2016

Investigating Semantic Alignment in Character Learning of Chinese as a Foreign Language: The Use and Effect of the Imagery Based Encoding Strategy

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Investigating Semantic Alignment in Character Learning of Chinese as a Foreign Language: The Use and Effect of the Imagery Based Encoding Strategy

by

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A dissertation submitted in partial fulfillment of
the requirements for the degree of

Doctor of Education
in
Learning and Leading

University of Portland
School of Education

2016

Abstract

For learners of Chinese as a foreign language (CFL), character learning is frustrating. This research postulated that this difficulty may mainly come from a lack of semantic understanding of character-denoted meanings. Language theories support that when a learner's semantic meaning increases, the orthographic structures that represent the underlying meanings also improve.

This study aimed to reveal CFL learners' cognitive abilities and processes in visual-semantic learning of Chinese characters. Particularly, this study investigated the process by which English-speaking adolescent CFL learners, at the beginning to intermediate level, made mental images of character-denoted meanings to visually encode and retrieve character forms. Quantitative and qualitative data were gathered from image making questionnaires, writing, and reading tests, after learning characters in three commonly-used teaching methods (i.e., English, pictorial, and verbal). The data were analyzed based on a triangulation of the literature from Neuro-Semantic Language Learning Theory, scientific findings in cognitive psychology, and neuroscience.

The study found that participants' semantic abilities to understand character-denoted meanings emerged, but were still restricted in familiar orthographic forms. The use of the imagery strategy as a semantic ability predicted better performances, most evidently in writing; however, the ability in using the

imagery strategy to learn characters was still underdeveloped, and needed to be supported with sufficient contextual information. Implications and further research in visual-semantic learning and teaching characters were suggested.

Acknowledgements

I owe a great deal of gratitude to Dr. Ellyn Arwood, the chair of my dissertation committee and a professor for the core courses of my doctoral program. Her profound thinking in human development and cognition has deepened and refined my thinking. Her expertise in guiding adult learners has elevated me to be a scholar and educator toward a new direction – neuroeducation – that deserves a whole life to work for.

I would like to thank Dr. John Watzke and Dr. Kimberly Ilosvay, my committee members and professors, who offered many invaluable suggestions and assistance to strengthen the experiment design and language use in this dissertation. Special thanks also go to Dr. Nichole Ralston who helped to modify some of the instruments used in this study.

My heartfelt gratitude would surely go to many professors and cohort peers in this program. The warm and intellectual ambiance they have created in the program brought forth growing efficacy and intellectual thoughts in me.

Last but not least, I would like to deliver my sincere thanks to the teachers and students who participated in this study. Mr. Hongsheng Fang and Ms. Liye Zhou offered their precious time in and outside of their classes, and helped all the way to collect data and evaluate student performances in writing. Without these teachers and their sweetest students, this study would not be possible.

Dedication

This dissertation is dedicated to my husband, James. I herein express my deepest love and appreciation to his strongest support and sacrifice for me in this graduate program. I also appreciate his belief in me to reach what I am searching and working for.

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Chapter One: Introduction

Overview

English and Chinese languages represent two of the most mature language networks which use writing systems in alphabetic and logographic forms, respectively. An alphabetic language such as English is an auditory or sound-based system in which written forms (i.e., letters) represent spoken language (Arwood, 2011). Conversely, a logographic language such as Chinese is a visual language with written forms (i.e., characters) representing underlying meaning. In view of these differences, it should be reasonable to foresee that learning Chinese characters in an English auditory world may pose great challenges to learners of Chinese as a foreign language (CFL). The greatest challenge may come from character reading and writing; or, in other words, whether the CFL learner is able to relate character forms to the character-denoted meaning (i.e., semantic encoding of character forms) for literate communication.

This dissertation aimed to explore this challenge by looking into how English speaking CFL learners, at the beginning to intermediate level, used a visual-semantic strategy to learn characters. In particular, the researcher investigated the use and effect of the student-perceived imagery-based strategy to semantically encode and retrieve character forms (i.e., the imagery-based encoding strategy; IBES). The results are explained under the framework of the

Neuro-Semantic Language Learning Theory (NLLT; ibid) with scientific supports from current findings in cognitive psychology and neuroscience studies about language. It was hoped that investigating direct semantic access to character learning, opposite to auditory access, may help to reveal students' visual-semantic learning abilities and reduce challenges stemmed from linguistic and cultural discrepancies.

Although using imagery methods of teaching and learning Chinese characters was not a recent idea, investigating this issue within a neuro-semantic framework was a new approach to addressing the challenge. In addition, by building interrelations among disciplines from language theories, cognitive psychology, and neuroscience, this dissertation developed a neuro-educational model to investigate the cognitive processes in the acquisition of characters by CFL learners. In the meantime, it provided data towards applying the model to further research. Generally, the results and implications may be applied to understanding the underlying knowledge for all languages and learning processes.

Learning Chinese as a foreign language has grown exponentially in the past 20 years (Williams, 2010; 2013). In America, the requirements on Chinese literacy have been raised to a national standard in primary and secondary schools (see ACTFL, 2012). Despite a growing number of CFL learners, some common difficulties in reading and writing characters continue to be reported amongst these learners (Tan, Spinks, Eden, Perfetti, & Siok, 2005; Williams, 2010, 2013). The difficulties encountered by CFL learners have been attributed to spatially-arranged

orthographic structures (e.g., Ke, 1996; Lu, Hallman, & Black, 2010), insufficient phonetic information of the character, and negative transfer of the learner's first language (L1). For example, research in character learning strategies showed that CFL learners carried the phonetic strategy predominantly used in their alphabetic native language to learn Chinese characters (Williams, 2010; 2013).

The current study posited that the dominant use of the phonetic strategy may be because of a lack of semantic knowledge of the character; i.e., the underlying meanings or ideas which are represented by the character forms and spatial configurations. The literature from the semiotic viewpoint of language may support the validity of this assumption in view of the original connections and relative transparency between the deep structure (i.e., meanings) and surface structure (i.e., orthographic forms) of Chinese characters (see Lakoff 1969; Pierce, 1931-58). Therefore, a directional hypothesis of this study was that understanding character meaning represented by the corresponding forms might help with meaning-form integration and lead to a better memory of the character. However, as stated earlier, the challenge is that CFL learners might not be able to understand the meanings denoted in a character, due to differences between the learner's semantic knowledge acquired in English L1 and character meanings evolved from the Chinese context. So, the semantic ability of the learner to align existing semantic knowledge to the meanings of the Chinese character was considered instrumental in character learning (e.g., the concept *brightness/*明 is linked to the sun/日 and the moon/月 in the Chinese character).

Previous studies on visually encoded (i.e., information integration and consolidation) and retrieved (i.e., recall) character forms by making mental images of character and component meanings did not explain the interconnection between meanings and images, or the mechanism of semantic representation (e.g., Kuo & Hooper, 2004; Wang & Thomas, 1992). The current study attempted to build the bridge between meanings and visual images. Research in neurobiology showed that visual form images can be generated from semantic representations that access stored visual information about the object or experience (Gardini, De Beni, Cornoldi, C., Bromiley, & Venneri, 2005; Kosslyn, 1994; Lloyd-Jones & Vernon, 2003). As described in NLLT, semantic knowledge or concepts are made up of images integrated from layers of semantic features (mostly visual features) acquired from sensory inputs. The visual features of a Chinese character were assumed to be represented by the components of the character (Law, Yeung, Wong, & Chiu, 2005). So, visually encoding and retrieving characters by making images of the meanings of the character and components were taken as a feasible semantic strategy to help to integrate images of meanings and forms, and code the information into semantic memory, a relatively longer memory (Squire, 1987; Tulving, 1972; Yee, Chrysikou, & Thompson-Schill, 2014).

To explore the cognitive processes of semantic-imagery encoding and retrieval in character learning, this study analyzed the results of the students' reading and writing data of newly-learned characters by examining the basic components. The results distinguished character reading from writing in terms of

the learners' cognitive abilities and processes. Writing for semantic meaning activates the imagery networks (see Kosslyn, 1994; Mazard, Laou, Joliot, & Mellet, 2005). Imagery differs from perceptual processes in the recruitment of extended semantic networks and requirement of richer encoded information or semantic elaboration (Cui et al., 2007; Heikkila, Alho, Hyvonen, & Tiippana, 2015; Olivetti Belardinelli et al., 2009). In consistency with the literature, character writing in this study was found to have activated significantly more imagery processes than reading, which was suspected to have involved more of the perceptual processes for newly-learned characters. In other words, this study supported that writing may help the learner consolidate or elaborate semantic circuits of a concept while accessing visual information to generate mental images. Nevertheless, imagery and perception interrelate to each other just as the writing and reading processes interrelate. Studies of native Chinese learners also revealed that character writing plays an essential role in Chinese reading acquisition as the deconstructing process supports the formation of connections among orthographic, semantic, and phonological units of the writing system (Tan, Hoosain & Siok, 1996; Tan & Siok, 2005; Tan et al., 2005), and may be associated with the quality of character encoding in long-term memory (Shu, 2003). Thus, it is believed that CFL learners would also benefit from mastering basic character writing on their way to higher reading skills.

This dissertation was an application of cognitive theories and findings in psychology and neuroscience in the study of language to a genuine educational

setting to help to solve a difficult learning problem – Chinese character acquisition by CFL learners. In facing the reality that neuroimaging techniques were unavailable in this research, the researcher utilized existing scientific literature and theories as the underpinnings to explain the empirical results of character learning, and attempted to reveal the participants' cognitive abilities underlying the learning process. Although the literature contents, which included many various pieces from multiple fields, may not seem to be the most connected and easiest to follow, the researcher believed that integrating these fields and connecting the related theories and research findings should be a desirable path to study a language function (i.e., to use language to think and act), considering the distributive and synergistic cognitive capacities of the human brain. In other words, instead of studying isolated structures such as orthographic forms, as numerous language studies did by using empirical methods, a better way to study language acquisition may be to look at it as a language function; that is, to study about the underlying thinking processes represented by the language structures. Educational studies of language and cognitive abilities of student learning should be predictable to be increasingly influenced by integrated data from interdisciplinary theories and findings. The current dissertation was made to run as an example.

Statement of the Problem

Character learning is deemed to be the most laborious and many times discouraging work in the entire Chinese learning process for non-native learners. A body of literature has been focused on the structure and configuration of character

orthographic forms. Studies suggested that the structural complexity or density of a character significantly impacts visual perception and production of characters (Ke, 1996; Lu, Hallman & Black, 2010). Lin and Collins (2012) found that orthographic regularity and consistency played an important role in character reading. In addition, knowledge in stroke order might be an issue. Research showed that character recognition improved when stroke order was demonstrated in animation (e.g., Chang, Stafura, Rickles, Chen, & Perfetti, 2014; Nakamura et al., 2012). Based on the literature, practical teaching and learning methods were suggested. For example, Chung (2003; 2007) and Lee and Kalyuga (2011) and suggested ways to reduce cognitive load when presenting characters with their prompts (e.g., the English equivalent and phonetic transcription). Some researchers also proposed that explicit instruction of character components may be more effective in character learning, but often it was not emphasized in classroom instructions (Taft & Chung, 1999).

Williams (2010, 2013) also found that learning strategies might pose a problem. His research showed that English speaking CFL learners at high-intermediate level depended on underdeveloped phonological knowledge to access characters, rather than using learned semantic components. Previous literature accorded with this result, indicating transfer of phonetic knowledge in English to character learning among CFL learners (e.g., Bassetti, 2006; Everson, 1998; Lin & Collins, 2011). In comparison, native Chinese speakers relied on visual information or semantic components extensively in reading Chinese texts

(Chikamatsu, 1996; Hao, Chen, Dronjic, Shu, & Anderson, 2013). The Chinese L2 learners, however, did not use the semantic and phonetic components of characters sufficiently (Zhang, 2009).

Pertaining to character-denoted meanings, Chinese characters are unique in the connections between component meanings and characters. In light of this uniqueness, some CFL educators argued that a plausible way of teaching characters is to use pictures or motion pictures to interpret the connections between component meanings and characters (e.g., Gu, 2006; Lu, 2011; Tan, 1998; Wang & Zheng, 2005; Zhang, 2005). It was suggested that using pictures to improve semantic understanding of basic characters (mainly pictographs) may improve students' conceptual understanding of the components and their ability to apply the knowledge to complex characters (Gu, 2006).

However, research results in using pictures to teach and learn characters are inconclusive. Research on beginning Chinese learners has revealed highly positive effects in the character form and semantic recall with picture support, compared to those without this support (Lu, 2011; Luk & Bialystok, 2005). Conversely, other research has revealed using pictures to learn to be unreliable (e.g., Hamilton & Geraci, 2006; Kuo & Hooper, 2004). Wang and Thomas (1992) pointed out that for a better effect of Chinese character retention, mnemonic images must be learner-generated, while teacher-supplied encodings may only prove immediate benefits in the classroom.

Presumably, the problems of the visual presentation were found to be related

to types of characters (e.g., ideographs or compounds and characters with concrete or abstract meanings), types of visual supports (e.g., static or motion), and levels of cognitive demands (e.g., contents in a picture). For example, Kuo and Hooper (2004) found that characters with concrete meaning produced higher scores in reading than those with abstract meaning, because characters with concrete meaning gave rise to better visualization in the learner. However, few of the studies addressed the problem of the inconsistent results of visual support from the learner's semantic understanding of the images that may help with generating mental images of the character meanings to visually encode character forms.

Therefore, this dissertation is more concerned with the learners' semantic abilities in character learning; that is, using the imagery strategy to align the meaningful features learners acquired in English and those meaningful features contained in Chinese characters for character meaning-form encoding. However, due to English L1 interference (mainly from phonetics), it was unknown whether or not CFL learners at the beginning level are able to use IBES for character encoding. What was also worthwhile to know was how the learners use IBES to learn character meanings for character form encoding and retrieval.

