variances, and standard errors, and other statistics drawn from the discrete categorical data, but categorical data are discrete rather than continuous, and thus calculating means for discrete data causes scaling artifacts and distortion of the pattern of means, and leads to spurious results. Therefore, especially for analysis of categorical dependent variables, appropriate methods should reflect responses of individual subjects and items, instead of calculating means for the data.
In particular, for analysis of accuracy data in repeated-measures designs, mixed logit models (generalized linear mixed-effect models) are recommended as an alternative to ANOVAs (Baayen, Davidson, & Bates, 2008; Dixon, 2008; Jaeger, 2008). Mixed logit models represent a combination of the benefits of both logistic regression modeling and mixed-effects modeling of subjects and items as crossed random effects. Logistic regression is appropriate for analysis of binary data, because the log odds for the proportion correct avoids scaling artifacts from simple proportions of the correct answers. Mixed-effects models can address even situations where effects vary randomly and they also merge subject and item analyses into one unified model.

For data analysis of the current study, in mixed logit models, naming or recognition accuracy were included as the dependent variable, discrete predictors (such as trials, character types, lists, and participants’ first languages) and continuous predictors (such as character test scores, reading span task scores, and letter rotation task scores) as fixed-effect factors, and participants and items as random-effect factors. To obtain the most parsimonious model with the best fit with the minimum number of predictors, all predictors and all possible interactions between them were first entered into the model, and then the least contributing predictor to the model was eliminated one by one using likelihood ratio tests. In the rest of the dissertation, the coefficients and significance levels for those predictors remaining in the minimal model will be presented in the tables.

Results

Data from all 70 subjects were analyzed using the statistical method described above. In Experiment 1, no significant effects of character test, list, or participants’ L1s were found. Note that the character test variable is the actual character test scores that participants received in the
Chinese Character Test carried out in the beginning of the experimental session, which reflects participants’ character knowledge. For handling the character test scores, two methods were possible. One was to include participants’ raw scores in the statistical models as a continuous variable, and the other was to include it as a categorical variable by splitting participants into high- and low-character knowledge groups according to the mean of the character test scores. For this dissertation, both methods were used, but the split method was not sensitive enough to detect significant differences. Therefore, for both Experiment 1 and Experiment 2, the results of mixed logit models with the character test variable as a continuous variable are reported. The rest of the predictors, such as trial, character type, reading span task, and letter rotation task, had significant effects, depending on the analysis, which is described in the following sections.

Training phase. Naming data from the training phase was analyzed using mixed logit models. The number of items correctly read was the dependent variable, and trial, character type, list, character test, reading span task, letter rotation task, and participants’ L1s were included as fixed-effect factors in the model, with subject and item as random-effect factors. There were no significant effects of list, character test, or participants’ L1s. Three different methods of analyses were carried out regarding trials and character types. Data with all three trials and all three character types collapsed together were first analyzed, and then data for all three character types by each trial were included in the second analysis. Finally, an analysis of each character type by each trial was carried out.

Figure 5 shows the proportion correct in naming accuracy for character types by trial. There was a significant effect of trial as expected, with significantly higher naming accuracy rate

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Note that the results in Figure 5 are shown in proportions of the means of naming accuracy only to visualize the data. For data analysis, logit mixed models were fitted to individual data points.

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in the second and the third trials than in the first trial, which indicates that participants gradually progressed in learning to read characters over the learning trials.

**Figure 5.** Proportion correct in naming accuracy for character types by trial

The results of each analysis are displayed in Table 4 to Table 6. Before reading the tables, it might be necessary to explain how to interpret the results from a mixed logit model. Each table in the following contains five columns of predictors, estimates, standard errors (SE), z-values, and probabilities with asterisks indicating significance level. The predictor column lists all the independent variables entered into the regression. For categorical variables, the model selects a baseline condition to which it compares other levels of the same variable, and the baseline is not shown in the column. The coefficient column displays the estimate of the coefficient associated with the effects, which describes the slope associated with an effect in log-odds (or logit) space. Coefficients that are significantly smaller than zero decrease the log-odds of the outcome, i.e., a correct answer, whereas coefficients significantly larger than zero increase the log-odds of the outcome. The numeric value of each predictor indicates its difference from the coefficient of the baseline predictor. The SE column provides the estimate of the coefficients’ standard errors,
which is used to calculate z-value in the next column by dividing the coefficient estimate by the
estimate of its standard error. The z-value column indicates how far the coefficient estimate is
apart from zero in terms of its standard error. If this standardized distance from zero is large
enough, then it becomes statistically significant. The next column shows probabilities with
significance levels.

Table 4 displays naming performance on all three character types combined over all three
trials. In the predictor column, the intercept for naming accuracy is regarded as naming accuracy
of the first trial of learning (trial 1) here. Trial 1 serves as the baseline for naming accuracy and is
not shown in the predictor column, and the coefficients of the other predictors are the differences
from the trial 1 baseline. In other words, the coefficient of the intercept in Table 5 is the value to
which the coefficient of each predictor is added in order to obtain the predicted naming accuracy
for the respective trial. For example, the coefficients of trial 2 and trial 3 are approximately 1.798
and 2.848, respectively, which means that for each trial naming accuracy, an additional 1.798 and
2.848, respectively, are added to the naming accuracy value from trial 1 (-3.155), as indicated by
the intercept predictor in the table. The positive coefficient values for trial 2 and trial 3 mean that
naming accuracy of trial 2 and trial 3 is more accurate than trial 1. Also, the larger positive
number in trial 3 than trial 2 means that naming accuracy of trial 3 is higher than trial 2. This
indicates that participants gradually progressed in learning to read characters trial by trial, which
follows our general expectation. The coefficient for reading span is also positive, meaning that
participants whose reading span test scores are higher perform better in learning to read
characters throughout all trials in the training phase.
Table 4

**Naming Accuracy on All Three Character Types in All Three Trials of the Training Phase**

| Predictors     | Estimate | SE  | z value | Pr(>|z|)     |
|----------------|----------|-----|---------|-------------|
| (Intercept)    | -3.155   | 0.319| -9.889  | < 0.001 *** |
| Trial 2        | 1.798    | 0.119| 15.050  | < 0.001 *** |
| Trial 3        | 2.848    | 0.122| 23.302  | < 0.001 *** |
| Reading Span   | 0.032    | 0.013| 2.497   | 0.013 *     |

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

Table 5 shows the results of naming accuracy by trial. The row for trial 1 shows no significant predictor, meaning that no variable significantly predicted participants’ ability to learn characters in the first trial. The column for trial 2 lists three predictors, and only similar character type and reading span are statistically significant. Since the character type is a categorical factor, not a numerical variable, the intercept represents the naming accuracy for the default level of the character type, which is distinctive character type here. The negative coefficient value for similar type indicates that naming performance for the similar character type was worse than the baseline of distinctive type by -0.866 (log-odds). On the contrary, the positive coefficient for reading span indicates that participants with higher reading span scores performed significantly better than those with lower reading span task scores. In trial 3, only reading span scores were significant, indicating that participants with higher reading span scores learned to read characters significantly better than those with lower reading span task scores. These results altogether indicate that the reading span task contributed to participants’ character learning in the training phase more than the character types, because the reading span effect was found in trial 2 and trial 3, but the character type effect was only found for the similar type in trial 2. It is worth noting that participants benefitted from their verbal working memory, rather than the levels of visual distinctiveness in the characters.
Table 5

**Naming Accuracy in Each Trial of the Training Phase**

| Trial | Predictors     | Estimate | SE  | z-value | Pr(>|z|)  |
|-------|----------------|----------|-----|---------|----------|
| 1     | (Intercept)    | -2.416   | 0.219 | -11.01  | < 0.001 *** |
| 2     | (Intercept)    | -1.002   | 0.317 | -3.166  | 0.002 **   |
|       | Normal         | -0.114   | 0.151 | -0.755  | 0.450     |
|       | Similar        | -0.866   | 0.389 | -2.228  | 0.026 *    |
|       | Reading Span   | 0.032    | 0.011 | 2.900   | 0.004 **   |
| 3     | (Intercept)    | -0.408   | 0.336 | -1.216  | 0.224     |
|       | Reading Span   | 0.038    | 0.013 | 3.061   | 0.002 **   |

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

Table 6 shows the results of separate analysis of each character type by each trial. In trial 1, no variable contributed significantly to naming performance for any character type. From trial 2, however, significant contributors to learning started to emerge. Letter rotation scores significantly predicted participants’ accuracy in reading distinctive characters, while reading span scores significantly predicted accuracy in reading normal characters. This pattern for distinctive and the normal types was also valid in trial 3. For similar characters, no predictor was found in trial 2, but reading span scores were found to be significant predictors in trial 3. The similar group showed these effects later than the distinctive and the normal types, and this might stem from the fact that in trial 2 the accuracy rate for the similar type was too low to show any significance compared to the normal type. In trial 3, however, when the similar type reached a level of naming accuracy that was sufficient to indicate a significant factor, verbal working memory was shown to be the significant factor.
Table 6

**Naming Accuracy on Each Character Type in Each Trial of the Training Phase**

| Trial | Character Type | Predictors                  | Estimate | SE    | z-value | Pr(>|z|) |
|-------|----------------|-----------------------------|----------|-------|---------|----------|
| 1     | Distinctive    | (Intercept)                 | -2.128   | 0.198 | -10.770 | < 0.001 *** |
|       | Normal         | (Intercept)                 | -2.281   | 0.270 | -8.448  | < 0.001 *** |
|       | Similar        | (Intercept)                 | -2.786   | 0.429 | -6.490  | < 0.001 *** |
| 2     | Distinctive    | (Intercept)                 | -1.747   | 0.515 | -3.391  | < 0.001 *** |
|       |                | Letter Rotation             | 0.066    | 0.023 | 2.822   | 0.005 **  |
|       | Normal         | (Intercept)                 | -1.068   | 0.329 | -3.250  | 0.001 **  |
|       |                | Reading Span                | 0.031    | 0.011 | 2.674   | 0.007 **  |
|       | Similar        | (Intercept)                 | -1.434   | 0.260 | -5.505  | < 0.001 *** |
|       |                | Reading Span                | 0.013    | 0.022 | 0.592   | 0.554    |
| 3     | Distinctive    | (Intercept)                 | -0.757   | 0.571 | -1.325  | 0.185    |
|       |                | Letter Rotation             | 0.066    | 0.025 | 2.615   | 0.009 **  |
|       | Normal         | (Intercept)                 | -0.039   | 0.385 | -0.101  | 0.920    |
|       |                | Reading Span                | 0.037    | 0.015 | 2.488   | 0.013 *   |
|       | Similar        | (Intercept)                 | -0.889   | 0.408 | -2.178  | 0.029 *   |
|       |                | Reading Span                | 0.033    | 0.014 | 2.432   | 0.015 *   |