Purposes of the Study

As previously mentioned, this study investigated the ways in which English speaking CFL learners at the beginning to intermediate level of Chinese used IBES to visually encode and retrieve character forms. Learners who perceived to have generated their own mental images or incorporated supplied images to associate

characters with meaning during character learning and recall were considered to be carrying out the semantic-imagery strategy, IBES. The use and effect of IBES were compared among three commonly-used teaching methods; i.e., characters presented with English translation (i.e., English), characters presented with pictorial presentation (i.e., pictorial), and characters explained by verbal instruction (i.e., verbal). In particular, this study aimed to find out which of the teaching methods led to a higher employment rate of IBES, and better performances in character reading and writing. Several other possible factors (i.e., gender, Chinese proficiency, and character type) were also tested in the current context for their effects on the student-perceived IBES.

Two major assumptions were held in the process of this investigation. The first assumption was that making mental images of a character form connected with the learner's semantic knowledge may enhance understanding of the character and help with meaning-form integration for semantic memory. The second assumption was that CFL learners' existing conceptual knowledge of newly learned characters may not automatically connect to character forms; so, it is necessary that semantic features be modified or aligned to facilitate mental representation, recognition, and semantic encoding of characters.

Based on the assumptions, the major hypothesis for this study was that the CFL learner's ability to align meanings with the Chinese character should predict a better performance in character reading and writing. As this study focused on the visual-semantic processing of Chinese characters, it bypassed the phonetic

pathway (at least in Chinese) to process characters.

Research Questions

Based on the research purposes, three questions were addressed to guide the study. These questions were considered general guiding questions from which further sub-questions were derived for the measurements in data analysis and result discussion.

1. Did any of the three commonly-used teaching methods, i.e., English, pictorial, and verbal, result in a higher employment rate of the imagery-based encoding strategy by adolescent CFL leaners at the beginning to intermediate level?
2. Did any of the three teaching methods, i.e., English, pictorial, and verbal, lead to better performance in character writing and reading?
3. Did the three factors, i.e., gender, Chinese proficiency, and character type, affect student-perceived use of the imagery-based encoding strategy?

Summary of the Chapters

Chapter Two provides a review of the literature. The literature covers cultural-linguistic studies and theories of language systems; the theories and scientific findings in cognitive psychology related to language acquisition; and, neuroscience about semantic processes and networks, as well as imagery mechanisms. The researcher attempted to bring together literature from multiple disciplines for the purpose of understanding the cognitive processes of semantic adaptation and visual image making toward character acquisition by CFL learners.

Chapter Three presents research methodology with the information of the participants, the materials and instruments used in the study, the procedures, and grading criteria developed for cognitive analyses of character writing. Chapter Four presents the results in consistency with the research questions. In addition, the qualitative data are also summarized. Chapter Five discusses the results linked to the literature. A neuro-educational model for character learning analysis is proposed in this chapter. Following the conclusions, the researcher also discusses implications of this research for teaching applications and gives suggestions for future research based on the data from this dissertation.

Chapter Two: Literature Review

The previous chapter introduced the problems facing the researchers and educators in CFL teaching and learning, as well as the purposes and research questions of this dissertation. Chapter Two provides a review of the literature. To meet the current study purpose, studying character learning based on CFL learners' semantic abilities through visual imagery encoding strategy, the literature was tied to theories and findings from extended but interrelated disciplines or fields that can be mainly placed into three literature modules: theories of language studies in semantic knowledge and acquisition, cognitive neuro-scientific findings in semantic networks and imagery pathways, and psychological studies of semantic memory and imagery effects in character learning. The first module sets the theoretical foundation of this research to examine the nature of semantics (i.e., meaning) in language acquisition based on the most prominent classical and contemporary models. The second module provides cutting-edge research findings that substantiate the theories in the first module and meanwhile provide evidence for the analysis of the research results in Chapter Five, Discussion and Conclusion. The third module places part of the literature into the methodology of the current study on the imagery-encoding strategy in character learning. The three modules of literature are linked and juxtaposed, forming a new triangulation model for conducting educational research in understanding cognitive processes of character

learning by CFL students. The triangulation model will be discussed in Chapter Five.

In this chapter, the theories and findings of the three modules are also discussed together with relevant information that the researcher found significant to understanding the current problem. Therefore, instead of arranging this chapter into three sections corresponding to the three modules, the researcher arranged the contents into five scholarly topics, thus five sections, which may help to organize subtopics in a logical flow and bring together theories and findings of related topics with complementary information drawn from different disciplines and research areas.

This chapter begins with an introduction of the Chinese language and character, in comparison with the alphabetic English language. The second section examines the relationships of deep and surface structures in character acquisition from the viewpoint of semiotics, the theoretical foundation of the current research. The third section introduces the Neuro-Semantic Language Learning Theory (NLLT), which not only serves as a major theoretical framework in this research, but also, together with scientific findings in semantics and imagery, provides methods for the analysis of the research results. The fourth section focuses on cognitive processes of character learning with an emphasis on the distinction between imagery and perceptual processes in writing and reading. The fifth section looks at character learning by native Chinese and CFL students, as well as the effects of using the imagery strategy to learn characters.

The Chinese Language and Character

An alphabetic language versus a logographic language. Though recent neurological studies have verified universal brain networks shared by all human languages, specific pathways and processing strategies vary from language to language, and even differ in units of the same language (see Bolger, Perfetti, & Schneider, 2005; Nakamura et al., 2012). English and Chinese, in particular, which represent two distinct linguistic systems as well as their cultures, vary in a wide array of aspects, linguistically and functionally, compared to languages of their own groups. These differences, undoubtedly, result in cognitive gaps and conceptual vagueness where improper translations occur and difficulties of learning these languages loom large. Understanding some discrepancies may help learners of the two languages to acquire meta-linguistic knowledge beyond the surface forms, so as to initiate strategies necessary in the target language. In the following, a list of these differences between English and Chinese from linguistic and cultural points of view is briefly introduced. While viewing these differences as language specific, it is better to bear in mind that language specificity and universality coexist with historical preferences and cultural conventions of the people who use it.

First, in general structure, English is an alphabetic language while Chinese is considered as a logographic language. This classification is based on their distinct writing systems in which the modern English is represented by 26 Roman letters and Chinese by 560 logographemes as their basic functioning units (Han, Zhang,

Shu, & Bi, 2007). English follows prescribed spelling rules that temporally string letters representing spoken sounds into lexicons or words separated by spaces. These letters and combinations of letters represent the sounds people utter to make meanings. Chinese is composed by a multilayer stroke system, from which logographs are built and packed in square-shaped characters, spatially arranged about the same size. Logographemes, the smallest blocks in a character (ibid.), are an orthographic form that can contain the semantic meanings of an object or idea. A majority (65.6%) of Chinese words are two-character words (Chen, Tseng, Huang, & Chen, 1993). In other words, characters are higher-level morphemic meanings with a fixed set of logographemes. In order to avoid any confusion, all the logographemes are referred to as components in this dissertation.

Second, at the semantic-phonetic level, English follows a morphophonemic system, as compared to Chinese which follows a morphosyllabic system. Morphophonemic system in English refers to the interaction between morphemes, the smallest meaning unit, and the phonemes within them. As the functional meaning (e.g., parts of speech) of a morpheme changes, the phonemes change accordingly under morphophonemic rules, such as *sleep* and *slept*, *produce* and *production*, *knife* and *knives*. Assumptions about this system are that morphophonemic representations are the key access to English reading; and, by learning a series of morphophonemic rules, learners convert deep semantic meanings to surface productions in written or oral forms (Leong & Joshi, 1997). In Chinese, a similar relationship occurs between characters and their corresponding

syllables. Chinese characters start to combine morphemes and sounds together upon visually independent orthographic forms. Each character is pronounced as a syllable constituted by separated consonant-vowel clusters (a monosyllabic language system). This morphosyllabic system differs from the morphophonemic system in that the character-syllable relationship is fixed, but entirely arbitrary. The only exception is that the phonetic components in some compound characters provide some phonetic clues to character pronunciation (see the following section in detail).

Third, English pronunciation is stress-based versus Chinese a tone-based language. In English, every word with more than one syllable is pronounced with regularly-arranged stressed and unstressed patterns. Together with adjacent words in a sentence, this stress-unstress alternation forms recognizable rhythms that native speakers expect from the sound patterns which carry meanings in a prosodic flow. As stress changes, meaning changes accordingly, such as the verb-noun conversion in many two-syllable words (e.g., the verb con′tent means feel happy; the noun ′content means substance). Conversely, in the Mandarin Chinese suprasegmental (prosodic) system, meanings are conveyed in four tones or voice inflections – high, rising, low-rising, or falling – on top of each syllable (Taylor, 2001). The sound transcription of Chinese phonetics with the combination of syllables and tones is called *Pinyin*. For all the 20,000 characters in the Chinese character corpus, each character shares the same sound (or Pinyin transcription) with several other characters – called *homophones*. As a result, meanings of speech

production must be distinguished either through contextual environments or by referring to specific characters. That is how Chinese people from various dialect areas are able to communicate with each other.

Fourth, English is a time-based language as opposed to Chinese a visual-spatial language (Flaherty, 2003; Yim-Ng, Varley, & Andrade, 2000). This difference is manifested not only in the surface form in speech production and orthography, but also in the use of vocabularies and grammar. As aforementioned, English letter sounds merge into rhythmic patterns to convey and interpret meanings. Chinese characters are represented with specific spatial layouts of the components so as to be recognized and distinguished in meaning (Yim-Ng et al., 2000). Time is a property of English represented by a variety of temporal words (e.g., first, then, when, etc.), as well as by the structure of the language and the use of specific ways to assign meanings (Arwood, 2011). In Chinese, temporal meanings are commonly expressed by spatial words. For example, the characters, 上 and 下 meaning *up* and *down*, are also used in the words to mean morning and afternoon. In addition, explicit temporal words in many cases are omitted to avoid redundancy in contexts, such as the omission of *when* and *while* at the sentence level.

Fifth, corresponding to the sound-and-time based language features English is a low context language. In contrast, Chinese is a highly contextual language in relation to its visual character features. By low context, it means that English does not require much set-up or context for the listener to be able to understand the

meaning of a word or utterance (Arwood, 2011). The listener can understand a word without a context. In contrast, the Chinese language is highly dependent on the context due to its irregular character-sound relationships. The inclusive culture, e.g., philosophy within characters, individuals within groups, and time within space, may contribute to the development of this highly contextual language, or vice versa. The context-dependent differences in English and Chinese can be understood in the studies of visual field sensitivity. A number of studies in cultural psychology found that East Asians represented by Chinese speakers are significantly more sensitive to surrounding areas for holistic processing of a visual space, while Westerners represented by English speakers tend to focus on central visual areas for analytic processing of a visual space (Chiao & Immordinao-Yang, 2013; Park & Huang, 2010). The differences in visual field sensitivity might be considered a direct issue in learning the visual language for English-speaking CFL learners.

In the above, the researcher listed five linguistic and cultural differences that are prevalently noticed or studied. These differences, undoubtedly, reveal cognitive gaps from both the structural and conceptual levels between people of the two languages, and might be predicted to cause difficulties for all CFL learners in Chinese character learning, as some of the difficulties have been discussed in the previous chapter. In the following, the researcher will describe, in more detail, the Chinese character used within the Chinese.

The Chinese character. Chinese characters have been in existence for over 5,000 years (Tan, 1998). It is believed that characters were formed originally from humans' imitations of footprints of birds and beasts (Gu, 2006). It was in the 25th century B. C. that Cang Jie, a governmental historical recorder, transformed drawings into character forms for the purpose of recording government matters and administration (Wieger, 1965). In the earliest scripts, characters represented concrete objects and natural phenomena (Gu, 2006). Complex meanings were expressed by adding and embedding components into existing scripts to form a unified square-shape character. For example, the character 塞 (to obstruct) is made up of three components from the top to bottom, including a house with a roof and a wall made of bricks (the top), two hands pressing on the wall (the slanting lines in the middle), and a pile of earth which stops rain or wind from coming into the house (the bottom). Not surprisingly, some people describe Chinese characters as paintings (Wang & Zheng, 2005) and some others describe them as stories that can be broken down into components with story formats (Williams, 2010).

With the evolvement of Chinese characters in shape and connotative meanings, several other ways of character formation emerged. Xushen (58 A.D.-147 A. D.), the first Chinese lexicographer, categorized Chinese characters in six types, which are still considered the most accepted methods for character categorization and structure analysis. All of the 9353 characters in *Shuowen Jiezi* (100 A.D.), the first Chinese etymological dictionary compiled by Xushen (Serruys, 1984), fall into these six types: pictographs, indicatives, ideographs,

semantic-phonetic compounds, transformed cognates, and phonetic loan characters (Lu, 2011). Table 2.1 illustrates the six types of character formation methods.

Table 2.1.

Xushen's Six Types of Character Formation Methods in Shuowen Jiezi (100-121 A.D.).

Types	Formation Methods	Examples
1. Pictographs	Pictographs were created from images or pictures of objects.	水(water)，火(fire) 雨(rain)
2. Indicatives	Indicatives are usually formed with symbols indicating functional meanings.	大(big)， 小(small)，上(up), 下(down)
3. Ideographs	Ideographs usually combine several pictographs to denote complex ideas.	明(bright)= 日(the sun)+ 月 (the moon); 森 (forest)= triple 木 (wood)
4.Semantic-phonetic Compounds	Compounds are composed of two of more components or characters. One of them suggests the meaning, and the other provides the pronunciation cue for the character.	洋(ocean)= 氵(water)+ 羊 (yáng/sheep); 装 (pack)= 壮 (zhuàng/strong) + 衣 (clothing)
5.Transformed cognates	These characters usually borrow the shape of an existing character and carry a similar meaning.	老(old) ← 考(old)
6. Phonetic loans	These characters are borrowed from an old character with similar pronunciation, but the old ones are lost in meaning.	来(come) ← 来 (grain in the old meaning)

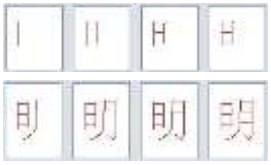
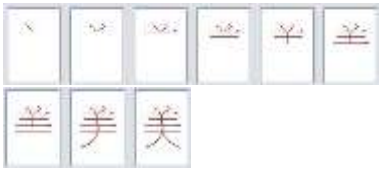
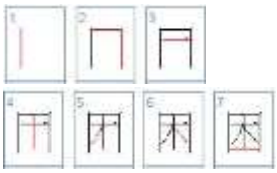
Note. The slash (/) separates a Chinese sound on the left and an English meaning on the right. Adapted from "The Effect of Instructional Embodiment Designs on Chinese Language Learning: The Use of Embodied Animation for Beginning Learners of Chinese Characters," by M. P. Lu, 2011, doctoral dissertation.

When writing characters, native Chinese usually follow precise rules to compose characters in a hierarchical order; single strokes into block-like and square-shape components which are arranged into characters. These rules mainly include knowledge of stroke types, stroke directions, length or position of strokes in relation to others, stroke orders, and placement of components. For example, native Chinese speakers may know that a typical semantic component, usually called a radical, is placed on the left of a compound in the left-right structure. Beginning learners typically learn by practicing writing with a grid as a guide (Chen, 2005). Misplacing these components result in confusion, non-characters, or characters of totally different meanings. There are four basic structures in Chinese characters: left-right (e.g., 好), top-down (e.g.,要), outside-inside (e.g.,问), and symmetrical (e.g.,坐).

After analyzing the structure, a skilled native writer starts to deconstruct parts or components into intricate strokes, and write the strokes in conventional orders and directions. For a right-handed person, strokes are drawn from top to bottom and from left to right. Theoretically, there are nine basic strokes, from which seventeen are derived and used (Tan, 1998; Wieger, 1965). Table 2.2 illustrates the nine basic strokes, stroke directions, and examples of characters composed by conventional stroke orders.

Table 2.2.

Nine Basic Strokes, Stroke Directions, and Examples of Character Structure and Stroke Order

Stroke Type	Writing Direction	Examples of Character Structure and Stroke order
1. The horizontal	→	Left-Right: 明 （ bright ） = 日 + 月 
2. The vertical	↓	
3. The downward to the left	↙	Up-Down:美（beauty）=羊 + 大 
4. The downward to the right	↘	
5. The dot	↘	
6. The upward	↗	Outside-Inside:困（confine）=口+木 
7. The hook	↲	
The horizontal turn	↴	
9. The vertical turn	↳	

Note. Adapted from “What’s in a Chinese Character?” by H. P., Tan, 1998. Copyright 1998 by New World Press.

Chinese characters have undergone thousands of years of evolvement from as many as eighty-four strokes in one character to nowadays an average of eight strokes (Shi, 2012; twelve strokes for traditional characters). Above ten strokes, it is viewed as difficult in writing (Lu, 2011). Due to simplifications over time, many

Chinese characters used at present have lost their etymological meanings or left little traces of their formation methods; instead, many have become more like arbitrary symbols packed in square shapes. Despite the simplification, a large number of characters today, especially the most basic and frequently used ones, still bear more or less traces of the actual objects or original meanings (Gu, 2006). These basic characters, a large number of them, evolved into building blocks or components of contemporary scripts with the original meanings of the basic characters being layered down in the current meanings. In this sense, learning characters through their underlying meanings of these components can be instrumental, especially for CFL learners, due to the benefits from recognizing and understanding the meaning-related blocks. In the following, the researcher will review the current status of Chinese learning and methods of character teaching in ordinary classrooms in the United States.

Learning Chinese as a foreign language in the United States. As China has become the second largest trade partner of the United States since 2006, the number of learners of the Chinese language has been dramatically growing in elementary, secondary and higher education classrooms. According to an ACTFL report, the enrollment of Chinese, as a foreign language, in American public schools increased three-fold from 2005 to 2007 (ACTFL, 2015). There is a 100% increase of Chinese programs in two years in the US (Shao, 2015). In some states such as Colorado, Chinese has surpassed all other languages as students' first choice for foreign language learning (Lofholm, 2012).

Recognized as a less-commonly-taught critical language for the U.S. economy and national security (National Security Education Program, 2016), Chinese programs have been broadly funded (Zhang, 2009). Teacher training programs and seminars have attracted thousands of Chinese teachers annually across the US. Starting from 2004, the Chinese government, through The Confucius Institute Headquarters (generally called *Hanban*), has launched a global campaign to promote the Chinese language and culture by sponsoring overseas Chinese programs and dispatching native Chinese teachers. The United States has been its largest recipient, hosting 100 Confucius institutes and 384 Confucius classrooms in 2015 (Confucius Institute Headquarters, 2015).

A "Chinese Fever" has emerged (Liu, 2008). Textbook books and materials in Chinese character teaching and learning have surged in the market; and, various approaches to character teaching and learning have been suggested. In general, there are books centering on stroke order and structure building writing (e.g., Mathews & Mathews, 2006; Zhe, 2014), or on etymological meanings of basic characters illustrated with pictures (e.g., Tan, 1998; Zhang, 2005). Also, there are attempts at adapting the etymological meaning of characters to the modern shapes, for which newly-designed illustrations are used to integrate components into logical meanings (e.g., Gu, 2006; Matthews & Matthews, 2007). Matthews and Matthews (2007) described this new method as "telling an imaginary story." This method, parallel with the study methods in this research, may indicate a possibility that visual-semantic strategy may be applicable to characters of different types and

origins; and, CFL students can learn in this way, if they are given sufficient meaningful information of the character.

Software tools for character learning are rare, though some researchers designed stroke animation (Shi, 2012) and graphic animation programs to learn basic characters (Li, 1996; Lu, 2011). Most of the character writing on the computer is done by using phonetic-character transcription on word processors, which leads to fewer character errors. Students, however, often regard Chinese writing as stroke-by-stroke character formation (Kang, 2011). They find it useful to practice character writing on cellphone applications (e.g., PLECO, a mobile phone dictionary) which identify strokes and components that they can then convert to intended characters.

Despite newly developed technology and methods, it seems that few of the approaches have been effectively applied to everyday classrooms. Chinese is still regarded as the most difficult language in terms of literacy acquisition for learners of CFL. It is estimated that, using the same amount of time, learning Chinese from level 1 to level 2 equals three times more than learning other languages such as French, Dutch, and Swedish (Lu, 2011). Zhang (2009) reported that ninety-percent of the students who quit after first-year Chinese quit because of the difficulties in learning characters. This setback has caused a long-term debate on whether characters should be introduced at the beginning level of Chinese learning (Kang, 2011). Having recognized the common difficulties in Chinese reading and writing, ACTFL has allowed a one-year delay on reading and writing skills for CFL

students compared to students learning Spanish, French, and German (ACTFL, 2012). There is not a consensus on a desirable way to teach characters. At present, the traditional way of translation and rote memorization is still the dominant method in beginning and intermediate CFL classrooms (Lu, 2011). Up to now, it is not yet certain whether it is CFL learners' lack of abilities in acquiring the visual language or the traditional way of teaching that has caused the delay of literacy in Chinese. However, at present, it is time that people drew more attention to more meaningful methods for character teaching and learning in everyday classrooms; the visual-semantic way should be worth serious studies. The following section may give some fundamental knowledge about the relationships of character meanings and forms. Understanding these relationships should be essential to the acquisition of the language.

Deep and Surface Structures in Chinese Character Acquisition

Deep and surface structures are the concepts borrowed from the generative grammar theory proposed by Noam Chomsky (1972; 2013) in his book, *Studies on Semantics in Generative Grammar*. In this book, Chomsky defines surface structures as the structures mapped into phonetic representations by the phonological rules. Deep structures are the post-lexical structures (including some grammar) which are mapped into semantic representations by the semantic rules. This definition of deep structures received criticisms of mapping the grammar structures to semantics, equating to say that grammar pre-exists semantics. The later generative transformational theorists reversed the process, indicating that

through transformational rules deep structures can be transformed into surface structures (Lakoff, 1969). That is to say, semantic meanings generate and transform into surface forms, which will be later discussed in this section.

Applying these linguistic notions to the Chinese character, surface structures should be regarded as the structures mapped into orthographic representations by the orthographic rules, i.e., the strokes and configuration rules of the strokes to a character form. The deep structures of a character entail the underlying semantic meanings and the rules that constitute the meanings. The semantic rules, which users of the Chinese language should be aware, include the constituent meanings of a character or phrase, and the placement of the constituents that carries the semantic relationships with other constituent meanings (e.g., where the radical is positioned in a compound). Though Chinese texts are not a concern in this study, they also follow these rules (see the transformative rules in generative semantics; Chomsky, 1972, 2013).

This section only uses these two concepts as the general terms representing similar terms used by different scholars or theorists to analyze the deep and surface structures in Chinese characters. To be more specific, the researcher analyzes the relationships of character deep and surface structures under the framework of semiotics. Although semiotics did not directly use the terms, deep and surface structures, the discipline can be taken as a methodology that deals closely in language studies, especially in language acquisition, for analyzing symbol-meaning relationships (Arwood, 1983); so, semiotics should also be

applicable to the analysis of the Chinese symbolic system.

Deep and surface structures in semiotics. Semiotics sets the theme for investigating the necessity of symbolic cognition in general. It refers to the study of signs and symbols to their referents, and particularly in language (Jakobson, 1980). Two dominant models of signs are credited to two prominent figures in semiotics: the linguist Ferdinand de Saussure (1857-1913) and philosopher Charles Sanders Peirce (1839-1914). Although these models have been applied to various fields and linguistic levels, the analysis in this section is limited to the way in which these models can be applied to basic language units such as the character.

Saussure (1959) in his *Course in General Linguistics* introduced a dyadic sign model, which is composed of a *signifier* and a *signified.* The signifier refers to the orthographic or phonic component of a word, equivalent to surface structures. The signified is the ideational component that connects with the concept, paralleling deep structures. The sign is the whole that results from the association of the surface structures with the deep structures. They are two distinct but correlated planes, neither pre-existing the other (Chandler, 2014). Rather than proclaiming a logical relationship between the two components of a sign, Saussure emphasized the arbitrariness; i.e., there is no direct connection between the sound (or the orthographic form) and the concept. He also posited that their association comes into being only through conventions and uses. According to him, no sign makes sense on its own but only in relation to other signs (Saussure, 1983).

The arbitrariness principle later became the cornerstone in the structural

linguistics in analyzing linguistic structures especially for alphabetic languages. However, this principle can only be loosely applied to the logographic Chinese in which referent meanings gave rise to orthographic forms of the character. Even for modern scripts, research showed that half of the simple characters are iconic in reference to their concepts that can direct the reader to their meanings (Luk & Bialystok, 2005). Nevertheless, the interpretation of the same character may vary person by person. Even for some non-arbitrary characters, the same sign can be interpreted in multiple ways and generate multiple meanings. For CFL learners, this sign system can be totally arbitrary until they have learned to associate deep semantic meaning or deep structures with corresponding surface structures and have acquired the rules that constitute the layers of each structure level. Saussure's arbitrary principle of signs received many criticisms. Later, he introduced the concept of relative arbitrariness (Saussure, 1983); that is, there is a degree of arbitrariness among signs.

In terms of language systems, Saussure emphasized the operation of the arbitrary principle upon each language system, because exact equivalents for words between one language and another seldom exist (ibid.). Reality, using words as the arbitrary units for analysis, could be divided up into arbitrary categories by every language and the conceptual world (Chandler, 2007). People may perceive and therefore conceive the world in great difference due to meanings that have previously been assigned in different environments to similar concepts. In other words, the arbitrariness may not just occur between surface and deep structures,

but also within the acquisition of meanings for the deep structure. The concepts in deep structures and how the deep structures are related to surface structures are founded on social and cultural conventions (ibid.).

About the same time to Saussure's dyadic model of signs, Peirce formulated a triadic model. In this model, a sign is made up of three components which he called the *representamen*, *object*, and *interpretant* (Merrell, 2001). The representamen is the form which the sign takes. The interpretant is best understood as the interpretations made to the sign. What the sign stands for is its object or referent (Peirce 1931-58). According to Peirce, the object can never be identical to the real object, but only certain features of an object are signified (see Merrell, 2001).

Relating these three concepts to the previous semiotic concepts, the representamen is similar in meaning to the signifier or surface structures (Silverman, 1983). The interpretant on the basis of the object is similar in meaning to the signified or deep structures. The relationship of the three sign components can be best illustrated in Chinese character examples. For the surface form 羊 (the representamen), it connects the learner to some ideas related to the animal class which they have learned previously (the interpretant), and then activates an obscure image of a sheep with the horns but not the complete features of the sheep (the object).

The beauty of the triadic model lies in the developing process of a sign. The meaning of a sign is not contained within it, but arises in its interpretation

(Chandler, 2007). The interpretant relates to and mediates between the representamen and the object. As a result of such mediation, the sign takes on value, meaning, as the interpretant interrelates and participates with other signs (Merrell, 2001). An interpretant serves to further generate more developed signs of the object; which, through some features, generates an additional interpretation. This process leads to an infinite chain of signs. The most important part in this process, according to Pierce, is the interpretant (Peirce, 1931-58), or interpretation from which the meanings of a sign can further refine in meaning. To apply this principle to character learning, one can see a developing process at multiple levels, such as from radicals to characters. The most important step in this process depends on the interpretant (i.e., the learner's interpretation) to mediate among signs.

In Peirce's view, there are three kinds of signs (Peirce, 1894). First, there are the likenesses, or icons; a type in which the form is perceived as resembling or imitating the object, e.g., the Chinese pictographs. Second, there are indications, or indices, the type in which the form is directly connected in some way (physically or causally) to the object or ideas, such as radicals in Chinese characters. Third, there are symbols, or general signs, which have become associated with their meanings by usage, e.g., many simplified characters such as 义 (righteous). Peirce (1894) noted a regular progression in the three orders of signs: icons, indexes, and symbols, which are referred to as firstness, secondness, and thirdness. Such a progression is apparent in the evolution of Chinese characters from the

most primitive iconic signs towards the symbolic signs. It is the symbolic mode that is granted a greater status (Chandler, 2013). Peirce (1931-58) noted that symbols are the only general signs essential to reasoning, so he called the symbol parts of signs “concepts”. It is only out of symbols that a new symbol can grow, and by thoughts and use with people, meaning grows across time (Pierce, 1894).