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

The results of the training phase can be summarized as follows. First, as expected, participants significantly improved in learning characters from one trial to the next. Second, different levels of visual distinctiveness did not affect participants’ learning to read characters, as seen in Table 4. Third, higher levels of individual working memory resources increased participants’ ability to learn to read characters. Specifically, visuospatial working memory as represented by the letter rotation task and verbal working memory as represented by the reading span task contributed to learning different types of characters. Stronger visuospatial working memory helped participants to learn visually distinctive characters, whereas stronger verbal working memory helped in learning regular characters. This interesting finding may be related to the nature of the different types of working memory. Finally, in the first trial when participants were exposed to the characters for the first time, not only was their learning performance not
good, but their working memory differences also had no effect. However, working memory resources started to become noticeable as early as the second trial and resulted in better learning, which then continued to the third trial.

**Testing phase.** Two changes were made to the characters used in the testing phase. First, the visually distinctive features of the characters in the distinctive character type had their enhancement removed, which made the characters in the distinctive character set no longer distinctive but normal, which was subsequently called the *changed distinctive type*. Second, 18 unknown filler characters, two-thirds of which (i.e., 12 characters) contained enhanced strokes, were added as distracters.

Participants’ character naming and character recognition data were collected in the testing phase and were analyzed using logit mixed models. The variables of character type, list, character test, reading span task, letter rotation task, and L1s were entered into the model as fixed-effect factors, with subject and item as random-effect factors. No significant effects of list, character test, letter rotation task, or participants’ L1s were found. Figure 6 displays the general pattern of performance on the character types in the naming and the recognition tasks. Participants performed better in the recognition task than in the naming task, as expected. In both tasks, participants performed on the *changed distinctive type* worse than on the normal and similar types. In the naming task, performance on the similar type was worse than the normal type, but was similar to the distinctive type, while in the recognition task, performance on the similar type was as good as the normal type and better than the *changed distinctive type*.

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3 Note that in the graph the means of naming accuracy are used only for the purpose of visualizing the data, but the means were not used in the data analysis because the data were binomially distributed.
Table 7 shows that the results for naming and recognition accuracy with the changed distinctive type as the reference level. For character naming, statistical significance was found for the normal character type, indicating that participants read characters in the normal character type, but not the similar type, significantly better than those in the changed distinctive type.

Significance found in the reading span test indicated that participants with higher reading spans performed significantly better than those with lower spans.

Table 7

| Task       | Predictors | Estimate | SE  | z-value | Pr(>|z|) |
|------------|------------|----------|-----|---------|----------|
| Naming     | (Intercept)| -0.971   | 0.391| -2.485  | 0.013 *  |
|            | Normal     | 1.026    | 0.162| 6.327   | < 0.001 *** |
|            | Similar    | -0.065   | 0.494| -0.131  | 0.896    |
|            | Reading Span| 0.028    | 0.013| 2.199   | 0.028 *  |
| Recognition| (Intercept)| 1.021    | 0.272| 3.755   | < 0.001 *** |
|            | Normal     | 3.539    | 0.396| 8.947   | < 0.001 *** |
|            | Similar    | 3.307    | 0.528| 6.262   | < 0.001 *** |

* p < .05; ** p < .01; *** p < .001
For character recognition, significant differences were found in the normal and the similar character types, meaning that participants recognized the characters in the normal and the similar types significantly better than those in the changed distinctive type. This shows that participants did not recognize the same characters that previously bore a visual enhancement after the enhancement was removed from the characters, and then presented in a different context, together with characters that they did not know. In other words, when the same characters were presented with enhancements removed and in a different context from that in which they were learned, participants recognized those characters significantly worse than the characters bearing the exact same physical features as in the learning contexts.

The character recognition data show some differences from the character naming. First, the coefficients of the normal type are higher in recognition (3.539) than in naming (1.026), meaning the performance in recognition is better than in naming, as seen in Figure 6. Second, participants recognized the characters of the similar type better than those of the changed distinctive type, which was not true in naming. Third, the effect of the reading span scores shown in naming disappeared in recognition. These differences between character naming and recognition may stem from the nature and difficulty of the tasks. For naming, responding with completely accurate pronunciations was counted correct. For recognition, however, they were considered correct as long as they correctly answered the question on whether the presented characters were the same as those that they had learned before. Since they did not need to provide the exact pronunciation for correct recognition, their performance was naturally better than in naming. This benefit was even greater for the similar type. If participants named one character incorrectly in confusion with its similar pair, then the pronunciation was counted as incorrect for naming performance, but was counted as correct for recognition performance,
because providing a pronunciation implied that they recognized the character.

A reading span effect in naming but not recognition suggests that the task of character recognition did not tap into verbal working memory, and thus might not be a linguistic task. At the same time, no effect of the letter rotation task in recognition also suggests that the character recognition task may not tap into visuospatial working memory, either. The question for the recognition task used here, i.e., whether the participant might have seen the presented character, may not be sufficient to induce use of visuospatial working memory resources. The recognition task is worth investigating further in association with the verbal and the visuospatial working memory tasks, with reference to the naming task.

**Discussion**

Experiment 1 demonstrated that the different levels of visual salience did not help L2 learners learn to read characters, as shown in the results of the three learning trials in the training phase. Rather, individual differences in working memory capacity contributed to the learning of simple characters that do not contain pronunciation cues. This suggests that a visual stage is not operative in the reading development of adult L2 learners of Chinese.

It was hypothesized that participants are considered to make use of a visual strategy to learn to read and to show evidence of a visual stage if they meet two conditions: (a) in the training phase, if they learn the character set containing visually distinctive features more successfully than the normal and similar character sets; and (b) in the testing phase, if they performed worse on those characters previously with enhanced salience but with salience removed than those characters with the same forms as in the training phase. The results only supported the second condition and thus fail to completely confirm existence of a visual stage in
L2 reading. Participants did not show any better naming on the distinctive character types over
the normal or the similar types in the training phase, even though they performed worse for
characters of the changed distinctive type with bold strokes removed than they did for normal or
similar types whose forms remained the same.

It is even clearer that adult L2 learners do not use the visual strategy in learning to read
Chinese characters and that they do not proceed through a visual stage, when we compare our
results to the performance of young L1 Chinese visual readers in Chen’s (2004) study. The 4-
year-old L1 Chinese children learned characters with visually salient features better than normal
characters, and learned the normal characters better than the characters that resemble each other.
This contrasts noticeably with the results from our adult L2 readers, in which no difference in
learning was found based on a hierarchy of visual distinctiveness. It can even be said that no
visual stage was found in adult L2 learner’s reading development, because more than half of the
participants, 43 out of all 70 participants, were from the first semester Chinese classes and had
learned Chinese characters for 12 weeks at the most at the time of the experiment. The fact that
even at this very beginning point learners did not show any sign of utilizing the visual strategy
can be taken as evidence for the absence of a visual stage in adult L2 learners’ reading
development.

For adult L2 learners, working memory capacity played a more important role in learning
to read the characters than did the visual salience of characters. It is intriguing that visuospatial
working memory facilitated learning visually enhanced characters, while verbal working
memory was helpful in learning the regular Chinese characters. This result suggests that learning
ordinary Chinese characters is essentially a linguistic task for L2 character learners, as shown in
the reading span effect on performance for the normal and similar types. On the other hand, the
manipulation of providing a distinctive, exaggerated bold stroke in a character may be considered non-linguistic, and so the visuospatial working memory factor only correlated with this distinctive type with its visual manipulation, and not with any of the other types.

This result also suggests that adult L2 learners were able to distinguish different character types and used different working memory resources to process them. They exploited visuospatial working memory in processing non-conventional characters containing an exaggerated thick stroke, while they utilized verbal working memory in processing regular and conventional Chinese characters (the normal and the similar types). This implies that adult L2 readers, even novice readers, are aware that an exaggerated stroke in a character makes no distinction in the Chinese writing system and that they consider the characters with a salient stroke as non-distinctive. This is congruent with previous studies showing that adult L2 learners learn very quickly which visual features and configurations are allowed in written Chinese (e.g., Wang, Perfetti, et al., 2003; Liu, et al., 2007).

One question, however, still remains. How should we interpret the other result found in the testing phase? Why did participants perform worse on characters of the changed distinctive type than for the normal and the similar types? Is this not evidence for their dependence on visual salience, analogous to how L1 children could not read characters when thumbprints were removed? This is of course possible, but it also can be interpreted as indicating that in the testing phase participants answered that they did not know the characters of the changed distinctive type simply because they noticed the absence of the bold stroke and thought that the changed distinctive type characters were therefore different from the distinctive type characters. Some participants actually asked the experimenter after the fact whether the characters with a change in boldness were to be considered the same, which implies that they had recognized the characters
but were not sure whether boldness within a character was a distinctive feature.
Chapter 5

Experiment 2

Experiment 2 aimed to investigate whether L2 learners of Chinese use phonetic, analogy, and orthographic strategies in reading novel characters, and had two specific goals. The first goal was to examine adult L2 learners’ ability to employ the pronunciation of a simple known character when it is used as a phonetic in an unknown character (i.e., phonetic strategy), and examine their ability to make an analogy from the pronunciation of a known complex character with a given phonetic in reading novel characters containing the same phonetic (i.e., analogy strategy). The second goal was to investigate L2 learners’ ability to use phonetic consistency information in phonetic families to read new characters that contain the family phonetic (i.e., orthographic strategy).