For both Saussure’s dyadic model and Pierce’s triadic model of signs, all these kinds of signs can be generally classified into deep and surface structures, which are distinct but interrelated planes. Semantic deep structures give rise to and determine the function or semiotic value of the surface structures. Furthermore, interpretations of deep structures grow into more developed deep structures and so on, in the process by which meanings arise. Unlike Saussure’s model, Pierce’s model does not support the notion of absolute arbitrariness among signs. They differ in how arbitrary (or transparent) the signs are in relation to reality and how “the use” of the signs are interpreted (Chandler, 2014). Hence, within the framework of semiotics, it is reasonable to argue that in learning a foreign language such as Chinese, developed deep structures in the learner’s mind account for a developed representation on the surface structures. This suggests that the underlying meanings are culturally distinct; and, as such, influence interpretation of the surface forms. Likewise, the differences between Chinese and English, at the surface level, represent the underlying semantic difference. Both the deep and surface structures could be responsible for the difficulty that English speakers have in learning the characters of Chinese.

Structures vs. semantics in language learning. Structuralism has dominated academic fields, especially linguistics, in the 20th century. Language structures, including words, sounds, sentences, parts of speech, and so forth (Arwood, 2011), are prevalently used in language classrooms for parsing, distinguishing, and analyzing language patterns up to the present. Structuralism in linguistics was founded upon Saussure's semiotic model of the arbitrariness of signs (see Matthews, 2001). The assumption is that signs are interrelated with each other by conventional use. Coupled with the doctrines of behavioral psychology from the 1940s, structural linguistics became a dominant theory applied in second language learning classrooms. In this model, learning a language aims to condition learners to make the right association between stimuli and the desired responses (e.g., seeing and naming). Behaviorists declared that only behavior observed can be described and explained as the valid account of learning (Rachlin, 1994). In this paradigm, memory consolidation is mainly realized through drillings and repetitions. Semantics, the study of meaning, is ignored in this process (Ellis, 1999). It is believed that language could be dismantled into small pieces or units, described scientifically, contrasted, then added up again to form the whole (Brown, 2006).

These surface units are drilled in response to models; and, this type of paradigm prevails in current CFL classrooms where characters including orthography, phonetics, and English equivalents are learned through times of mechanical drilling and copying (Kang, 2011; Lu, 2011). Though studies have

yielded positive results of stroke modeling and repetition in learning Chinese characters (e.g., Chang et al., 2014; Nakamura, et al., 2012), the long-term effect of structural training in learner performance and learning-related affective issues were not considered. More focused studies should be needed in these aspects (Anderson, 2011).

In contrast with structural linguistics, a learning paradigm with an emphasis on semantics is committed to meaning and contextual, or relational, information in language learning (Arwood, 2009). It is Pierce's notion of pragmaticism[1], analyzing the relationships of three components of signs, that has built the foundation of nowadays language studies with a focus on meaning (Arwood, 1983). As described in the previous section, Pierce's notion of meaning, different from linguistic structures such as isolated words, is a dynamic process of an infinite interpretation of signs derived from the original object (Arwood, 1983; 2011). In Peirce's view, things are not viewed from the parts (the specifics) to the whole, but rather should be taken as a complex that bears the relation of the whole to the parts (Foster, 2011); i.e., the meaning and context predetermine the structure. The term pragmaticism itself means the whole is greater than the sum of the parts (Arwood, 1983). That is to say, meaningfulness of the language naturally came before structures or surface forms. In the same vein in language acquisition (both in L1 and L2), ideas or the meanings of a sign (i.e., sounds or orthographic forms)

[1] Pierce labeled his own theory "pragmaticism", distinguishing from the theory of pragmatism proposed by William James, due to their differential treatment in the study of logic of signs (Apel, 1981).

invoke the acquisition of the sign in relation to other signs.

Character learning should also consider the pragmatic operation of learning: from contextual meanings comes the acquisition of the orthographic form based on conventional use. It is not only because character forms represent the underlying meanings, but because Chinese characters cannot be isolated or used out of context. Homonyms and synonyms constitute a large reservoir of the character inventory, and even semantically independent two-character “words” many times must be interpreted in situational contexts. As mentioned previously, Chinese is a high-contextual language. So, mechanically memorizing the form and sound of a character, most of the time, leads to incorrect associations. Errors in Chinese learning, including those by native children and CFL learners, usually originate from a lack of semantic processing of characters (Weekes, Yin, Su, & Chen, 2006).

In short, meaning is not a static entity. The deep structures of meaning constantly develop as the meaning or semantic relationship that forms concepts refines in changing contexts, uses, and forms. Therefore, it is not difficult to infer that the meaning of multi-layered deep structures results in learning at various levels that require different amount of cognitive resource; hence, different learning results.

Among levels of meanings that affect learning results, two types of meaning – concrete and abstract meanings – have been distinctly identified and studied for their effects in learning (e.g., Bleasdale, 1987; Romani, McAlpine, & Martin, 2008; Walker & Hulme, 1999). Character learning should also be affected in the levels of

meaning represented in the learner. Therefore, it may be assumed that when meanings are more easily represented (e.g., concrete meanings), character forms representing the meaning should be easier to be acquired or encoded into memory. In contrast, difficulty of meaning representation (e.g., abstract meanings) may require more advanced learning processes or various strategies. Previous studies in the effect of concreteness in character learning seemed to corroborate this assumption (e.g., Kuo & Hooper, 2004; Lu, 2011). It was found that pictographs or ideographs, i.e., characters considered to represent more concrete meanings, are much easier to be learned than other types of characters, such as some of the compounds with abstract meanings. The following section briefly analyzes the concrete and abstract meanings in character learning from the semiotic perspective. Furthermore, recent discoveries of the brain mechanisms of concrete and abstract meanings are provided for a glimpse at the underlying mental processes in the depth of meaning.

Levels of deep structures: Concrete vs. abstract meanings. Studies of concreteness and abstractness have a long history in psychology and philosophy. Recent empirical research supported this dichotomy (Skippper & Olson, 2014). In terms of language learning, extensive research results showed that concrete concepts are easier to learn, use, recall and recognize (Bleasdale, 1987; de Groot, 1989; Howell & Bryden, 1987), while abstract concepts are relatively difficult. Investigations of concrete concepts focused on concrete entities or events that can be perceived directly; e.g., objects, tools, buildings, animals, foods, musical

instruments, etc. Abstract concepts include those related to cognitive processes, emotions, social activities, and those that describe intangible experiences (see Wilson-Mendenhall, Simmons, Martin, & Barsalou, 2013).

Correspondence to the dichotomy between concrete and abstract meanings, Pierce's semiotic theory renders indexical and symbolic signs more abstract than iconic signs, and indicates that abstract meanings were originally evolved from concrete meanings in a sequence of firstness, secondness and thirdness of the three types of signs (see Chandler, 2007; Peirce, 1931-58). Of the three signs, symbols serve to synthesize and crystallize abstract meanings so that thoughts become stable and clear (Vygotskiĭ, 1962). In the theoretical field, distinctions between concreteness and abstractness also give rise to *embodied theories* which anchor cognition in human body perception and action (Scorolli, 2011). In light of the embodied nature of basic Chinese characters, the theory is also suggested as a grounding theory in Chinese character learning at the beginning level. Lu (2011) applied the body-image-action interaction method in this theory to English speakers without a Chinese language background to learn pictographs; and, the results showed significant difference between the experiment group and the control group. In other words, the research suggested that taking advantage of the concrete level of meaning in basic character learning might be a plausible consideration in teaching.

Recent neuroimaging studies may have shed light on the mechanisms of processing concrete and abstract concepts. Providing evidence for the embodied

theory, neuroimaging research found that meanings are mostly grounded in sensorimotor features (Pulvermüller, 2013; Wilson-Mendenhall et al., 2013) as well as in affective systems (ibid; Kousta, Vigliocco, Vinson, Andrews, & Cel Campo, 2011) for both concrete and abstract concepts. While concrete concepts are more model-specific, anchored in sensorimotor systems (e.g., vision, olfactory, tactile, and motor), the meanings of abstract concepts arise from distributed neural systems that represent concept-specific content (Barsalou, 2013). A meta-analysis by Wang, Conder, Blitzer and Shinkareva (2010) found that concrete and abstract concepts elicit greater activities in specific brain areas. For processing abstract concepts, greater engagement was found in the verbal system (i.e., language), and for concrete concepts greater engagement was found in the perceptual system (i.e., sensory), likely via mental imagery. These findings led support to a multi-layered semantic system of acquisition of language (see NLLT in the next section). As for the difficulty of processing abstract concepts relative to concrete concepts, a hypothesis was that the weak connections between neural representations of verbal symbols and their multiple sensorimotor instantiations may be the key to the difference (Pulvermüller, 2013). This suggests that abstract concepts may require more layering of the input across time to strengthen the connections among neural networks so as to create the depth of meaning.

In spite of abundant evidence for differential representation levels of meaning or the deep structure, it seems that a stringent distinction between concreteness and abstractness is still open to question, because the research results available did not

mark a distinct line or suggest a continuum among meaning levels. Thus, the traditional way to categorize concrete or abstract words for testing the effects of learning these words might not reveal the conceptual level of a learner in a learning task (e.g., Bleasdale, 1987; de Groot, 1989; Howell & Bryden, 1987). Or, it might be that the studies of this kind have not concerned about differences in individual background knowledge of the conceptual world. As to the meaning representation and acquisition for individual learners, the neuro-semantic framework reviewed in the following section offers a methodology for investigating the development of deep structures in relationship to the surface structures.

Neuro-Semantic Language Learning

The Neuro-Semantic Language Learning Theory (NLLT). Since 1990s, neural imaging studies on human language abilities have drawn the interests of many researchers and educators in the fields of language acquisition and disabilities. These research results have been transferred into classroom applications and educational theories which seek to resolve problems and facilitate learning. The Neuro-Semantic Language Learning Theory (NLLT) (Arwood, 2011), integrating theories and scientific evidence, affords a four-stage model of how a learner acquires language, and suggests ways to consider the meta-cognitive thinking of an individual in the acquisition of concepts. Neuro-semantic language learning, as defined in NLLT, is the acquisition of language across the neurobiological hierarchy of the human learning system: sensory, perceptual, conceptual circuits, and language (i.e., neuro-semantic networks; ibid.).

Turning against the traditional structural approach of learning, the theory emphasizes learning the function of language which represents conceptual thinking. By function, Arwood (2011) means the way that the learning system acquires the meaning or thoughts of cognition for social development as a human being. Of the four stages posited in NLLT, each stage depends on scaffolding from previous stages, with the goal of learning at a healthy cognitive development for a child. The four stages show interface between the learner's brain and the environment (Arwood & Kaulitz, 2014). Specifically, the four neuro-semantic stages are listed below.

(1) Sensory receptors across the body receive inputs according to the input's properties, e. g., light waves and acoustic sounds;

(2) As sensory inputs overlap in multiple forms to create patterns, the cellular structures, mostly at the sub-cortical level, start to recognize patterns, the response of which is typically an imitation;

(3) As various patterns continue to bundle and integrate to form large patterns, the firing of cells moves the patterns along cerebral circuits where old and new patterns connect to create layers of images, i.e., the creation of conceptual meanings;

(4) Concepts or neural circuits of meaning continue to layer deep within cortex across hemispheres to develop patterns of meaning for language function.

The important notion in this theory is that concepts are created through layers

of images within cerebral circuits and then across networks. Auditory concepts can form from acoustic patterns overlapping with visual patterns within auditory pathways (Arwood, 2011; Arwood & Kaulitz, 2014; Campbell, 2008; Stevenson, VanDerKlok, Pisoni, & James, 2011). But, individuals can also form visual conceptualization by overlapping visual patterns. The distinction between concepts and perceptual patterns aligns with the deep and surface structures of language in the way to distinguish visual semantic meanings from auditory forms. Parallel to the principle that the whole is greater than the sum of parts (Arwood, 1983), the NLLT shows that semantic deep functions should come before surface structural patterns.

The central component of the theory emphasizes the role of the learner in the learning process, i.e., how learners use sensory inputs to form concepts to be represented by language. Survey studies showed that about 85 percent of the general child and adult population in the English culture think with a visual system where the visual inputs form visual images or concepts, rather than thinking with the auditory system (Arwood & Kaakinen, 2008; Arwood, 2011). Since the NLLT proposes utilizing learners' strengths to design a strength-based approach, learning concepts necessitates learning the language by accessing the visual pathway for conceptualization for most learners.

Based on the NLLT, various visual methods have been applied to ordinary classrooms for both neuro-typical and neuro-atypical learners to enhance their conceptual understanding. Some of the practice-proved methods were summarized

and incorporated as part of the NLLT for practical use of the theory (Arwood, 2011). These methods can also be used in character learning in all-around ways to design and use visuals that can be better recognized by learners' neural systems. The following section briefly introduces some of the methods which will be used for material design in this study.

The Viconic Language Methods. The Viconic Language Methods (VLMs) consists of a series of learning methods based on the NLLT's key theme, using visual pathways to learn concepts. In order to make auditory English language learning match a visual thinker's way of developing new concepts, Arwood and Brown (2002) developed multiple literacy methods that utilize visual properties of language to facilitate visual language processes of thinking, and to help learners translate visual cognition into auditory English. The commonly used VLMs include cartooning, the use of oral viconic or relational language, hand-over-hand shaping of words, picture dictionaries, context creation by "I stories," adjustment of materials to create more visual context, and drawing concepts in real time (see Arwood, 2011 for details).

Applying the literature about how language is semantic and how most learners use a visual meta-cognition for character learning, it is reasonable to expect that VLMs can also be drawn upon to translate visual concepts into semantic-visual character forms. It may be beneficial particularly for semantically non-transparent characters (i.e., characters showing no direct connection between character meanings and forms), such as symbolic characters and compounds (e.g., 狂/crazy;

a connection between an animal on the left and a king on the right needs to be made in the picture). The idea is that by adding or adapting some visual properties in a picture in alignment with character components or component relationships, CFL learners may find it helpful to translate visual concepts into character forms. Meanwhile the integration of the visual concepts and visual forms may lead to mental elaboration and thus better memory. Among the VLMs, two of the methods for the adaptation of the pictures used in the material design in this study were used.

First, the adjustment of materials to create direct visual features was used to facilitate character learning. The adjustments included reducing and adding visual properties from or onto original pictures (see materials in methodology) to create more direct visual features related to the character denoted meanings. Visual properties included component images (based on semantic features discussed later), contextual images, and arrows to show relational meaning. Component images indicate component meanings (e.g., the image of a radical). Contextual images do not contain component meanings but support component images to create a story, if necessary. Arrows were added to indicate the semantic relationship between images and character components.

Second, the use of oral viconic or relational language method will be used to help learners conceptualize character meanings in relationship with the forms. Oral viconic language is a spoken way to help learners generate mental images for conceptual understanding (Arwood, Kaulitz, & Brown, 2009). In the character

learning, the viconic language content includes the meaning of each component, the relationship of the components to form a story (if there is), and the character meaning in the Chinese culture (if necessary). Verbally introducing the relationships among components may help learners putting words to mental pictures about an event, similar to drawing pictures to indicate the meanings (Arwood, 2011). These mental pictures supported with language can provide greater conceptual meaning for all individuals (Arwood et al., 2009). More of the visual materials and methods used in this study will be described in the methodology section.

The brain mechanisms of semanticity. In the NLLT theory, semanticity is a language function which refers to an increase of meaning for any concept (Arwood, 2011); or, from the semiotic viewpoint, it is a process to map a sign upon another sign to expand the meaning of these signs, e.g., a character meaning developed from its original meaning. In the long quest for understanding the brain mechanisms of thinking and language, empirical and neurological findings in semanticity seemed to be the most fragmentary (see Baars & Gage, 2010).

Traditional psychological and early neurological theories, grounded in a unimodal paradigm, assumed that there are specific brain areas that generate semantic meanings from sensory inputs, distinguished from other regions of the brain that serve for other specific functions (e.g., vision, hearing, olfactory, planning, attention, etc.) (see Ghazanfar & Schroeder, 2006; Klemen & Chambers, 2012). Some distinct regions identified as semantic processing areas have received

focused attention; e.g., the inferior frontal cortex, the superior temporal cortex, the inferior and middle temporal cortex, anterior temporal cortex, and the parietal cortex (Bolger, Perfetti, &Schneider, 2005; Pulvermüller, 2013). Parallel with the unimodal paradigm, the information processing pathway is believed to follow a linear, hierarchical, and mainly feed-forward route (Klemen & Chambers, 2012; see also Twomey, Duncan, Price, & Devlin, 2011). That is, sensory information follows a processing pipeline from the subcortical area, via sensory areas to higher-order temporal, parietal, and frontal integration sites, presumably forming cognitive pathways for cognitive functions such as language. The integration of the information along the feed-forward route is delayed after extensive processing in sensory cortexes (Felleman & Essen, 1991). The rationale of this unimodal assumption was built upon considerable evidence of functional deficits of distinct areas due to brain lesions (Ghazanfar & Schroeder, 2006).

Mounting evidence from recent neurosciences, however, has provided insights in an alternative way. Instead of being processed in specific regions or networks of the brain, semantic knowledge is processed in widely-distributed regions, including all primary and secondary sensory-motor systems (see Gallese & Lakoff, 2005; Ghazanfar & Schroeder, 2006; Klemen & Chambers, 2012; Pulvermüller, 2013). Drawing on evidence from neural and cognitive sciences, Gallese and Lakoff (2005) argued that conceptual knowledge, including concrete and many abstract concepts, is embodied and mapped within the sensory-motor systems which are multimodal in nature, rather than unimodal as structuralists have

suggested. The sensory-motor systems not only afford structures to create conceptual contents, but also characterize the semantic contents in the way that people interact with the environment. Language function or conceptual development is inherently multimodal, grounded in the sense, sight, hearing, touch, motor actions and so on. Within the sensorimotor systems, semantic meanings may be processed in either higher-level multisensory integration regions or lower-level sensory cortexes (Ghazanfar & Schroeder, 2006). This notion parallels the NLLT and supports the use of a conceptual based approach to learning characters. Different types of interactions (e.g., auditory with visual messages) may enhance message binding and perceptual certainty (Klemen & Chambers, 2012). They may also function as the underlying mechanisms of semantic conceptualization.

At the higher-level integration stations, multisensory integration is believed to be the norm (see Gallese & Lakoff, 2005). For example, in the prefrontal areas, research found that the brain responds to both the visual and auditory signals, and activities can be cross-modulated by the two signals, depending on the congruency of the two signals, also known as *synchrony* (Fuster et al., 2000; Ghazanfar & Schroeder, 2006). These findings suggested that an integration of the visual and auditory components occurs in the neurons of the prefrontal areas, corresponding to a previous speculation that the left inferior prefrontal area is involved in making decisions on lexical meanings associated with auditory sounds (Poldrack, Wagner, Prull, Desmond, Glover, & Gabrieli, 1999). This is supportive of a semantic system that is not structurally hierarchical but depends on cross-modal congruency or

synchrony among inputs. Therefore, using semantic-based or meaningful materials for learning provides an external form of congruency with the strengths of the learners' neurobiological conceptual learning.

In the sensory cortices, multisensory convergence is found to occur in the interaction of distinct sensory cortices and even in single neurons (Ghazanfar & Schroeder, 2006). Auditory neurons in the auditory cortex can be modulated by visual inputs (Barraclough et al., 2005). Studies have raised the possibility of audio-tactile and audio-visual interactions in the human auditory cortex (Fu et al., 2003; Giard & Peronnet, 1999; Schwartz et al., 2004). This suggests that the creation of pathways or circuits that include multimodal inputs may well provide the most meaning. Likewise, the neurons in primary and secondary visual cortices were found to receive inputs from the core and belt regions of auditory cortex in feedback projections (Falchier et al., 2002). These studies may explain the mechanisms of conceptual processing from acoustic inputs integrated with visual images that form the traditional auditory processing such as concept naming. So, how well these cross-modal inputs are processed determines how well a learner is able to process auditory inputs. As mentioned earlier, Arwood (2011) has reported that the majority of learners are using a visual meta-cognition rather than depending on a unitary modality of the auditory system for meaning representation.

At the single neuron level, for example, research showed that neurons in the premotor area integrate motor, visual and somato-sensory modalities for the

purpose of controlling actions in space and perceiving peri-personal space (Fogassi et al., 1996; Rizzolatti & Gallese, 2004). Obviously, these neurons do not function in isolation at a cortical level, as multiple layers of processing have to occur prior to the function of neurons at a premotor area of the prefrontal cortex. These studied neurons may be the underlying mechanism for the formation and processing of the motor-related concepts such as *kick, grasp, and run*, providing combined integrated messages of visual motion images and spatial control of the involved body parts (see Baars & Gage, 2010). As the visual-motor sensory cortices receive a substantial amount of sensory input for a neuro-typical person, compared to other sensory modalities, it is reasonable to postulate that visual properties constitute a relatively larger number of components in embodied meanings, and further serve to converge with other sensory properties to form larger meaning units.

The multisensory model poses another question on the prior assumption of the unisensory and modality-specificity model. Besides the linear feed-forward integration, large-scale multisensory integration can only be possible via feedback from the higher-order multisensory integration sites, especially for higher-level conceptual understanding and cognitive tasks. Klemen and Chambers (2012) estimated that there exists a greater abundance of backward rather than forward connections in the brain. That is to say, neural feedback may play a more crucial role in higher-level cognitive functions in terms of integrating new inputs with previously integrated sensory or perceptual units. This provides support to creating meaningful education based on a learner’s own use of concepts so as to provide

such feedback to the learner's system. Ghazanfar and Schroeder (2006) have expressed an expectation of a paradigm shift in cognitive neurosciences from the unisensory and linear-forward integration model to the multisensory and interactive connection model between the lower and higher brain regions and networks.

This sub-section only delineates a panoramic view of the dynamic process of meaning making in the deep semantic structure. The subsection in the following boils down to the organization and contents of the deep semantic structure, proposed in several prominent models evidenced by research findings.

Semantic knowledge and semantic features. As summarized in the last section, semantic meanings are coded as multisensory units distributed across the brain, and meanwhile wired into semantic structures also known as *semantic knowledge*. Broadly speaking, semantic knowledge or concepts are our knowledge about the world, including internal representations about words, things, and their properties (Montefinese, Ambrosini, Fairfield, & Mammarella, 2013). Semantic knowledge is represented (at least partially) in terms of *semantic features.* Semantic features were originally proposed in linguistics for analyzing the existence of semantic properties by using plus and minus signs (Hatch & Brown, 1995). For example, cat is [+animal], [+fur], [+four legs], [+mew], [-bark]. In this way, the word meaning *cat* can be distinguished from the word meaning *dog*. In the neurosemantic framework, semantic features are mainly sensorimotor-based features composed of shape, color, action, taste, and smell (or multisensory units),

which we have acquired from our past experiences (Marques, 2007; Montefinese et al., 2013).

In the distribution framework of semantic structures, a more precise view is that the distribution is not random, but fairly organized corresponding to the layout of sensory modalities and their parallel layout of organized cortical layers of distribution. The distributed semantic representations are anchored in modality-specific categories, depending on specific sensory and motor experiences during concept acquisition (Kiefer & Pulvermüller, 2012). This distributed-categorical view of semantic representations is well established based on the evidence from neurophysiological studies. For example, Gainotti (2004) reported that patients with lesions in frontal and/or parietal motor areas showed impairment in accessing knowledge of artifact objects (e.g., tools). Tranel, Logan, Frank, and Damasio (1997) along with McRae and Cree (2002) found that the visual channel is the most dominant sensory channel for acquiring concepts of natural objects (e.g., animals). The clinical findings were consistent with empirical studies on normal subjects which showed that the visual perception plays a dominant role in the representation of living beings and the somatosensory data of tools (Martin, 2007; Vigliocco, Vinson, Lewis, & Garrett, 2004). These studies were dealing not just with the sensory modalities but with the acquisition of concepts through the senses. It might be that semantic units or semantic features of the same kind may be grouped in adjacent brain areas for encoding and retrieval.

Furthermore, a refined view of modality-specific conceptual representations

holds that conceptual representations are composed of a cluster of semantic features (Kiefer & Pulvermüller, 2012). Semantic features, the meaningful parts of semantic knowledge, constitute organized conceptual representations. Semantic features, including visual, acoustic, action-related, and emotional features, are represented by cortical cell assemblies distributed over sensory, motor, and emotional regions of the brain (ibid.). These features parallel the semantic inputs described in the NLLT. Word meaning, for example, is established by binding the distributed features underlying concept representations for the purpose of language use (Vigliocco & Vinson, 2007). This suggests that words are the products but the lexical unit or concept is based on an underlying semantic acquisition of the sensory features (NLLT).

Although a linear-forward view of formation and organization of a concept is untenable, as discussed previously, the organization and processing of sensory inputs to compose a larger concept seems to need to follow a general timeline through identifiable pathways. Take the visual systems as an example. Clark and Tyler (2014) conducted an fMRI study examining brain activations related to semantic similarities by processing similar and dissimilar objects. The results supported a progressive processing pathway in the ventral vision channel. The ventral stream is thought to play a leading role in the construction of visual categories for forms and colors, as well as in the integration of visual features with other perceptual features in higher visual levels so that people can visually perceive these features. Comparatively, the dorsal stream plays a leading role in the

construction of categories serving to guide action and is mainly integrated with proprioceptive and tactile information (Gainotti, Ciaraffa, Silveri, & Marra, 2009). Along the ventral stream, perceptual activities are followed by the visual properties of objects, which tend to converge, forming the multimodal representations of concepts (referred to as images in the NLLT) along the way to the anterior areas (see ibid.). The anterior medial temporal lobe serves to integrate complex object information with multimodal representations or images and is increasingly engaged in distinguishing fine-grained semantic similarities (Clark and Tyler, 2014). Semantic similarity between objects is captured with semantic features (Tyler et al., 2013). Bozeat et al. (2003) and Lambon Ralph et al. (2003) found that patients with sematic dementia lost more fine visual features than functional attributes. These findings are consistent with Pexman, Siakaluk, and Yap (2013) in that semantic features give rich representations to concepts. In other words, the semantic processing of features (Level 1 of NLLT) creates an overlap of these features (Level 2 of NLLT) to create representations or images of concepts (Level 3 of NLLT) that will ultimately form networks for language (Level 4 of NLLT).

The entire process of semanticity is actually a process of encoding information into the memory system, from which the concept and related semantic features may be retrieved through connections with the semantic networks. The sub-section that follows briefly describes several models of semantic memory along with research findings about the underlying mechanisms.

Semantic memory. Definitions of semantic memory are various. Many researchers equated semantic memory to semantic knowledge, or at least made up of the latter (Montefinese el al., 2013; Yee, Chrysikou, & Thompon-Schill, 2014). Proposals to define semantic memory as a distinct system for storage and organization of semantic knowledge were also widely accepted by theoretical and experimental psychologists (e.g., Tulving, 1972). In psychology, semantic memory has been considered a type of memory independent of specific experiences; or, the storage of the general knowledge about the world such as that characters are made of components called radicals. The traditional taxonomy was to categorize semantic memory into explicit or declarative memory of which information can be recalled and manipulated (Tulving, 1972; Yee, Chrysikou, & Thompon-Schill, 2014).

From a neuropsychology perspective, theoretical models to study semantic memory overlap with the studies of the formation and organization of semantic knowledge. Among them, the sensorimotor and correlated feature-based models, as discussed in the above sections, have been supported with mounting evidence and accepted as the most prominent theories accounting for basic mechanisms of semantic memory. It is believed that these models are also compatible with a modality-specific organization, but do not seem to fit the traditional psychological taxonomy of implicit and explicit memory cleanly (see Yee, Chrysikou, & Thompon-Schill, 2014). Despite some incompatibility, all these theories seem to converge on a notion that semantic memory is a relative long-term memory (Squire,

1987), compared to short-term memory that enters through perceptual (sensory) systems before consolidation (refer to Baars & Gage, 2010 for details about short-term memory). Even for visual memories such as a visual scene, psychological vision scientists found that the long-term memory effect reflects conceptual understanding of the scene which enables it to be categorized at several meaningful levels (Enns, 2004).