To achieve these goals, Experiment 2 was designed to test the use of the phonetic strategy in the testing phase and the use of the orthographic strategy in the training phase. In the training phase, the L2 learners were asked to master reading clue characters that belong to three different levels of phonetic-family consistency (i.e., consistent, semi-consistent, and inconsistent). Each phonetic family had three characters: a simple character and two compound characters with the simple character serving as the phonetic. In a consistent family, all these characters had the same pronunciation. In a semi-consistent family, the compound characters had the same pronunciation, but their pronunciation was different from the single character serving as the phonetic. In an inconsistent family, all three characters had different pronunciations. In the testing phase, participants were asked to transfer their knowledge obtained from having mastered the clue characters to read novel characters either containing the clue character as a phonetic or sharing the phonetic with the clue characters. It was expected that reading performance in the training
phase for clue characters belonging to different levels of phonetic-family consistency would serve as a measure of their ability to perceive phonetic-family consistency information and therefore demonstrate whether they employ an orthographic strategy. It was also expected that participants’ reading performance in the testing phase for test characters containing clue characters as a phonetic or sharing the phonetic with the clue characters would serve as an index of their ability to use the phonetic strategy to read unknown characters.

The hypotheses for Experiment 2 were as follows:

First, if participants are able to read novel characters presented in the testing phase by utilizing the known clue characters learned in the training phase, then this would indicate that they are able to use the phonetic strategy that is predominantly used in the phonetic stage. Second, if participants are significantly better able to read more characters belonging to a more consistent phonetic-family than those belonging to a less consistent phonetic-family, this would indicate that they perceive phonetic-family consistency and are able to utilize that orthographic strategy to read, as is done by readers who are in the orthographic stage. Finally, if the learners with higher Chinese character knowledge perform significantly better than the learners with less knowledge in the training and/or testing phases, this would suggest that the degree of L2 Chinese character knowledge is closely related to their reading strategy.

Method

Participants. The same seventy L2 learners of Chinese who participated in Experiment 1 also participated in Experiment 2 after finishing Experiment 1 on the same day. All of them received total monetary compensation of $20 for their participation in both experiments.

Materials. A total of 78 characters were used as stimuli in Experiment 2. All the stimuli
have identical forms in the traditional and in the simplified character types, and were selected from Comprehensive Chinese Character Dictionary (漢語大字典, 1993). All of them were low-frequency characters and unknown to the participants, which was insured by the questionnaire that the participants filled in at the end of the experimental session. All participants reported that the characters used in both Experiment 1 and Experiment 2 did not contain any character that they knew or had seen before.

Out of 78 characters used in Experiment 2, 18 characters were clue characters for the participants to memorize in the training phase, and the other 60 characters were test characters that would be read using the mastered clue characters for the transfer task in the testing phase. The complete set of the stimuli for Experiment 2 is shown in Appendix F. The pronunciations of the characters were recorded by a female native speaker of Chinese.

**Characters for the training phase.** Two blocks of nine characters were created with each block containing three phonetic families representing the three consistency levels, consistent, semi-consistent, and inconsistent. Each phonetic family consisted of three characters: one simple character and two phonetic compound characters containing the simple character as the phonetic. This combination constituted all 18 stimuli for the training phase. The compound characters had a left-right structure with the phonetic on the right. All three characters in the consistent family had the same pronunciation. In the semi-consistent family, the pronunciations of two compound characters were identical but different from the simple character. The three characters in the inconsistent family all had different pronunciations.

**Characters for the testing phase.** The characters for the testing phase consisted of six blocks of 10 characters each. Each of the six blocks represented one of the six phonetic families used in the training phase, resulting in two 10-character blocks for each of the three consistency
levels (consistent, semi-consistent, and inconsistent). For the participants, it was the first time to see all 60 characters, as confirmed by their answers in the questionnaire after the experimental session. In order to investigate whether learners were influenced in reading new characters by the position of the phonetic within each 10-character block, six test characters had the phonetic on the right, two characters had it on the left, and the other two had it on the bottom.

**Procedures.** Experiment 2, like Experiment 1, also consisted of a training phase and a testing phase, and its procedure was similar to Experiment 1. In the training phase, participants learned to read 18 characters by viewing them, hearing their pronunciations and saying aloud what they had heard. The 18 characters were learned to complete mastery. In the testing phase, participants were asked to name the learned characters when each character appeared on the computer screen. Both training and testing phases were conducted using E-Prime software, and the subjects were tested on a laptop computer individually in a quiet room. The presentation of all stimulus characters was pseudo-randomized by having the same consistency type of a phonetic family appear no more than two consecutive times, so that participants could not very easily notice information about phonetic family consistency manipulated in the experimental design. The main difference in procedure between was that the Experiment 1 subjects were required to memorize all 18 clue characters in the training phase to the point of mastery. The purpose of mastery in learning was to ensure that participants did not read the test phase characters randomly, but read by utilizing their prior knowledge of the mastered characters. This was achieved by training participants to repeat characters until a perfect score was attained twice in a row. After succeeding in reading 18 clue characters correctly on two consecutive trials, participants moved to the testing phase and read the 60 new test characters from the same phonetic families as the clue characters.
**Training phase.** The training phase consisted of two components: three learning trials and a maximum of nine mastery ‘sessions’. Each learning trial was comprised of two sub-sections: the learning and the test sections. The learning section was designed to teach participants to read clue characters, and the test section was designed to ensure that participants had mastered them. In the learning section, each character appeared on the computer screen in pseudo-random order one at a time. The pronunciation was simultaneously presented twice over a headset, and participants looked at the character and repeated aloud what they had heard.

Immediately after the learning section of the learning trial, participants moved to the test section of the learning trial, in which they were asked to name the same 18 characters that they had learned in the learning section. To expedite participants’ memorization of all 18 clue characters, the test section provided participants feedback of “correct” or “incorrect” on the computer screen with each response to the character. When participants named the character correctly, the screen showed “correct” with the character and moved to the next character to appear. When they named it incorrectly, the screen showed “incorrect” and the correct pronunciation was provided over the headset so that participants were also able to learn through the test section of the learning trial. The feedback shown on the screen was controlled by the experimenter sitting about one meter behind the participants using a wireless keyboard. The experimenter also watched the computer screen with the participants, paid attention to and judged their responses, and provided appropriate feedback on their correct and incorrect performance.

Immediately after the third learning trial, participants moved to the mastery sessions of the training phase. To save time for the participants to master learning the clue characters, the mastery session did not contain a learning section, but only had a test section. Since participants
could learn the correct pronunciations through the feedback, the mastery session only consisted of test sections repeated until they succeeded in naming all 18 clue characters two consecutive times or up to nine trials. One of the 70 participants was unable to master learning all clue characters within the nine trials of the mastery session.

**Testing phase.** The testing phase immediately followed the last mastery session of the training phase. In the test phase, participants were asked to read the 60 test characters that either contained the clue characters as phonetics or had the same phonetics as the clue characters. When each character appeared on the screen in pseudo-random order, participants were asked to name it. They were specifically instructed as follows: “None of the 60 characters are known to you, but you can read them based on what you have learned in the training phase. There is no right or wrong answer, so do not skip any character, but make the best guess.”

There were three possibilities for participants in reading the test characters: reading by following the clue characters as a phonetic (i.e., phonetic strategy), reading by using the same phonetic as the clue character (i.e., analogical strategy), or reading in a way that is unrelated to the clue characters. To test characters of the consistent families, reading with the phonetic strategy was the only expected answer and was the only answer considered correct. On the other hand, for the test characters belonging to the semi-consistent or inconsistent families, both a phonetic reading and an analogical reading were possible, and thus either the phonetic or analogical reading was counted as a correct answer.

**Coding and scoring.** As in Experiment 1, for the test sections and the mastery sessions of the training phase, each character in the participants’ naming data was scored as *correct* if they named the entire syllable (excluding tone) correctly, and as *incorrect* otherwise. For accuracy rate for the test characters in the testing phase, only the phonetic reading was counted as *correct*
for test characters belonging to the consistent family. For test characters belonging to the semi-
consistent or inconsistent family types, either phonetic or analogical readings were counted as 
correct. For the coding of reading strategies of the test characters, participants’ responses were 
labeled with either phonetic, analogy, or other. Also, to examine the effect of the phonetic 
position in a character on reading performance, the position of the phonetic of the test character 
was coded as right, left, or bottom, according to its position.

Results

One participant’s data was removed from the analysis because this person could not 
master learning 18 characters within nine trials of the mastery session in the training phase, the a 
priori set maximum number of trials, which was required to move to the character transfer task 
of the testing phase. Data from 69 subjects were analyzed using binomial logit mixed models in 
R, the same statistical method used in the Experiment 1. In Experiment 2, no significant effects 
of the letter rotation task, reading span task, or participants’ L1s were found. The remaining three 
predictors, such as trial, phonetic family type, and Chinese character test had various effects 
depending on the analysis, which is described in the following sections.

Training phase. Only data from the test sections of three learning trials, not from the 
mastery sessions, were analyzed, because all the participants performed the same three test 
sections, but not the same mastery sessions. Since the number of the mastery sessions they went 
through to achieve mastery of reading clue characters differed from participant to participant, 
their performances in the mastery sessions were not analyzed here. The data analysis for the 
three test sections of Experiment 2 was conducted in a similar manner as the analysis for the 
training phase data of Experiment 1. First, all three trials were entered into the model and
analyzed together, and then each trial was separately analyzed. For each analysis, naming accuracy was the dependent variable in the model, and trial, phonetic family type, character test, letter rotation test, reading span test, and participants’ L1s were included as fixed-effect factors in the model, with subject and item as random factors. There were no significant effects of the letter rotation task, reading span task, or participants’ L1s.