Relating to the current study, these theories and findings support the current hypothesis that semantic knowledge of characters may help with character form memorization; that is, integration of the deep structures of a character with the character forms may sustain longer memory of the character so as to enhance students' Chinese literacy. This study's concern is how semanticity or the process of making meaning contributes to long-term memory of newly learned information. Two accounts seem to have provided some insights on this issue, i.e., feature structure differences and semantic contextual relationships.

The *typicality effect* proposed by Woollams (2012) claims that words' feature structure is important to semantic memory. Empirical studies on feature listing revealed that words that generate more features produce faster naming, semantic decision, categorization, and recall (Hargreaves, Pexman, Johnson, & Zdrazilova, 2012; Yap, Pexman, Wellsby, Hargreaves, & Huff, 2012). In other words, as semantic features increase in quantity (i.e., semanticity), the semantic memory is also enhanced, accompanied by less cognitive load for accessing the stored information. According to *differential weighting hypothesis*, semantic features, as

the source of semantic knowledge, are activated at different levels contributing to a concept, while differing in the weighting (Gainotti et al., 2009; Kiefer & Pulvermüller, 2012); that is, the higher the weighting (e.g., more visual features), the easier activation of the concept in the category.

Compared to other sensory modalities, the visual sensory systems are a dominant channel for data perception, encoding, and integration within and across hemispheres. When a meaningful visual input is perceived, it is identified at a conceptual level very fast, and the related information is activated for elaborate processing (Potter, 2012). Part of the reason may be because of rich visual features which are involved in multimodal processing. Multi-modal processing increases the areas of the brain activated for access to meaning. Visual features contain many different types of data, color, shape, type of motion, visual texture, size, etc., resulting in many different types of concepts marked by language. Therefore, memories invoked by visual conceptions were consistently reported to have better memory effect than other formats (e.g., auditory), probably due to richness of the visual features that lead to higher weighting effects.

The weighting of the features may also depend on relevance of the features to a given context; that is, the degree of semantic relationships among features and concepts, for example, relating a radical to a new character. Semantic knowledge that does not directly enter through our senses (e.g., characters are logographs.) depends more heavily on contextual information (Yee, Chrysikou, & Thompon-Schill, 2014). From the current flexibility standpoint of neural activities,

nearby neurons flexibly cluster with each other, and are connected in circuits across modalities, under the influence of specific contexts. This notion is in line with the *Hebbian principle* which claims that cell assembly allows integrating critical features of local representations within distributed neuronal networks (Baars & Gage, 2010). In the neurobiological integration process of cells, circuits, and networks, the context of a concept plays a critical role in the dynamic recruitment of semantic features to form an ever-developing concept. So, when new information, relevant to the contextual meaning, is recruited to existing neural circuits or a concept, the existing knowledge of the concept may carry over to the new features and encode them together into the semantic systems. This kind of neural recruitment may be an explanation for the "arbitrary" connections between signs proposed by Saussure. Likewise, CFL learners may depend on this mechanism to develop their character learning by contextually acquire new semantic features and using them for expanding semantic relationships.

However, Gainotti et al. (2009) concluded that the clustering of these features into concepts vary across individuals, circumstances, and cultures. The connections or recruitments can be difficult especially when contextual information is not congruent to the learner's acquired semantic system. In other words, contextual information mediates in the integration of past sematic knowledge with new features. Nevertheless, whether or not the integration can be successful, or encoding as a semantic memory, also depends on the learner's interpreted relevance of the contextual information with the structures of the semantic

features.

In summary, the neurosemantic framework (NLLT) has set a foundation in understanding the nature of language and the brain mechanisms in language acquisition. Under this framework, semantic meanings are context-mediated mental entities. They are comprised of semantic features which are flexibly recruited, formed, and distributed with modality-specific brain regions through levels of feed-forward and feedback integration processes. This framework, relating to character learning, gives support of acquiring a character through clusters of the semantic features (represented by the components), which may be culturally specific and need to be purposefully incorporated into the learner's existing conceptual networks. This process may be facilitated with character learning that elaborately encodes new semantic features and their composition into the learner's existing semantic circuits with the assistance of contextual relevant information. The next section examines the relationships of semantic meanings and visual images in the case such as character learning, with an emphasis on writing to look at the character encoding process.

Writing as a Visual-Semantic Encoding Process

A normal writing task is fulfilled through a complex chain of mental and physical processes, which involve brain-wide network associations and information representations, and finally the initiation of the physical movement with hand-eye coordination. At the stage of learning to write, the process may be different for learners. The learner must first learn to construct perceptual forms

(sound-letter or visual graphic forms) into patterns, which are then integrated with the semantic meanings acquired earlier. It is generally a bidirectional route of feedforward-feedback interaction. However, instances of writing by children or learners at an early language stage have shown to be mainly focused on the visually feed-forward route (perceptual channels) while failing to associate written forms with the underlying semantic meaning. This phenomenon may be partly due to inadequate mental resources which can be allocated to form-meaning integration, or stems from product-driven teaching approaches (Arwood, 2011). This section first briefly reviews theories and findings in neuroscience related to writing at an early learning stage. The comparisons of visual perception and imaginary for information encoding through writing are later discussed. This section also distinguishes between visual perceptual writing and visual semantic writing, and suggests visual-semantic writing as the goal even for writing at an early learning stage.

Writing at an early learning stage. From the neurosemantic viewpoint, writing is the ability to encode motor patterns into meaningful constructs that others read (Arwood, 2011). Encoding here does not only correspond to memory encoding and formation in a general manner, but is more specific; i.e., to convert perceptual patterns into spoken or written ideas. The gist of the encoding process lies in the semantic integration of learned patterns which may create semantic meanings, so as to facilitate memory storage and retrieval of both the symbol and its underlying meaning. By going through this process, the new link between the

patterns and the conceptual meanings takes on the language function that can be flexibly used as symbolized meaning, and further connects with incoming new information (see Heikkila et al., 2015). In other words, there exists a relationship between surface patterns of writing and their underlying deep meanings where the writing is a representation of thinking.

The social cognitive theory of writing, stemmed from Vygotskiĭ's (1962) social-historical theory of language, is in line with the neurosemantic view that writing demonstrates the interrelationship between thought and language as a communication process between an individual and society (Flower & Hayes, 1981). There are three critical elements of writing: the environment (similar to context of acquiring language), the writer's previous knowledge (already acquired concepts and language or deep structures), and the writing process (surface structures). In foreign language learning, the environment can be referred to as the writer's semantic understanding of who, what, where, when, why, and how they are writing. The previous knowledge includes their functional use of the language and the meanings of the language concepts acquired in their first language (L1) that a second language (L2) or symbols can be mapped onto for the new symbolic system. So then, the learner plans and initiates the writing process based on the first language. Therefore, in this process, foreign language learners are in the center of their own writing, encoding the surface structures from their L1 deep structures which flexibly interact with the surface structures.

Current neuroscience, as discussed earlier, suggests that the use of language, as

generated in writing, is based on multiple points of access (cortical points of networks) across multi-modal representations of past learning, including representations from the visual and auditory networks. Numerous studies (mostly targeted at the first language) have supported the two channels for information representation (e.g., Perfetti & Tan, 1998; Tan, Spinks, Eden, Perfetti, & Siok, 2005; Williams, 2010, 2013). Consistent with these findings, *the dual coding theory* posited that, while the verbal and visual channels are distinct pathways for information representation, the two channels also overlap with each other (Pavio, 1986). The overlap is manifested in the way visual images aid learning (Reed, 2010); and, when verbal codes are activated, images underlying the verbal codes may also be activated. The theory further postulated that integrated verbal and visual codes should predict a better effect on memory compared to the information coded one way (Pavio, 1971; 1986). This postulation is in line with the NLLT in the notion that language which provides contextual relationship information supports mental pictures in the learner's conceptual development (Arwood, 2009).

Applying the notion of distinct pathways to language learning, e.g., the development of writing skills in both L1 and L2 learning, it may be reasonable to believe that a primary pathway for information encoding and retrieval should exist. Chinese character learning, especially for CFL learners, is found that the visual channel or visual-semantic pathway can be the primary and direct pathway for visual form encoding and retrieval, independent of auditory pathways (details will be discussed in the following section). Williams (2010; 2013) pointed out that

Chinese characters may be one of the best means for studying the activation of the visual-semantic route. Comparatively in English literacy, the verbal channel or sound of words might be the primary pathway for encoding and retrieving information (Williams, 2010, 2013).

Numerous studies have supported the prominent visual-semantic effects of information encoding and retrieval (e.g., Heikkila et al., 2015; Lu, 2011; Williams, 2010, 2013). Kuo and Hooper (2004) found that English L1 subjects without Chinese language background were able to base on images acquired from English to encode character forms. Likewise, Lu (2011) also found that motion images significantly enhanced CFL learners' memory of Chinese pictographs (i.e., characters congruent with the referent meaning), presumably due to activated images for the underlying semantic encoding. When comparing semantic and non-semantic memory tasks, Fliessback et al. (2010) found that a subsequent memory effect was present in the right fusiform gyrus. The authors suggested that the analysis of visual object features contributed to the enhanced memory encoding. All these research results indicate that the visual-semantic pathways, relative to the auditory pathways, can be a distinct route for character/word encoding and retrieval; and, may be especially useful at the early learning stage for the learner's conceptual development.

In the overall writing process, writing is comprised of complex mental and physical activities. Even for word/character writing at the beginning level of learning a language, the process involves mental cognitive integration of

perceptual visual constructs with the underlying meanings represented by visual-semantic features or images. Particularly for character writing, the congruency of the logographs and the semantic object establishes a direct route to the integration (Weekes, Yin, Su, & Chen, 2006). The learner writes to encode the perceptual constructs into semantic meanings, through which the new integrated link is stored in longer networks, until this new link is consolidated enough that writing becomes a self-generated imagery process.

Visual perception and imagery in reading and writing. Visual perception is what we see through the physical eyes with the images analyzed by the visual centers of the brain, thereby revealing the place of an object or scene (Baars & Gage, 2010). Imagery is the mental visualization of previously memorized patterns (Mazard et al., 2005). An important characteristic of visual perception is that the brain tends to organize visual features into coherent perceptual groups, also known as Gestalt laws, so that these coherent visual representations can be later matched with an object stored in memory (Baars & Gage, 2010). Imagery is usually generated through stored memory and was found to be largely engaged in mental image transformation (e.g., rotation, size change, etc.) (Belardinelli, Palmiero, & Di Matteo, 2011; Mazard et al., 2005). Reading and writing for semantic decoding and encoding may involve a combination of the two processes. Visual perception and imagery cannot be separated, and may overlap in the encoding of word forms into memory, just like reading and writing largely overlapping and facilitating each other (see Tan et al., 2005). However, visual perception and imagery differ in the

meaning-form integration, which is very limited in the perceptual process (see Irwin, 1993; Johnson, Spencer, & Schoner., 2009). This section distinguishes between reading and writing involving mainly perceptual processes and those involving imagery processes.

As aforementioned, when perceived visual patterns are integrated with semantic meanings, the new link is encoded into long-term memory to be stored as multimodal representations, which can be reactivated or retrieved when knowledge is needed to represent a category (Barsalou, 201). Repeated reactivations and retrievals of the link lead to strengthened encoding within the link or with other links to create more connections. These processes are realized through one of the important brain mechanisms at the cellular level called *long-term potentiation* (LTP), which allows persistent strengthening of synapses through repeated activity. LTP is deemed to be one of the underlying mechanisms for learning and memory (Cooke & Bliss, 2006). Under this mechanism, continuous encodings occur in the dynamic perception and retrieval (e.g., imagery in the visual pathway) processes in reading and writing. So, reading and writing can facilitate each other in the way to strengthen the form and meaning association.

Psychology and neuroscience studies have confirmed the view that visual perception and imagery share common mechanisms and processes (see Belardinelli, Palmiero, & Di Matteo, 2011). In fact, the two processes were found overlapping in many of the same brain areas (Enns, 2004). Therefore, it may be legitimate to speculate that imagery experiences, on most occasions, resemble perceptual

experiences even when a scene or object is not present.

However, research also found that imagery and perception were shown distinct activity patterns (Belardinelli et al., 2011). An fMRI study showed that both hemispheres were engaged in perception and imagery; and, activation was significantly stronger in the left occipito-temporo-frontal network during mental imagery of objects, presumably involving semantic networks (Mazard, et al., 2005). The effect was stronger during imagery than during perception in the left inferior frontal and the left inferior temporal gyrus, suggesting that imagery implicates higher levels of processing probably due to requirements of multiple accesses from the feedback route. Recent research found that imagery tasks could also elicit activation of earlier areas in the visual cortex than perception tasks (see also Cui et al., 2007; Olivetti Belardinelli et al., 2009). The researchers, in line with the view of higher-level processing, concluded that a top-down process occurred during visual imagery. This provides evidence for the belief that mental imagery involves the generation of underlying semantic representations that access visual information stored in long-term memory (Enns, 2004; Kosslyn, 1994). The semantic process must follow a bidirectional route from bottom-up forwarding of the information to then be integrated and given top-down feedback for synchrony in a dynamic and synergistic system (Arwood, 2011). Conversely, the traditional product-driven pedagogy mainly relies on bottom-up perception at lower function level without emphasis on conceptual understanding at higher levels. In this sense, visual imagery is the process that recruits expansive areas of the brain compared to

visual perception, and requires higher-level processing of information with stronger cognitive activities. In other words, acquisition processes manifested by more flexibly retrieving and manipulating mental images are not the same as teaching products for responses.

Images that are integrated with semantic meanings are easier to be memorized and retrieved due to richer encoded information (Heikkila et al., 2015). The *levels of processing* theory describes the depth of mental processing at encoding as an effect in memory recall (Craik, 2002; Craik & Lockhart, 1972). According to the theory, the amount of semantic elaboration increases the strength of memory traces so that deeper levels of processing give rise to stronger traces. Fliessback et al.'s (2010) study found that the depth of processing is not because of longer processing time during the study phase, but attributed to different types of processing (e.g., visuals). This finding also coincides with the dual coding theory that multimodal processing leads to better memory formation and recall. Therefore, the integration between visual and semantic information is assumed to elicit stronger performance compared to other types of integration, because vision is a stronger modality when dealing with semantically meaningful objects (Heikkila et al., 2015).

Comparatively, visual perception is processed at a rather superficial level before the pattern is combined with sufficient semantic information. English word naming and Chinese character copying largely fall in this category. When retrieving visual-semantic representations, the imagery information is loaded on a short-term visual working memory (Johnson et al., 2009), where the information

can be manipulated and transformed due to semantic interpretation (Belardinelli et al., 2011). However, detailed visual perceptual representations formed during visual fixation quickly fade as the eyes receive new visual inputs (Irwin, 1993). It is estimated that the visual working memory is highly limited to only three to four items (Johnson et al., 2009), given limited involvement of semantic processing. With such a limited capacity, most visual information is unable to be transmitted into long-term memory, unless continuous updating or multimodal integration is available.

In summary, visual imagery and perception are two distinct processes, though they overlap in some brain areas or mechanisms. Visual imagery requires multimodal semantic integration with visual forms, and recruits larger cortical areas with higher-level processing activities. The process of imagery is essential to meaningful acquisition of information and multiple neural functions (NLLT Level 3-4). Visual perception requires lower meaningful integration with visual patterns, and limited neural functions with limited memory capacity holding and transforming information (NLLT Level 1-2). Thus, when learning to read and write, the processes should be distinguished between those using the visual-semantic networks encoded with visual images and those only using the visual perceptual processing for pattern recognition and memorization. In the following, some examples of writing strategies and the relevant research results are discussed.

The dual visual pathways for semantic and perceptual writing. As previously mentioned, neurophysiological research found two parallel pathways in

the visual cortex, the ventral and dorsal pathways (Ungerleider & Mishkin, 1982). Commonly known as the “what” pathway, the ventral pathway leads from lower primary visual areas onward to many areas of the temporal lobe. The dorsal pathway, known as the “where” pathway, sends major projections to many regions of the parietal lobe (Baars & Gage, 2010). Norman (2002) summarized the major distinctions in the function and characteristics of the two pathways. Consistent with the research for semantic categorization, his model explains that the ventral stream is important for recognition of detailed static visual properties such as color, shape, and objects, and the dorsal stream for representing spatial information and visually guided behavior. The two pathways demonstrate a different characteristic in the memory effect. In the ventral stream, long-term stored representations become more and more involved, while in the dorsal stream the memory storage is usually limited and short. Although the ventral-dorsal pathways differ in functions and characteristics, there is plenty of cross talk between them (Baars & Gage, 2010). For example, word form recognition and handwriting gestures involve other brain regions in the frontal premotor and motor areas, suggesting that both streams may be engaged in higher order thinking; or, processes of semantic integration of images with perceptual forms.

Writing may happen only in the perceptual system, especially at the early learning stage. Differing from skilled writing which recruits large areas of semantic-visual-motor networks, perpetual writing mainly relies on the working memory and motor systems, with little or limited semantic information being

associated. In the ventral stream, several visual working areas have been suggested as sensitive to word processing, among which the left ventral occipito-temporal (VOT) region has received focused attention. This is where the hypothesized visual word form area (VWFA) is located, and is proposed as the first stage where visual word recognition occurs prior to accessing semantic and phonological information (Twomey et al., 2011). It is therefore considered a crucial area for word orthographic processing, including the logographic forms (Xue, Chen, Jin, & Dong, 2006). Consistent research also renders that the left VOT acts as an interface linking visual form critical for orthographic processing with nonvisual processing in both bottom-up and top-down directions (Devlin, Jamison, Gonnerman, & Matthews, 2006; Kherif, Josse, & Price, 2011; Twomey et al., 2011). This shows that these word form areas do not function in isolation during the processes of writing concepts, but connecting with higher semantic networks for meaningful interpretation (alignment with NLLT level 2-3).

Although traditional accounts state that orthographic information is progressively detected from letters to more complex structures at more anterior parts of the temporal cortex, the VOT is also found to be a full-word processing area if attention is drawn (Dehaene, Cohen, Sigman, & Vinckier, 2005; Kronbichler, Hutzler, Wimmer, Mair, Staffen, & Ladurner, 2004). According to the visual word form hypothesis, this area develops to be especially sensitive to the visual form of language through accumulative learning experience which fundamentally changes the visual brain structures (Xue et al., 2006). The VOT

together with other areas in the ventral stream (e.g., the V4) compose multiple working memory stations that show varied activity patterns in response to different visual inputs. However, their functions in maintaining memory traces are still limited. The visual motor memory distributed mainly in the dorsal stream plays an interacting role in visual perceptual memory. Research showed that VWFA encodes not only the visual shape configuration but also the dynamic aspect of the writing script (Yu, Gong, Qiu, & Zhou, 2011). This result manifests that the static and dynamic systems may be integrated into a network in response to functional tasks, such as handwriting.

Two dorsal areas are noteworthy in their functions in motion perception and planning. The middle-temporal area, or what is commonly called area MT, is an important motion detector (Baars & Gage, 2010). Neurons in area MT are direction-selective and respond well to patterns of motion, meaning that this area can integrate many different motion directions and compute the overall direction of an object (Albright, 1984; 1992). Writing technique depends on these motor detectors to establish automatic visual motor memory of writing symbols such as letters and character components. At an early learning stage, the sequence and the direction codes of writing is thought to play a critical role when the expert VWFA system is not fully developed. However, research of tracing writing strokes has yielded interesting results. Previous research has established that tracing produces a distinct motor memory trace and that this additional source of information aids visual recognition (Hulme, 1979). Gonzalez et al.'s (2011) research in the effect of

tracing and copying word forms showed better results in shape and dimensional accuracy after tracing, but the advantage faded in the retention test relative to copying. This result points to the capacity of perceptual writing or writing of basic patterns, even when multiple techniques are adopted. The finding matches with previously-discussed semantic memory, a long-term memory based on the acquisition of semantic features rather than forms to be traced and copied (Woollams, 2012), or a writing process not representing one's thinking and semantic knowledge.

When skilled readers perceive static visual words, the dorsal areas related to motor handwriting are automatically activated (Nakamura et al., 2012; Katnoda, Yoshikawa, & Sugishita, 2001).[2] The dorsal premotor-parietal network is involved in translating the static forms on paper. One prominent area that was found to be critical is known as Exner's area in the left dorsal premotor cortex, which serves to plan and guide hand movement in writing. This area has been reported to be sensitive to both logographic and alphabetic writing in cursive forms (Nakamura et al., 2012). In the traditional teaching of semantic patterns, the memory of a word form and reproducing an approximation of the form through visual motor memory are deemed to be essential cognitive capacities for orthographic representations (Waterman, Havelka, Culmer, Hill, & Man-Williams, 2015). It is believed that detailed and dynamic orthographic encoding can lead to relative deeper processing

[2] It doesn't mean that the activation of the motor areas during reading leads to conceptual meaning; it might be the way the readers were taught to write with letters or forms.

of the form in visual motor memory, facilitating the visual form memory. Thus, automatic and consolidated memory may reduce cognitive loads and free resources for the development of higher-order language skills (ibid.); e.g., meaning-form integration with images named by language. Waterman et al. (2015) found a clear relationship between visual motor memory and standardized writing scores in school-aged children. Consistent research has verified the positive effect of motion writing in word form storage and even the general literacy skills including reading (James & Engelhardt, 2012; Longcamp, Zerbato-Poudou, & Velay, 2005; Tan et al., 2005). It should be noted that these studies within the traditional teaching paradigm are limited in only looking at the surface forms of the language, while not taking into consideration the conceptual level of the students, especially when the students have fully acquired concepts in their L1.

Given that the ventral and dorsal perceptual systems generate visual motor memory and consolidate orthographic forms, the process is usually long and laborious, in face of a large lexicon inventory of a new language. Teaching of the forms in an additive way requires a large amount of practice of the forms for habituated memory or associated memory. A learning process mainly depending on feedforward information that is temporarily stored in working memory systems is separate from the functional use of the language or concepts of the acquisition language process. Traditional writing methods often view perceptual writing (if structures are correct) as important at the very early stage of literacy skills to build the orthographic system for reading and writing. The perceptual reading and

writing methods may detour learners in deciphering surface forms while bypassing the underlying meanings of the language. A target learning strategy that would consider the underlying meaning of language would be to integrate the visual-motor writing with semantic representations and to set a writing goal based on the functional use of language.

Chinese Character Acquisition and Strategy Use

Though alphabetic and logographic languages differ significantly in the writing systems, converging evidence from neuroimaging studies has revealed that universal brain networks exist across languages. In the meantime, differential processing patterns between languages have also been found, indicating coexistence of the universal networks and language-specific processing patterns. This section summarizes the findings of a culturally shared network and specificities related to Chinese character processing. It focuses on two groups of people, Chinese native speakers and CFL learners, to provide a more comprehensive view toward character representation and acquisition. The research on native Chinese with difficulties of reading and writing is also included as an additional source to understand character representation as well as a reference to the challenges faced by CFL learners.

Universal neural networks and specificities. Traditional assumptions pointed to diverted brain areas for processing alphabetic and Chinese languages, and believed that alphabetic languages are left-lateralized (i.e., auditory areas that are consistent with temporal aspects of English) while Chinese processed

dominantly in the right hemisphere (i.e., visual and spatial areas consistent with spatial properties of Chinese) (Tan et al., 2000). Current neural imaging studies have begun to shed light on this issue, and established a different view from the traditional assumptions. Converging evidence from neuroimaging research of varied tasks has found that languages are mainly left-lateralized disregarding writing systems, and that universal brain networks for the three processing components –phonology, orthography, and semantics – can be identified. Several meta-analysis of interlanguage studies consistently reported specific brain areas that are actively engaged in different types of tasks (e.g., Bolger, et al., 2005; Wu, Ho, & Chen, 2012). As well, these studies also revealed the areas that belong specifically to Chinese or alphabetic languages, and discussed the underlying functions for these specific activations.

Bolger, Perfetti and Schneider (2005) conducted a meta-imaging analysis on single -word reading across writing systems. The authors concluded that writing systems engage largely the same systems of gross cortical regions, with localization interacting within these regions for specific writing systems. In their study, distinct areas were classified into three processing networks[3], within which three distinct regions showing prominent activations were discussed. These regions include the left superior posterior temporal gyrus, the left inferior frontal gyrus, and the left occipito-temporal region, which associate with phonology,

[3] Networks correspond to the 4th level of the NLLT where language represents thinking or concepts of the 3rd level of language acquisition.

phonological lexicon, and orthographic processing, respectively, for both alphabetic and non-alphabetic languages (including Chinese). This study and other studies (Bolger et al., 2005; Nakamura et al., 2012; Wu et al., 2012) have supported the notion of emerging universal networks. Semantic understanding of written scripts, disregarding different surface forms, is operated synergistically through a chain of neural networks.

To summarize the findings of these studies, the occipital cortex is responsible for primary visual processing, the inferior occipito-temporal regions for processing visual word forms, the posterior temporo-parietal for grapheme-to-phoneme conversion, the inferior/middle temporal areas for semantic analysis, the inferior frontal gyrus for phonological and semantic processing, and the precentral gyrus and the insula for speech production (Chen, Xue, Mei, & Dong, 2009; Jobard, Cruivello, & Tzourio-Mazoyer, 2003; Wu et al., 2012). When all of these areas function together, as integrated networks, then language function begins to emerge.

Although these networks have been criticized to be alphabetically biased, studies on Chinese processing have shown that character reading recruits similar cortical networks. Parallel with the universal networks, differential activities also display at specific areas for English and Chinese (Bolger et al., 2005; Wu et al., 2012), especially with regards to the differences in surface forms or patterns of grammar. For example, at the phonological level, it was found that the anterior/mid portions of the superior temporal gyrus responds only to alphabetic languages, a speculation of assembled phonemic processing which is absent in Chinese (Wu et

al., 2012). The left mid-fusiform area (VWFA) shows high activation across all the languages; however, the Chinese written forms involve bilateral activities of this area, comparable to the spatial processing parameters of the fusiform areas. Liu and Perfetti (2003) postulated that the right mid fusiform provides support for intricate character processing. As the left hemisphere detects the functional forms (e.g., radicals), the right hemisphere supports spatial resolution of these forms. These studies suggest that surface forms are language structures that require differential brain areas to process unique structural properties of that language, such as character forms and spatial patterns. The salient differences between English and Chinese in surface structures, as discussed previously, should be reflected in distinct brain activity related to differences in deep semantic properties.

Another area, the left middle frontal gyrus, which shows uniqueness in Chinese character processing, has drawn various explanations, e.g., visuospatial analysis of Chinese logographemes (Tan el al., 2001), coordination of phonological or semantic processing (Tan et al., 2000; Tan et al., 2001), or associating with left premotor areas for a motoric representation or articulatory rehearsal (Kuo et al., 2004). Wu, Ho and Chen's (2012) meta-analysis consolidated findings for the left middle frontal region to be underlying visuospatial analysis of Chinese characters required for each type of research tasks. After all, the characters of Chinese are written in a visual-motor, spatial organization. The strong correlation between the left middle frontal gyrus and the left superior parietal area suggests an extensive

circuit in the dorsal stream that engages in the processing of spatial information during Chinese language tasks (Xiong et al., 2000). The studies further verify that characters represent the spatial processing of the Chinese language. This is very different for alphabetic properties of English (e.g., time properties).

Functional tasks recruit specific areas that wire into distinct neural networks such as those for all languages. These networks synergistically interact with each other during full language tasks and may simultaneously activate other areas when functions increase in complexity (e.g., Liu & Perfetti, 2003). Nakamura et al. (2012) found common brain networks for visual word perception and motor images of handwriting for both French and Chinese in cursive fonts, and that the two systems automatically activated during skilled reading processes. It may be that seeing a “word’ and producing a written form is a visual-motor task in any language. The authors concluded that cultural variability may result in microscopic modulations of the spatial extent and varied amplitude of brain activity within culturally universal brain networks. The authors set their conclusion on a neuronal *recycling hypothesis*. In agreement with the brain *economy principle*, this hypothesis predicts that at a macroscopic level, novel cultural acquisitions are implemented in preexisting networks with minimized cross-cultural variations (Dehaene & Cohen, 2007). Again, it emphasizes the underlying assumptions that language representations tend to remain the same across languages whereas in the surface structures which requires differential interpretations shows observable differences. This supports the semantic function basis underlying all languages

where the surface forms or patterns are learned strongly cultural-biased (NLLT; Arwood, 2011).