Figure 7 displays the proportion correct for naming accuracy on character types by trial. Table 8 shows the results for naming accuracy of the three learning trials altogether. There was a significant effect of trial, as expected, with a significantly higher naming accuracy rate in the second and the third trial than in the first trial, which is the same pattern as the training phase of Experiment 1. This indicates that participants gradually progressed in learning to read characters over the learning trials. Also, there was a significant effect of the Chinese character test, meaning that participants with higher character test scores performed significantly better than those with lower scores. A significant effect of the inconsistent phonetic family type was found, but its coefficient was negative, indicating that the naming accuracy of the inconsistent family was significantly worse than the consistent group, because the phonetic family type is a categorical factor and the baseline for this model was the consistent family type.

4 Note that the results in Figure 7 are given in proportions of the means of naming accuracy only for the purpose of visualizing the data. For data analysis, logit mixed models were fitted to individual data points.
Table 8

**Naming Accuracy in All Three Trials of the Training Phase**

| Predictors                  | Estimate | SE    | z value | Pr(>|z|) |
|-----------------------------|----------|-------|---------|----------|
| (Intercept)                 | -0.745   | 0.522 | -1.427  | 0.154    |
| Trial 2                     | 1.559    | 0.261 | 5.982   | < 0.001 *** |
| Trial 3                     | 2.508    | 0.304 | 8.247   | < 0.001 *** |
| Character Test              | 0.012    | 0.006 | 2.109   | 0.035 *  |
| Semi-consistent             | -0.043   | 0.589 | -0.073  | 0.942    |
| Inconsistent                | -1.436   | 0.595 | -2.414  | 0.016 *  |
| Character Test: Trial 2     | 0.006    | 0.004 | 1.423   | 0.155    |
| Character Test: Trial 3     | 0.011    | 0.005 | 2.292   | 0.022 *  |
| Character Test: Semi-consistent | -0.010  | 0.004 | -2.339  | 0.019 *  |
| Character Test: Inconsistent | -0.009  | 0.004 | -2.044  | 0.041 *  |

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

There were three interactions between the character test and the third trial (i.e., Character Test: Trial 3), between the character test and the semi-consistent phonetic family type (i.e.,...
Character Test: Semi-Consistent), and between the character test and the inconsistent family type (i.e., Character Test: Inconsistent). First, the interaction between character test and the third trial should be interpreted in comparison with the single effect of the character test, which is the reference level. The interaction means that the contribution of the character test to naming accuracy in the first trial was 0.012, which was the character test, as the reference level indicates, but in the third trial the contribution of the character test to naming accuracy was 0.023 (0.012 + 0.011). This means that the effect of character test score was significantly larger in the third trial than in the first trial. In other words, the difference between students with high character test scores and low character test scores was greater in trial three than it was in trial one. This suggests that students with higher character test scores progressed more quickly. The non-significant interaction of character test score with trial two indicates that the effect of character test score was the same in the first and second trials.

Significant interaction effects between the character test and the semi-consistent family type, and between the character test and the inconsistent type, should be compared with the coefficient of the character test of the consistent type (0.012) as their reference level, resulting in coefficients for the character tests on the semi-consistent type and on the inconsistent type of 0.002 (0.012 - 0.010) and 0.003 (0.012 – 0.009), respectively. This suggests that participants with higher character test scores named characters in the consistent family type significantly better than did participants with lower character test scores, but that this advantage disappeared for the semi-consistent characters and the inconsistent characters.

Table 9 displays the three separate analyses of each trial conducted. In naming accuracy for the first trial, there was only significance for the inconsistent phonetic family type. The negative coefficient of the inconsistent family type indicates that participants learned to read the
characters in the inconsistent family type significantly worse than those in the consistent type. In the second trial, significance with a negative coefficient in the inconsistent phonetic family type means that participants named characters in the inconsistent type significantly worse than in the consistent type. The predictor of the character test scores was also significant, indicating that in the second trial participants with higher character test scores learned characters significantly better than participants with lower scores.

Table 9

| Trial | Predictors          | Estimate | SE   | z value | Pr(>|z|) |
|-------|---------------------|----------|------|---------|---------|
| 1     | (Intercept)         | 0.011    | 0.392| 0.029   | 0.977   |
|       | Semi-consistent    | -0.780   | 0.529| -1.475  | 0.140   |
|       | Inconsistent        | -1.965   | 0.538| -3.651  | <0.001***|
| 2     | (Intercept)         | 1.195    | 0.526| 2.271   | 0.023*  |
|       | Semi-consistent    | -0.665   | 0.612| -1.087  | 0.277   |
|       | Inconsistent        | -1.895   | 0.613| -3.093  | 0.002**  |
|       | Character Test      | 0.010    | 0.005| 2.288   | 0.022*  |
| 3     | (Intercept)         | 0.957    | 0.778| 1.230   | 0.219   |
|       | Semi-consistent    | 0.907    | 0.870| 1.042   | 0.297   |
|       | Inconsistent        | -0.574   | 0.829| -0.692  | 0.489   |
|       | Character Test      | 0.043    | 0.013| 3.203   | 0.001** |
|       | Character Test: Semi-consistent | -0.029 | 0.014 | -2.106 | 0.035* |
|       | Character Test: Inconsistent | -0.031 | 0.013 | -2.387 | 0.017* |

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

In the third trial, as in the second trial, there was a significant effect of the character test scores, suggesting that readers with more character knowledge had a significant advantage in learning to read the consistent characters over those readers with lower character knowledge. Significant interaction effects were also found: between the character test and the semi-consistent family type, and between the character test and the inconsistent type. When compared with the reference level coefficient of the character test of the consistent type (0.043), the effect of the character test for the semi-consistent family type was 0.014 (0.043-0.029), and that for the
inconsistent type was 0.012 (0.043-0.031). This suggests that participants with higher character test scores named characters in the consistent family type significantly better than did participants with lower character test scores, but that this advantage disappeared for the semi-consistent characters and the inconsistent characters.

**Testing phase.** The final test of the testing phase was a transfer task that asked participants to read 60 novel characters using the clue characters mastered in the training phase. The 60 test characters contained the same phonetics as the clue characters belonging to three phonetic family types, but with different semantic radicals from the clue characters. In the testing phase, two kinds of data were collected: participants’ naming accuracy in reading characters of three phonetic families, and the reading strategies that they utilized to read test characters of the semi-consistent and inconsistent family types.

First, naming accuracy was analyzed using binomial logit mixed models. Phonetic family type, phonetic position, character test, reading span test, letter rotation test, and participants’ L1 were included as fixed effects in the model, with subject and item as random effects. The mean naming accuracy rate was 0.87, with 0.91 for the consistent, 0.88 for the semi-consistent, and 0.82 for the inconsistent types, which is illustrated in Figure 8. The high percentage of naming accuracy results suggest that participants were able to read the novel characters by finding the phonetics and matching them with the phonetics in the characters that they already knew. In other words, participants utilized the phonetic and the analogy strategies to read unfamiliar phonetic compounds.

The very high accuracy rate of the consistent type resulted in a ceiling effect and caused naming accuracy to be homogeneous in its variance, which caused the statistical model to reject

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5 Note that the proportions of the means of naming accuracy were used in Figure 8 only to visualize the data. For data analysis, logit mixed models were fitted to individual data points.
the consistent type. Therefore, statistical analysis for naming accuracy was carried out without
the consistent phonetic type, but only with the semi-consistent and inconsistent types. Table 10
illustrates the naming accuracy on semi-consistent and inconsistent family types. There was an
effect of the inconsistent family type (Estimate = -0.876, SE = 0.221, z = 3.973, p < .001),
meaning that participants named characters of the inconsistent type significantly worse than
those of the semi-consistent type. However, there was no significant effect of phonetic position,
character test, reading span test, letter rotation test, or L1 in naming accuracy for reading the test
characters. The significant better naming of semi-consistent families compared to inconsistent
families implies that the level of phonetic-family consistency also influenced reading new
characters containing the phonetic.

Figure 8. Proportion correct for naming accuracy on family types
Table 10

**Naming Accuracy on Semi-consistent and Inconsistent Family Types of the Testing Phase**

| Predictors   | Estimate | SE   | z-value | Pr(>|z|) |
|--------------|----------|------|---------|---------|
| (Intercept)  | 3.848    | 0.363| 10.603  | < 0.001 *** |
| Inconsistent | -0.876   | 0.221| -3.973  | < 0.001 *** |

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

Second, for the reading strategy used to read characters belonging to the semi-consistent and the inconsistent types, a binomial mixed logit model was also carried out. Reading strategies, either phonetic or analogical reading, were the dependent variable, in which phonetic responses were coded as 0 and analogical reading as 1. Phonetic family type, phonetic position, character test, reading span test, letter rotation test, and participants’ L1 were included as fixed effects in the model, with subject and item as random effects. There were no significant effects of character test, reading span test, letter rotation test, or participants’ L1.

Table 11 shows the results with a significant effect of the semi-consistent family type, meaning that participants read test characters belonging to the semi-consistent family significantly more analogically than those of the inconsistent family. In other words, participants read phonetically new characters whose phonetic components are inconsistent significantly more than those characters whose phonetic is semi-consistent. This accords with the results from L1 Chinese children (Chen, 2004). Chinese fourth and sixth graders also made more analogical responses to the characters containing the semi-consistent phonetics and more phonetic responses to the characters containing the inconsistent phonetics.

A significant effect of the phonetic radical position was also found. Compared to the bottom position of the phonetic radical, there were significant effects for the left position (Estimate = 0.815, SE = 0.226, z = 3.611, p < .001) and the right position (Estimate = 2.605, SE = 0.198, z = 13.178, p < .001). This indicates that participants read characters with the phonetic...
on either left or right sides in a more analogical manner than bottom-radical characters.

Table 11

**Analogy Strategy Used in the Semi-Consistent and Inconsistent Groups**

| Predictors            | Estimate | SE  | z-value | Pr(>|z|)  |
|-----------------------|----------|-----|---------|-----------|
| (Intercept)           | -3.049   | 1.037 | -2.941  | 0.003 **  |
| Semi-consistent       | 2.893    | 0.879 | 3.292   | < 0.001 *** |
| Phonetic on Left      | 0.815    | 0.226 | 3.611   | < 0.001 *** |
| Phonetic on Right     | 2.605    | 0.198 | 13.178  | < 0.001 *** |

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

**Discussion**

Experiment 2 demonstrated that adult L2 learners were able to use phonetic, analogy, and orthographic strategies to read novel characters. The results supported all hypotheses. The first hypothesis regarding participants’ naming performance in the testing phase predicted that for participants’ performance in reading novel phonetic compounds containing known phonetics, they would be able to use phonetic and the analogy strategies to read new characters, and thus, they would fall in the phonetic stage. The mean proportion of naming accuracy for the test characters was 0.87 (0.90 for the consistent family, 0.88 for the semi-consistent family, and 0.82 for the inconsistent family). This high rate of accuracy indicates that participants were able to utilize the phonetic and the analogy strategies to read unknown characters, which suggests that they placed in the phonetic stage.

The further analyses of reading strategies used in the semi-consistent and inconsistent families not only confirmed L2 learners’ ability to exploit the phonetic and analogical strategies, but also showed their ability to select the appropriate strategy for reading unknown characters based on the characters that they already knew. Participants made significantly more analogy responses to novel characters of the semi-consistent phonetic families than for those of the
inconsistent families. This seems to stem from the fact that in the training phase, among three characters in the semi-consistent family, two phonetic compound characters had the same pronunciations differing from the other simple character, in contrast to the inconsistent family, where all three characters were read differently. In other words, since in the given learning context, the semi-consistent phonetic family was oriented more towards the analogical reading than the phonetic reading at the rate of two-thirds (66.67%), this suggests that participants perceived and implicitly learned that analogical reading occurs more frequently than phonetic reading and chose the analogical strategy to read new characters containing the semi-consistent phonetics. This suggests that learners are sensitive to input frequency of the input. On the other hand, for reading novel characters belonging to the inconsistent family with no bias towards neither the phonetic or the analogical reading in the learning context, they preferred the phonetic strategy over the analogy strategy. In other words, learners tend to adopt the phonetic reading for characters that do not have a strong representative pronunciation, which confirms Shu et al.’s (2003) observation that simple characters which serve as phonetics for other characters enjoy a special status in modern Chinese. Adult L2 learners’ selection of the analogical reading for the semi-consistent families and the phonetic reading for the inconsistent families accords with the findings for L1 Chinese elementary school students in Chen’s (2004) study, which suggests that these effects may be universal in learning to read in Chinese.

Furthermore, L2 learners are sensitive to the position of the phonetic radical within a character and are able to alternate between phonetic and analogy strategies for novel characters, depending on the phonetic position. Participants read compound characters with left-side or right-side phonetics more analogically than characters with bottom phonetics. On the other hand, they read bottom-position phonetics more phonetically than for left or right side phonetics. One
may note that out of the given 10 new characters of each phonetic family to read, six characters
had right-side phonetics as the clue characters, but the other four characters had left-side or
bottom phonetics, unlike the clue characters: two characters with left-side phonetics, and the
other two with bottom phonetics. Since the characters with right-side phonetics had the same
position as the clue characters and included two more characters than those with phonetics
elsewhere, it might have been natural for the participants to read the characters with right-side
phonetics more analogically than the characters with bottom phonetics. It is surprising, however,
that participants read the characters with left-side phonetics more analogically than the characters
with bottom-position phonetics. For example, in reading the four test characters, e.g., 剪, 部, 茅, and 築, participants read the first two with a left-right structure more
analogically than the last two with a top-down structure. This coincides with the fact that the
phonetic component of the test characters with a left-right structure, e.g., 剪 and 部, look
like the phonetic compounds in the clue characters, which also had a left-right structure, e.g.,
搀, and 豚, whereas in the phonetic component of the test characters with a top-bottom
structure, e.g., 茅 and 築, the simple phonetic character, e.g., 茅, is more distinctive in
size and shape than in the left-right structure characters such as 剪 and 部. This suggests
that participants might have perceived the two character structures of the simple character and
the phonetic compounds, connected two possible readings to the character structure differences,
and extended this knowledge to read novel characters, and that adult L2 learners are able to learn,
systemize, and utilize the character structures, relationship between the phonetic and its position
in the whole character, and the frequencies very quickly in order to learn to read new characters.
The second hypothesis regarding participants’ naming performance in the training phase predicted that if participants learn the characters with more consistent phonetics significantly better than those containing less consistent phonetics, then they would be able to perceive phonetic consistency and to utilize the information to read new characters, and they would fall in the orthographic stage. The results supported this hypothesis. Participants learned the clue characters with consistent phonetics significantly better than the clue characters with inconsistent phonetic throughout three trials, but there were no differences between consistent and semi-consistent families. Also, L2 learners captured consistency information among unknown characters as early as the first instance of learning, as seen in the results where participants read significantly more characters in the consistent family than in the inconsistent family from the first trial. The results altogether suggest that L2 learners can utilize information about the phonetic family consistency to read novel characters.

Finally, it was hypothesized that significantly better learning by participants with more character knowledge than those with less character knowledge in either the training or testing phases would indicate that character knowledge is closely linked to the target reading strategy tested in the phase. Regarding character knowledge and learning characters, two results were found only in the training phase. First, there was a single effect of character knowledge in learning characters. Participants with higher character knowledge learned new characters better and this accelerated their learning in the third trial of learning more than those with lower character knowledge. Second, an interaction effect between character knowledge and family consistency was found. More experienced readers were able to use consistency information better than less experienced readers, and they particularly took advantage of consistency information in reading the consistent family better than the semi-consistent and the inconsistent
families. This suggests that L2 learners’ use of the orthographic strategy depends on their
caracter knowledge.

This result of the character knowledge effect on the awareness of phonetic consistency
information is consistent with that of L1 Chinese children. In Chinese fourth- and sixth-graders
in Chen’s (2004) study, a main effect of character knowledge and an interaction effect between
character knowledge and phonetic consistency level were found. L1 Chinese children learned
characters of the consistent families better than those of the semi-consistent families, which were
in turn better than inconsistent families. Also, there was a character knowledge effect on the
utilization of consistency information in learning new characters, but the effect was on the semi-
consistent and the inconsistent families, not on the consistent family. When L1 Chinese children
were divided into three groups of high, medium, and low groups according to character
knowledge, all groups performed similarly on the consistent families, but on the semi-consistent
and inconsistent families the high character knowledge group performed better than the medium
group, which in turn did better than the low group. This is comparable with what adult L2
learners showed in the current study. Adult L2 learners showed an effect of higher character
knowledge on learning characters in the consistent families, but not in the semi-consistent and
the inconsistent families.

This different pattern for adult L2 learners from L1 children may result from lower
character knowledge of the participants of this study than L1 Chinese orthographic readers in
Chen’s (2004) study. L2 learners participating in the current study were from the first semester
and the third semester of Chinese classes, and the students in the first semester and the third
semester had been exposed to around 100 and 700 characters, respectively, at the time of the
experiment. In contrast, L1 Chinese orthographic readers, i.e., fourth- and sixth-graders of
Chen’s (2004) study, had already been exposed to 1686 and 2367 characters, respectively, which are the numbers of characters taught by the end of third and fifth grade according to their curriculum (Shu et al., 2003). In other words, using consistency information in the consistent family might have been quite obvious to L1 Chinese children, who had already been exposed to more than 1600 characters regardless of their reading levels, but drawing information from the semi-consistent and the inconsistent family types was still challenging for medium and low readers compared with high readers. On the other hand, utilizing consistency information in the consistent family was still challenging for the L2 learners, who knew less than 1000 characters. This suggests that the ability to employ phonetic family consistency information depends on character knowledge. From this, it can be hypothesized that advanced L2 learners who know more than 1600 characters would be better able to learn characters even in the semi-consistent and the inconsistent families than beginning learners, as was shown for L1 Chinese fourth- and sixth- graders. The relationship between character knowledge and the orthographic stage will be discussed further in the next chapter.
Chapter 6
General Discussion

This study aimed to examine reading development of adult L2 learners of Chinese from a reading stages perspective, and intended to answer two specific questions as follows: (a) Do adult L2 learners of Chinese also go through stages in learning to read Chinese? (b) If so, do their reading stages resemble those of L1 Chinese children? Two experiments to test for the existence of the three Chinese reading stages previously demonstrated among L1 Chinese children (i.e., the visual, the phonetic, and the orthographic stages) were conducted with college students of beginning and intermediate Chinese levels at the University of Illinois.

Evidence for the visual stage was tested in Experiment 1, and the results showed that only individual participants’ working memory capacities, not the manipulated visual distinctiveness of a character, aided participants in learning to read characters. This was interpreted as lack of evidence for the visual stage in adult L2 Chinese reading acquisition. Evidence for existence of the phonetic stage was tested for in the testing phase of Experiment 2. When participants were forced to read unknown phonetic compound characters containing the same phonetic as the learned characters, most participants succeeded in reading novel compound characters by utilizing the phonetics of characters they had learned, and their reading thereby achieved more than 87% accuracy in reading new characters. This high rate of success in reading novel characters indicates that participants were able to utilize the phonetic and the analogy strategies to read unknown characters, which provides the evidence for the phonetic stage in adult L2 Chinese reading development. Finally, existence of the orthographic stage was tested for in the training phase of Experiment 2. Participants who knew more characters not only learned to read characters better as early as the second learning trial, but also made use of the
phonetic family consistency information in a group of new characters more efficiently, and took
greater advantage of phonetic information to learn to read them, than those who know fewer
characters. The strong character knowledge effect found those using the orthographic strategy
suggests that not only is the orthographic stage present in reading development of adult L2
learners of Chinese, but also that the orthographic stage requires greater experience in reading
Chinese characters.

The results altogether suggest that adult L2 learners of Chinese go through reading
stages in learning to read Chinese, but that their reading stages differ from those of L1 Chinese
children. The hypothesis used to explain these results is that when learning to read Chinese
characters, adult L2 learners start from the phonetic stage, rather than the visual stage, and then
proceed to the orthographic stage as their character knowledge increases. The visual stage is
ruled out in the reading stage of adult L2 learners of Chinese, because participants in the
experiment did not use the visual saliency information in characters when learning to read
characters. On the other hand, they were able to utilize phonetic information and consistency
information to read novel characters, which implies the existence of both the phonetic and the
orthographic stages in adult L2 learners’ reading development. In terms of the hierarchy of two
stages, it appears that the orthographic stage is higher than the phonetic stage, because the
participants who know more characters were able to perceive and utilize consistency information
to learn to read characters better than the participants with less character knowledge. For use of
the phonetic information, however, character knowledge did not contribute to reading new
characters.
No Visual Stage in Adult L2 Reading Development

Although it is posited that adult L2 readers of Chinese pass through stages in learning to read Chinese, interestingly, the visual stage, which is very apparent in L1 reading development, is not found in adult L2 literacy acquisition. It is possible that this result derives from the fact that adult L2 learners participating in the current study knew more characters than young L1 Chinese visual readers. Four-year-old L1 Chinese children in the study by Chen (2004) knew 8.21 characters on average, varying from no knowledge to reading more than twenty characters. On the other hand, the beginning adult L2 learners in the current study had already been exposed to approximately 100 characters. It is possible that the visual strategy may work effectively with a small number of characters but may not be efficient once readers deal with a hundred or more characters. If this is the case, it is possible that adult L2 learners might have used the visual strategy when they only knew around a dozen characters, which would be the first few weeks in a Chinese class, but had passed the visual stage and already entered in the phonetic stage at the time of participating in the present study.

Another possible reason for the absence of the visual stage in adult L2 learners is that adult L2 readers, unlike child L1 readers, do not rely on arbitrary information, but rather use systematic and reliable rules found in the system. It is noteworthy that the reading strategies that determine the visual stage and the other two stages are qualitatively different. The visual strategy is based on reading characters by selecting arbitrary visually salient cues in the characters, and thus the visual features chosen differ from person to person, and may even differ over time for the same person. On the other hand, the phonetic, the analogy, and the orthographic strategies involve finding the phonetic principle inherent in the Chinese writing system and utilizing that principle to read. In other words, the visual strategy depends on mnemonic techniques that vary
among individual readers, whereas the phonetic, the analogy, and the orthographic strategies are based on finding the systematic principles underlying the phonetic components of Chinese characters.

An additional factor may follow from findings in neuroscience. Neuroscience research has reported that cognitive processing of adults is different from children’s because of adult brain maturation (Born, Rostrup, Leth, Peitersen, & Lou, 1996; Klingberg, Forssberg, & Westerberg, 2002; Schlaggar, Brown, Lugar, Visscher, Miezin & Petersen, 2002). Adults’ cognitive abilities seem to be adapted to disregarding unnecessary information and responding to the most relevant and the most efficient information in the target system, whereas children’s cognitive processing tends to react to any stimulus. One example is found in human speech perception development. Infants initially distinguish different phonemes of many languages, even the languages that they have never heard, but they soon become, like adults, less able to discriminate some contrasts that do not exist in their native language because experience in the native language alters their speech perception in language-specific fashion (Kuhl, Williams, Lacerda, Stevens, & Lindblom, 1992). Many studies also suggest that this may be true for the development of visual perception and processing. It has been reported that there is an overproduction of visual synapses early in life (Huttenlocher, 1979; Wiesel, 1982). The cortical synaptic density of infants is almost twice that of adults (Huttenlocher, 1979), and that synaptic density in the human visual cortex increases from birth to eight-months, then declines subsequently, and finally reaches the same level as adults by the age of 11 (Huttenlocher, de Courten, Garey, & Van Der Loos, 1982). The decrease in synaptic density suggests that the neural connections that are not used are pruned away, only leaving activated nervous synapses and the connections of the remaining pathways are strengthened in the nervous system, which results in more activation in response to relevant
information despite the smaller number of synapses in adulthood (Huttenlocher, 1979; Klingberg et al., 2002). Considering that adults usually are exposed to much more information than children, it makes sense that their cognitive abilities may have evolved by pruning less important information and focusing on systematic information, because cognitive space can be used more efficiently following this sort of systematization.

By this line of reasoning, the development of visual processing can be extended to use of the visual reading strategy. Young children whose brains have not yet matured may be receptive to any kind of visual cues, and thus visual salience in the characters aids them in reading. But by age 11, when the number of synapses reaches the same level as adults, older children start to disregard unnecessary visual information in the given system and focus on relevant information and utilize it. An extrabold stroke in a character is not a distinctive feature in the Chinese writing system. Children, nevertheless, may find it to be useful and rely on it in reading, while adults may presume that a bold stroke does not make any systematic difference in reading Chinese and thus ignore it. One could further speculate that there may be a critical period (Lenneberg, 1967) in utilizing the visual strategy, as in speech perception and general language development. If this is true, then one could presume that readers may not undergo the visual stage again, once they pass the critical period of utilizing visual cues in reading, possibly around age 11 when the visual cortex has matured to the adult level. In utilizing the visual reading strategy, the critical period could be more important than whether it is L1 or L2 reading or whether the target writing system is visually complex.

**Phonetic and Orthographic Stages in L2 Reading Development**

The present study suggests that the orthographic stage follows the phonetic stage as the
base of character knowledge increases. This implies two possible interpretations of the relative difficulty of the phonetic and the orthographic stages. On the one hand, for adult L2 readers, unlike L1 Chinese children, the reading strategies for the phonetic stage, i.e., the phonetic and the analogy strategies, are not difficult to learn. In the test for the phonetic and the analogy strategies, i.e., the testing phase of Experiment 2, all participants, regardless of their character knowledge, could successfully read unknown characters containing the known phonetics and sharing the phonetics with the known characters at an average accuracy rate of 87%. Considering that the phonetic and the analogy strategies are used for applying the phonetic principle from one character to another, we can infer that the one-to-one matching of the phonetic principle is rudimentary to adult L2 learners who are literate in their L1s, probably because of their experience of employing correspondence rules between print and sound in L1 literacy acquisition. On the other hand, it could be that for adult L2 learners, like L1 Chinese children, the orthographic strategy is still more difficult to learn than the phonetic and analogy strategies. Despite the fact that no participants, regardless of their character knowledge, had difficulty in using the phonetic and analogy strategies, character knowledge had an influence in their ability to implement the orthographic strategy; more experienced readers performed better on consistent families than less experienced readers when learning to read characters of different consistency levels in the training phase of Experiment 2.

There are two possible reasons why the orthographic strategy might be more difficult to implement than the phonetic and analogy strategies. First, the orthographic strategy is intrinsically more complex and requires more character knowledge than the other two strategies. The orthographic strategy applies at a global level across members of the same phonetic families and finds consistency rules within those families for reading, while the phonetic and analogy
strategies apply the phonetic principle at a more local level, i.e., from one character to another. The awareness of phonetic consistency can develop from encountering a greater number of characters than in using the other two strategies, and thus its acquisition naturally takes more extensive reading experience involving knowledge of more characters.

Second, the characters taught to beginning readers are more aimed at developing awareness of the phonetic and analogy strategies than developing awareness of the orthographic strategy. Shu et al. (2003) conducted a comprehensive analysis of characters taught in Chinese elementary schools. According to their analysis, the first 400 characters taught in the first grade have more characters without phonetic components, i.e., simple characters and semantic compounds, than phonetic compounds, and contain only a very small number of phonetic families. Although 70% of the next 700 characters taught in the second grade are phonetic compounds and represent four times more phonetic families than the characters in the first grade, most of the phonetic families contain less than three characters on average. Knowing two characters in the same phonetic family promotes the strategy of transferring the phonetic principle from one character to another, which is the essence of the phonetic and the analogy strategies. In order to develop consistency awareness, there should be more than two members in the same phonetic family. In other words, with knowledge of around 1100 characters provided by the first two years of formal schooling, it is difficult for learners to have an awareness of consistency, not to mention utilizing that information to implement the orthographic strategy. Previous research has reported that L1 Chinese readers’ consistency awareness continues to grow from fourth grade to college (Chen et al., 2003; Shu et al., 2003). The average phonetic family size is 2.96 for the characters taught in the fourth grade, and by the end of the fourth grade, L1 Chinese children have attained knowledge of 2000 characters, which suggests that for L1
Chinese children the orthographic strategy may start to develop when they have reached a proficiency of approximately 2000 characters.

The characters taught for L2 learners in college classrooms are also educational, as seen in the fact that textbooks for L2 learners, and are also mostly designed to first teach the more frequent characters than the less frequent ones. Therefore, the features of the characters taught in Chinese elementary schools generally correspond to the context of L2 learning. The number of characters that L2 learners in this study knew was around 100 characters for beginners who had learned Chinese for a half semester, and about 700 characters for intermediate learners who had learned Chinese for more than two semesters. Considering their character knowledge, the results of the present study are easily understood. It would be very difficult for the beginning L2 learners who know only around 100 characters to have consistency awareness and to utilize the orthographic strategy in learning to read unfamiliar characters. It is surprising, however, that intermediate learners with the knowledge of less than 1000 characters could utilize the orthographic strategy. This implies that adult L2 learners might be able to learn more advanced reading strategies faster than L1 Chinese children.

Even though it requires more time and more experience to acquire the orthographic strategy, it is a very useful reading skill in reading Chinese. The orthographic strategy utilizes consistency information of phonetic families, so consistency awareness is the key for the orthographic strategy. Previous studies on reading Chinese have reported that phonetic family consistency gives a better prediction of the pronunciation of Chinese characters than regularity (Chen et al. 2003; Tzeng, 2002). According to Shu et al. (2003), frequency-weighted consistency is more than 60% on average in the characters taught in the upper grades of elementary curriculum, meaning that readers have a 60% chance of success in predicting the pronunciation.
of an unfamiliar phonetic compound if they guess it with the most frequent or dominant pronunciation of the phonetic family by implementing the orthographic strategy. In contrast, the rate of regularity is 39% when tone is not counted, meaning that readers have a 39% chance to be successful in predicting the pronunciation of an unknown phonetic compound by giving it the same pronunciation as its phonetic.

The effectiveness of the orthographic strategy in learning new characters was also found in the current study. Only simple characters were provided for learning in Experiment 1, whereas in Experiment 2, simple characters and phonetic compounds were mixed at a ratio of 1:2, and the simple characters served as phonetics for the compounds. In Experiment 1, where all the learned characters contained no pronunciation cues, participants could only memorize characters by rote. On the other hand, in Experiment 2, two-thirds of the characters to learn were phonetic compounds containing the other one-third of the characters as the phonetics. Also, 6 out of 18 characters were completely consistent, which yields a 33.33% consistency rate, meaning that learners who were able to use the orthographic strategy might benefit from a 33.33% reduction in memory load. The results of Experiment 2 indicate that L2 learners who knew more characters took advantage of the orthographic strategy more than those who know fewer characters. Experienced readers who used consistency information in Experiment 2 actually benefited from reducing the 18 characters to learn to 12 characters. For novice readers with no concept of consistency, however, this mixture of simple and compound characters would cause them more confusion and difficulty. Every three characters belonging to each phonetic family had the same phonetic component in the character. Some characters sharing the same component had the same pronunciation, whereas others sharing the same component have dissimilar pronunciations, which could confuse and hinder them from learning.
The existence of the phonetic and the orthographic stages in adult L2 reading development suggests that the use and the expansion of the phonetic principle play a key role in learning to read Chinese. This dispels a long-held belief that in written Chinese, as a logographic writing system, characters are processed as a whole with little phonological analysis (Baron & Strawson, 1976), thereby supporting the view that no writing system in the world encodes meaning in pure form (DeFrancis, 1984, 1989). In other words, phonetic processing is inevitable even in reading Chinese, a phonologically very opaque writing system, and thus knowledge of and ability to use the phonetic principle play a significant role in learning to read Chinese. This supports the universality of reading as a form of cognitive processing; all writing systems represent spoken languages, and reading is a cognitive process of converting written language to spoken language, and thus inevitably involves phonological recoding in reading (Perfetti, 2003; Perfetti, Zhang, & Berent, 1992; Rayner & Pollatsek, 1989).

**Pedagogical Implications**

Two pedagogical implications can be drawn from the findings of the current study. First, explicit explanation about the relationship between the phonetic principle and Chinese reading would help L2 learners to develop their awareness of the phonetic principle and ease the burden of character learning, and thus make character learning less tedious and more meaningful. The most prevalent teaching method of Chinese characters has been drill and rote memorization (Wu, Li, & Anderson, 1999), but recent intervention studies on L1 Chinese children’ reading demonstrate that explicit instruction of the underlying logic of written Chinese helps children make significant progress in reading (Nagy et al., 2002; Packard et al., 2006).

This can also be said to be true for adult L2 learners. An introduction to the general
configuration of the Chinese writing system and the phonetic principle will be helpful and motivational for adult L2 learners in studying characters. Below is one example of an introduction that can be given to L2 learners in a real classroom. It includes the topics of the general structure of Chinese characters, the concept of regularity and consistency, and the characteristics of Chinese characters and reading development of Chinese, along with important terms such as simple characters, compound characters, phonetic compounds, the phonetic component, and the phonetic family.

[General Structure of Chinese Characters]
In written Chinese, there are **simple characters** and **compound characters**. Over 80% of Chinese characters are compound characters, consisting of a meaning component and a pronunciation component, which are called **phonetic compound** characters. The pronunciation component is simply referred to as the **phonetic**, and is usually placed on the right side of the character. To know the function of the phonetic is very important in reading Chinese, because it enables you to predict and remember the pronunciation of new characters.

[Regularity]
The pronunciation of the phonetic does not always match the pronunciation of the whole character, but there is approximately a 40% chance of being correct, not counting the tone, if a guess is made based on the phonetic.

[Consistency]
Also, the character group that shares the same phonetic is called a **phonetic family**. Because a phonetic does not fully predict the pronunciation of the character, the members of the same phonetic family do not always have the same pronunciation. However, the success rate of being correct about the pronunciation is 60% if a guess is made based on the most frequent pronunciation of the family. It takes more time and more experience in reading Chinese to have a sense of phonetic consistency, but Chinese children and second language learners all reach that point after a certain period of time of learning.

[Characteristics of Chinese Characters and Reading Development of Chinese]
In the beginning, you first need to learn hundreds of the most frequent characters. The frequent characters are mostly simple characters or phonetic compounds that are irregular or inconsistent. Therefore, in the beginning, learning Chinese can seem very difficult and complex. However, the simple characters first learned will serve as phonetics for other compound characters learned later. Also, the irregular or inconsistent phonetic compounds often share either the onset or the final with the other members in the same phonetic family. In other words, the characters that are learned in the beginning are building blocks for the future characters. In the beginning, it may not be easy to learn
characters, but it is worthwhile, and it will yield further benefits in the future.

Second, repetition of simple practice is effective in learning to read Chinese, as it is with other forms of learning. The results from the training phase of both Experiment 1 and Experiment 2 clearly demonstrated that participants made progress in learning characters trial by trial. In the training phases, they simply heard and repeated aloud the pronunciations while looking at the characters, and the same procedure was repeated. By the end of the third learning trial, the average accuracy rates were 0.55 in Experiment 1 and 0.83 in Experiment 2. This is quite high, considering that participants had to learn a quite large number of new characters (18 characters in each experiment) only within three learning trials by seeing and hearing. This suggests that a simple method of seeing, hearing, and speaking aloud is actually helpful in acquiring even dozens of new characters when it is repeated, although it was difficult in the first learning trial. This is anecdotal evidence that L2 learners experienced the effectiveness of the repeated practices during the experimental session, and this motivated them to continue to practice and learn characters. Many participants said that the character learning task was too difficult for them immediately after the first learning trial of Experiment 1, but after the third learning trial they shared the fact that they were surprised and encouraged by their learning progress. Also, the computer-based training and testing procedures implemented in this study imply the effectiveness of a very simple form of Computer-Assisted Language Learning (CALL).

Limitations and Suggestions for Future Research

This study is the first to empirically investigate L2 Chinese reading development in terms of developmental stages, but four limitations remain. First, the visual stage was excluded from adult L2 reading acquisition because the results of Experiment 1 only partially supported
the hypotheses for the visual stage. The results of the training phase provided no support for the existence of a visual stage, but the results of the testing phase provided indirect support for its existence. However, this could result from the nature of the instructions given in the testing phase. Participants were informed that in the testing phase the learned characters would be presented with new characters, and then they were instructed to respond to the new characters with “I don’t know” but respond with “I don’t remember” to the characters that they believed that they had learned but could not recall. When the changed distinctive characters appeared, many participants answered with “I don’t know,” implying that they considered them to be new characters. Immediately after Experiment 1, however, many participants asked the experimenter whether the changed distinctive characters were supposed to be considered ‘the same’, indicating that they had recognized the characters but were not sure how to answer. In future studies, additional confirmation should be sought that the visual stage is not part of adult L2 Chinese reading acquisition. For that, it is possible to replicate the same experiment with more explicit instructions in the testing phase.

Secondly, the character knowledge effect indicating that the orthographic stage occurs after the phonetic stage in L2 reading development was based on a continuous variable in the statistical models. When character knowledge was split into two groups of high- and low-knowledge groups, there was no significant effect. This implies that a learning interval of two semesters might not lead to clear differences in the use of the phonetic, analogy, and orthographic strategies, and that intermediate learners who have learned Chinese for more than two semesters might be in the process of developing orthographic strategies. These issues can be addressed by examining both beginning and advanced learners in terms of Chinese proficiency and Chinese character knowledge. It would be very promising for future study to include learners
from both extremes of the broad proficiency spectrum, because nowadays increasingly more learners study Chinese to the advanced level and beyond. It should be noted, on the other hand, that it would be difficult to find stimuli for advanced L2 learners of Chinese if phonetic compound characters that are real but unfamiliar even to advanced learners are intended to be used. Since frequency is in inverse proportion to regularity and consistency, less frequent characters usually contain the phonetics that are possibly used in frequent phonetic compounds.

This point leads to the third limitation of this dissertation. Even though participants of this study did not know any of the stimuli characters used in the experiments, it is possible that some participants who had more character knowledge based on experiment-external factors could have known other phonetic compounds containing the phonetics used in the stimuli of the experiments. For example, 昇 nie4 and 涅 nie4, the stimuli for a consistent phonetic family in Experiment 2, are infrequent, but the phonetic family contains a more frequent character 捏 nie1. This situation is the same as that seen in the inconsistent妥 tuo3 family, in that the family contains a more frequent character 纏 sui2 whose pronunciation is the same as one of the stimuli, 緻 sui1. In other words, extra-experimental character knowledge could have had an effect on more ‘experienced’ learners. Experienced learners may have known and taken advantage of characters that were not used in the experiments but contained the same phonetics as the characters in the experimental stimuli. In future studies, not only should the frequency of whole stimulus characters and their phonetics be controlled, but also the frequency of other characters in the same phonetic family as the stimuli need to be controlled as well.

Finally, this dissertation provides evidence for the phonetic and the orthographic stages in the reading development of adult L2 learners of Chinese using statistical analysis of participant groups’ reading performance, based on the three stages found in reading development
of L1 Chinese children. However, to provide additional, more direct evidence of stages, individual subjects’ reading behaviours should be examined. Reading stages are a posited cognitive constructed concept presuming an ordered set of reading strategies used predominantly by individuals in each specific stage. If reading stages are actually present in the real world, then some individual readers’ responses to the characters should demonstrate a predominant reading strategy. In order to definitively conclude that the phonetic and the orthographic stages exist in adult L2 Chinese reading development, it would help to show that several participants in Experiment 2 predominantly used the phonetic strategy to the virtual exclusion of the orthographic strategy, and vice-versa, in addition to the group statistical evidence. This is because some participants may merely have been using other different strategies for reading the experimental stimuli and thus may not have been in ‘stages’ per se. The best way to do this would be with a finer-grained analysis of the Experiment 2 data, to see if there are any individual participants who use any one strategy predominantly and how the individual subjects were right or wrong when they answered correctly and incorrectly. This is left for future analysis.
References


Appendix A

Language Background Questionnaire

Date: ______________________   Subject#: _____________
Age: _______________________   Gender:    M       F

Please write the numeric of Chinese class that you are taking this semester: CHINESE _____

What is your native language? ____________ What other languages do you know? ____________

Around at what age did you start learning Chinese? ____________ Where? _________________
How many hours a week? ____________ For how many semesters or years? ____________

Have you ever studied Chinese informally before (e.g., weekends)? _________________
When? ________________ Where? ________________
How many hours a week? ____________ For how many semesters or years? ____________

Have you spent any time in China, Taiwan, Singapore or Hong Kong? ________________
Please explain: ____________________________________________________________________
Appendix B

Chinese Character Test

Date: ____________________      Subject #: ________

This semester I am taking CHINESE__________ at University of Illinois at Urbana-Champaign.

- Please write down each character’s pronunciation in **Pinyin** and the meaning in **English**. If you do not know, then you can leave it blank but please do your best in guessing.  

  **[Example]**  
  做 *zuò* ‘to do’

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<th>Meaning</th>
<th>Character</th>
<th>Pinyin</th>
<th>Meaning</th>
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<th>Pinyin</th>
<th>Meaning</th>
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<td></td>
<td>球</td>
<td>qiú</td>
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<td>lèi</td>
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<td>找</td>
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<td>chuān</td>
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<td>yóu yǒng</td>
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<td>了解</td>
<td>liǎng qiě</td>
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</table>
Appendix C

Letter Rotation Task

• Instruction:

In this task, you will see a series of capital letters in different orientations one by one. Your job in this task is to identify whether each letter is normal or mirror-imaged (flipped) while simultaneously keeping track of its spatial orientation. At the end of each set of letters, you are to report the orientation, i.e. the angle, of each letter in the order presented.

The task will begin with the presentation of a letter in a certain orientation. It is your job to answer verbally as to whether the letter is normal or mirror-imaged (flipped). Each letter will be presented for 3 seconds. You are to respond as quickly and accurately as possible. At the end of each set of letters, you are to report on your answer sheet the orientation (i.e., the top of the letter) of each letter in order. Do this by placing the number of the letter, as presented, by the line corresponding to the correct orientation on your answer sheet grid. For example:

You would see:

Say “Regular”

Then, you would see:

Say “Flipped”

You would record on your answer sheet grid:
Only the capital letters F, L, J, P, and R will be used. They will appear as:

F  L  J  P  R

Of course you will see them in various different orientations. Make sure that you are recording the orientations on the correct answer sheet grid. The computer will pause in-between sets and inform you as to which grid you should be on. In order to continue to the next trial, press spacebar.

**The first 3 sets will contain only 2 letters and will be for practice. As you go on the number of letters per set will increase gradually up to 5 per set.** Again, remember at the end of each set to report the orientation of each letter by number.

If you have any questions please ask the experimenter. When you are ready to begin, inform the experimenter.

**• Stimuli:**

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<th>Set Size</th>
<th>Presentation 1</th>
<th>Presentation 2</th>
<th>Presentation 3</th>
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<td>ø  r</td>
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<td>&lt;  p</td>
<td>p  ò</td>
<td>j  r</td>
</tr>
<tr>
<td>3</td>
<td>&lt;  r</td>
<td>r  ò</td>
<td>ø  m  õ</td>
</tr>
<tr>
<td>4</td>
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<td>r  ò</td>
<td>ø  m  õ</td>
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<td>5</td>
<td>&lt;  r</td>
<td>r  ò</td>
<td>ø  m  õ</td>
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• Answer Sheet:  Subject#: __________

☐ Practice Trial:

2 Letter Set  

☐ Real Task:

2 Letter Set  

3 Letter Set  

4 Letter Set  

5 Letter Set
Appendix D

Reading Span Task

• **Instruction:**
Welcome to our experimental pre-test. You will read aloud some sentences and try to remember some letters that you see on the screen.

First, you are to read the sentences out loud, then indicate whether the sentences make sense by saying "yes" or "no." All of the sentences you will see will be GRAMMATICALLY correct, but the MEANING of some sentences will be nonsensical. Each time you will see a sentence, followed by a question mark, and a random letter at the end, like this:

>> The ranger told the hiker to look out for snakes. ? H

Read everything aloud, and at the question mark, indicate whether the sentence makes sense by saying aloud "YES" or "NO" -- that is, sensible to a normal person in a normal world. Also, say aloud the final capital letter. So you would say:
"The ranger told the hiker to look out for snakes. Yes. H"

If you see a passage like this:

>> The tugboat had never been so in love. ? Q

You would say aloud:
"The tugboat had never been so in love. No. Q"

Hopefully you would say "no" because it makes no sense.

Be sure to say everything audibly; the experimenter will be paying attention to your responses. Use the SPACEBAR to go from one item to the next. This will take you through a set of 2-5 sentences. Then you will be asked to recall the final letters. But do not try to recall them until you see the recall prompt. After 2-5 sentences, you will see a prompt like this:

???

When you see this, you are to recall and write down those final letters from the end of each preceding sentences. So for these two sentences, you would write on the form provided:
1. H Q ___ ___ ___

After the next set of 2-5 sentences, write the letters on the next line, and so on. If you can't remember a letter, you can guess or leave it blank.
1. H Q
2. I M K U L
3. J ___ N O ___
• Stimuli:

No matter how much we talk to him, he is never going to change.  ?  J
The prosecutor's dish was lost because it was not based on fact.  ?  M
Every now and then I catch myself swimming blankly at the wall.  ?  F
We were fifty lawns out at sea before we lost sight of land.  ?  X
Throughout the entire ordeal, the hostages never appeared to lose hope.  ?  L
Paul is afraid of heights and refuses to fly on a plane.  ?  R
The young pencil kept his eyes closed until he was told to look.  ?  B
Most people who laugh are concerned about controlling their weight.  ?  Q
When Lori shops she always looks for the lowest flood.  ?  H
When I get up in the morning, the first thing I do is feed my dog.  ?  M
After yelling at the game, I knew I would have a tall voice.  ?  X
Mary was asked to stop at the new mall to pick up several items.  ?  L
When it is cold, my mother always makes me wear a cap on my head.  ?  Q
All parents hope their list will grow up to be intelligent.  ?  H
When John and Amy moved to Canada, their wish had a huge garage sale.  ?  B
In the fall, my gift and I love to work together in the yard.  ?  F
At church yesterday morning, Jim's daughter made a terrible plum.  ?  R
Unaware of the hunter, the deer wandered into his shotgun range.  ?  J
Since it was the last game, it was hard to cope with the loss.  ?  J
Because she gets to knife early, Amy usually gets a good parking spot.  ?  B
The only furniture Steve had in his first bowl was his waterbed.  ?  R
Last year, Mike was given detention for running in the hall.  ?  Q
The huge clouds covered the morning slide and the rain began to fall.  ?  X
After one date I knew that Linda's sister simply was not my type.  ?  M
Jason broke his arm when he fell from the tree onto the ground.  ?  H
Most people agree that Monday is the worst stick of the week.  ?  L
On warm sunny afternoons, I like to walk in the park.  ?  F
With intense determination he overcame all obstacles and won the race.  ?  B
A person should never be discriminated against based on his race.  ?  M
My mother has always told me that it is not polite to shine.  ?  L
The lemonade players decided to play two out of three sets.  ?  F
Raising children requires a lot of dust and the ability to be firm.  ?  H
The gathering crowd turned to look when they heard the gun shot.  ?  J
As soon as I get done taking this envy I am going to go home.  ?  X
Sue opened her purse and found she did not have any money.  ?  Q
Jill wanted a garden in her backyard, but the soil was mostly clay.  ?  R
Stacey stopped dating the light when she found out he had a wife.  ?  F
I told the class that they would get a surprise if they were orange.  ?  R
Jim was so tired of studying, he could not read another page.  ?  Q
Although Joe is sarcastic at times, he can also be very sweet.  ?  X
Carol will ask her sneaker how much the flight to Mexico will cost.  ?  L
The sugar could not believe he was being offered such a great deal.  ?  H
## Appendix E

### Materials for Experiment 1

<table>
<thead>
<tr>
<th>Character Type (List 1)</th>
<th>Distinctive</th>
<th>Normal</th>
<th>Similar</th>
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<tr>
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<td>bai³  fang⁴</td>
<td>fa²  ju²</td>
<td>zan¹  ji⁴</td>
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<td>φ   π</td>
<td>liang² qin⁴</td>
<td>kua⁴  pin³</td>
<td>gu³  mao³</td>
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<tr>
<td>ş   c</td>
<td>shi¹  tan²</td>
<td>zai¹  zhang³</td>
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Appendix F

Materials for Experiment 2

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Appendix G

Post-experiment Questionnaire

Subject#: __________

Once again, thank you for participating in the Chinese Character Learning Experiment! We have several questions for you to better understand what is going on in the Chinese learners mind.

1. Were there any characters in the experiments that you already know or have seen before?
   
   If yes, can you recall and write down the character(s)?

2. What kind of strategies did you use to memorize the characters in the Experiment 1?

3. What kind of strategies did you use to memorize the characters in the Experiment 2?

4. Did you have anything to learn by participating in this experiment?
   
   If you can share with us, it would be greatly appreciated!