Na**tive Chinese speakers and their challenges.** To master several thousands of characters, native Chinese children tend to start their literacy acquisition by rote memorization and repetitive practice of copying and writing (Chan, 1999). A survey study of the characters taught in primary schools showed that by the end of the first school year, native Chinese children should learn 94% of all the basic units of characters (i.e., the logographemes) which appear in the whole six years of instruction (Liu, Leung, Law, & Fung, 2010). Judging from this progress, it is reasonable to estimate that besides accumulative practices, other cognitive strategies and mechanisms should be involved in the learning process.

Apparently, phonological association, with the understood meaning that accompanies the commonly used characters, is an advantage of native Chinese children compared to CFL learners. In other words, if the native children have already learned the meaning of the character based on their oral language acquisition, then they are memorizing a character that represents a concept they have already known. This conceptual knowledge also gives native Chinese children more meaning or context for more connections onto which they can map the forms. Therefore, studies consistently revealed that native Chinese children demonstrate a greater skill to notice signs within signs in the character system than their English speaking peers (Williams, 2010). Pine, Huang, and Song (2003) stated that this appears to be very different from learning strategies employed by

Western beginning readers who often focus on beginning sounds and letter/sound associations from preschool years. Chinese speakers focus on semantic recognition of characters as a learning strategy, as opposed to phonology (ibid.). Sounds and letters in alphabetic languages do not directly carry meanings whereas most of the signs of visual characters do carry basic or categorical meanings in a language like Chinese. This means that the visual components of a Chinese character may give multiple meanings that Chinese speakers recognize based on their conceptual development. This supports the interpretation of component meanings within the character which are absent with the alphabet properties of English for beginning readers. It seems that mapping the recognizable components into a character for meaning-form integration and expansion may be another important strategy for native Chinese children, in addition to phonological access to character meaning.

Shu and Anderson (1997) determined that children who speak Chinese make extensive use of knowledge of character radicals for determining semantic information. In fact, these researchers found that phonological knowledge in a character is rarely used by lower-level learners. The phonology strategy is not shown in a consistent manner until sixth grade. On the other hand, higher-level readers of Chinese tend to have an equal level of representations for semantic and phonetic components, irrespective of their functions (Zhou, Peng, Zheng, Su, & Wang, 2013). In other words, once a Chinese L1 learner acquires a full command of meanings which are mapped into characters (6th grade learners), the learner is able to interpret the different properties of the language to support higher-level

literacy in Chinese.

In the studies of Chinese acquisition by Chinese L1 learners, several issues, as discussed in Chapter One, still remain controversial for the effect of literacy development. In this section, two commonly studied issues are discussed: stroke modeling and reading through the phonetic pathway. As aforementioned, children with Chinese L1 at beginning literacy were assumed to depend on motor memory to recall character forms. Stroke order and finger tracing practices are taught as two essential components for each child to consolidate fine-grained structures of characters and spatial information (though must be integrated with other cognitive functions) necessary for reading and writing. Empirical research supported the importance of the motor memory in building literacy skills (form consolidation) in native children (see Flores d' Arcais, 1994). For example, Yim-Ng, Varley, and Andrade's (2000) study showed that blind-folded Chinese adults failed to make mental images of the character form if spatial or sequential information was left out while finger tracing characters. This provides further evidence that motor-spatial coding is integrated with character forms that lead to the meaning of the character. However, this type of research usually fails to build the connection between semantics and motor construction due to a lack of consideration of how the synergistic brain acquired meaning represented by the symbolic language. Learning atomic structures precedence over the underlying meanings should not be considered adequate for the acquisition and use of the language in extended contexts. Further studies need to be carried out in this aspect.

As literacy skills develop, children with Chinese L1 may employ multiple strategies to decode and encode characters with varied properties (e.g., pictographs are connected with an image). For example, as mentioned previously, when native Chinese children are more experienced in reading, some of them are able to use the partial information from a phonetic component to pronounce an unknown character (Anderson, Li, Ku, Shu, & Wu, 2003). This ability may be attributed to a full command of characters connected with meanings, so then the phonological symbolization started to develop. However, teaching language skills through phonetics does not seem to only apply to alphabetic languages such as English (Arwood, 2011). Looking over the studies across languages, a collection of literature reported two pathways of reading processes, irrespective of language systems including Chinese, i.e., a semantic-orthographic and a phonetic-orthographic pathways (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001; Perfetti & Tan,1999; Weekes et al., 2006). According to the semiotic as well as neurosemantic theories in the language acquisition analysis, orthographic and phonetic forms represent the underlying meaning that is scaffolded from senses to circuits and finally on to networks. That is to say, the phonetic-orthographic pathway does not align with the purposes for reading and literacy at all levels; or, this pathway may be predicted to pose challenges in the Chinese reading and writing.

Based on the dual coding theory, Weekes, Yin, Su and Yin (2006) proposed a triangle model of Chinese reading and writing processes (Figure 2.1). This model

describes three levels of representation: semantic, orthographic, and phonological; all linked via two bi-directional pathways: the semantic pathway and non-semantic pathway. A lexical semantic pathway allows reading for meaning, and writing through access from meaning to orthography. This model describes a direct access from semantic to orthographic representations, in agreement with a study of a patient with phonological impairments (Law, Wong, & Kong, 2006). A non-semantic pathway may also be a direct pathway linking written forms to phonological representations and vice versa (Weekes et al., 2006). This pathway explains occurrences of writing to sounds without meaning, as well as errors made by people with acquired dyslexia and anomia in Chinese character processing (ibid.). The bidirectional pathways emphasize dynamic interactions of orthography, phonology, and semantics during Chinese character reading and writing. Though similar to alphabetic models, Chinese processing manifests its uniqueness in the relative close connections between the semantic information and orthographic representations, as well as the mediating role of the semantic information between the phonological and orthographic representations.

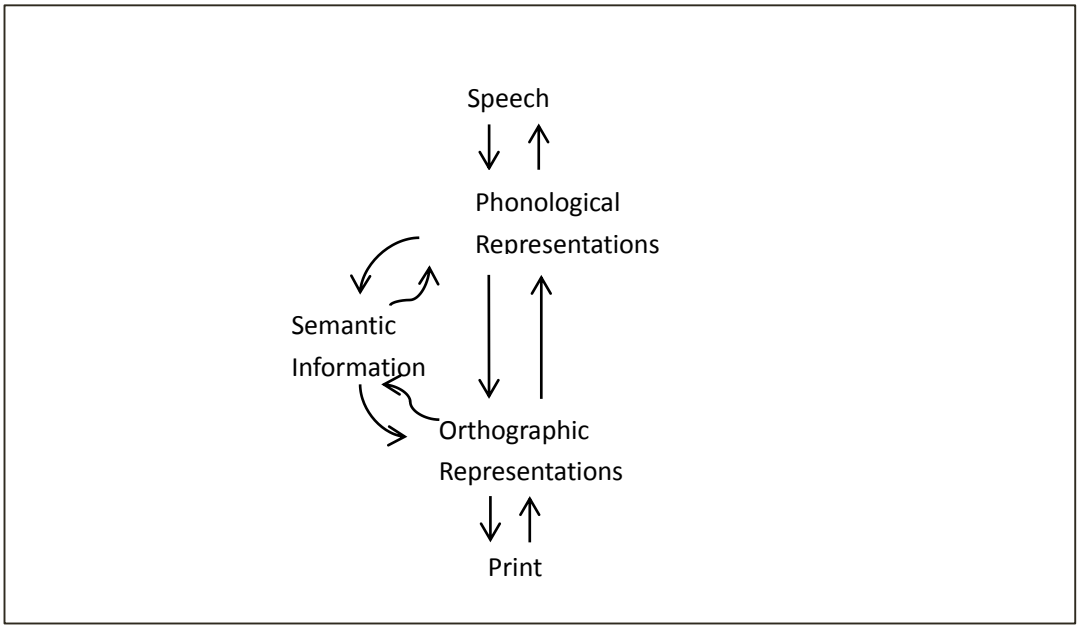


Figure 2.1. A functional model of reading and writing in Chinese. Reprinted from "The Cognitive Neuropsychology of Reading and Writing in Chinese" by B. S. Weekes, W. Yin, I. F., Su, & M. J. Chen, 2006, *Language and Linguistics*, 7(3), 595-617 with permission. Copyright 2006 by Sage Journals.

Studies showed that Chinese patients with dyslexia and dysgraphia commit a majority of writing errors on logographemes, leading to a conclusion that logographemes are the basic functional units of Chinese characters (Leung, Law, Fung, Lui, & Weekes, 2012; Lui, Leung, Law, & Fung, 2010). The sub-lexical items such as logographemes all represent at a same level, disregarding their sizes in characters (Law et al., 2005). This notion is manifested by a large number of substitutions of logographmes, which result in phonological, semantic, or non-character errors. From a case study on a patient with mild dyslexia and severe dysgraphia, Law et al. (2005) discovered that among all the writing errors, semantic components could be substituted, deleted, or added, whereas only substitutions or deletions of the phonetic components were observed. The researchers also found a semantic relationship between the substituted or inserted

semantic components and the intended characters in many non-character responses. They concluded that semantic radicals are directly connected with semantic features; and, when radicals are activated their semantic features are activated simultaneously. These studies indicate that semantic components in Chinese are essential constituents composing the concept of a character, as the icons and indexes that evolve to abstract symbols in Peirce's theory of pragmaticism (refer to the section Deep and Surface Structures in Character Acquisition). Therefore, studying the components of characters, including misusing the components, may be a key to understanding the cognitive processes of character learning and use.

The studies of Chinese with reading and writing difficulties offer implications for general character acquisition development, which follows a hierarchy of stroke-logographeme-radical-character (Law & Leung, 2000). Both the semantic and phonological pathways can serve directly towards lexical access and vice versa. However, the phonological pathway seems not to be a mature pathway at an early literacy level for Chinese children. Therefore, recognition of semantic radicals, as previously discussed, serves as the major strategy for reading and writing and for the acquisition of new characters for these learners. If semantic radicals are directly related to semantic features, using these features to identify and construct orthographic forms might be helpful also for CFL learners. Williams (2010) holds the same view that the semantic radical or pathway seems to hold a "privileged status" in character identification and production. Semantic deep structure appears to be central to understanding Chinese and character writing.

Character acquisition by CFL learners. CFL learners have been a unique group who has drawn growing attention from researchers interested in a variety of areas, including pedagogy, material design, cognitive learning, metacognitive strategies, etc., in second or foreign language acquisition. Some learning issues related to this group of learners have been discussed in the previous chapters and sections. This section mainly focuses on the acquisition process and prominent factors influencing Chinese character learning by CFL learners with English L1.

In second or foreign language acquisition, a robustly studied area lies in the transfer[4] of L1 to L2 (i.e., learn L2 based on L1). The hypothesis is that when the relevant structures of both languages are the same, there are usually *positive transfers*, whereas when the structures are different, *negative transfers* usually occur (see Ellis, 2008). Neuroimaging studies in cross-language differences and similarities, as discussed previously, partially support this hypothesis in that learners benefit from universal language networks to acquire a new language. For example, semantic representations are largely the same across languages, since the environment affords the brain similar sensory inputs which bundle (or integrate with multiple inputs) to form concepts (refer to NLLT in Chapter Two). So, translation of the meaning of the two languages is possible (though some differences may occur). The existing semantic system assimilates linguistic properties of L2 which represents the meaning also in L2. So, L2 learning is

[4] Transfer used in this dissertation refers to a general process of second language acquisition based on the first language, though most of the transfer may happen on the surface structures as the learner maps the surface structures upon the existing deep structures acquired in the first language.

basically an acquisition process of surface structures where transfer mainly occurs (see Ellis, 2008), for example, the phonetic transfer of using English (L1) spelling to encode and access characters. Studies also revealed that the learner is able to analyze the differences between the two languages in the surface structure, and thus adopts accommodation strategies for new inputs (Perfetti, Liu, Fiez, Nelson, Bolger, & Tan, 2007). However, many accommodations such as the spatial organization of Chinese characters do not come naturally. They have to be learned, rather than through L1 transfer, due to distinct spatial arrangements related to underlying character meanings.

In character learning, one difficult accommodation is to align the existing deep structures with the characters which carry their own meaningful features represented mainly by the components. Although semantic representations in the deep structure are similar among people, consistent with the *semantic equivalence hypothesis* by Ijaz (1986), the way to organize these representations or features to constitute a lexical meaning varies across cultures. Therefore, translation of lexical meanings many times confounds and complicates vocabulary acquisition in L2 due to ignorance of cross-cultural differences in word meaning[5] (Ellis, 1997). Semantic restructuring of concepts is often necessary in order to use the L2 vocabulary correctly (Jiang, 2004). Evidence suggested that development in lexical meaning is slow and often incomplete in L2 learning (Perfetti et al., 2007), and that even adult

[5] It should be noted that many of the linguistic studies consider a character equal to a word. However, the literature, as discussed earlier, shows that characters are based on contextual meanings to form concepts which are not equal to English words.

advanced L2 learners are heavily influenced by L1 lexical meanings (Ijaz, 1986). Jiang (2004) suggested that L2 vocabulary acquisition can be viewed as encompassing two dimensions: The status of a lexical entry in the mental lexicon, and the content of the lexical entry, i.e., the enrichment, expansion, and refinement of lexical meanings. In his opinion, learning L2 vocabulary requires understanding the underlying semantic properties of a word (or character), including its core, peripheral, figurative, connotative meanings, its semantic differences from its L1 translation, and other semantically related L2 lexical units. This is probably the most challenging task that many L2 learners face.

The semantic discrepancy between L1 and L2 is in line with neuropsychological studies on the structures of a concept and the role of semantic features, which have been discussed before, and is supported by empirical language research (e.g., Bogaards, 2000; Jiang, 2004; Wolter, 2001). Therefore, the component forms and their configuration, which indicate the underlying meanings, are considered essential to be acquired simultaneously with the character as one entire entity. In a bilingual English-Chinese meta-analysis, Perfetti et al. (2007) found evidence that English L1 speakers accommodate their existing neural network to the demands of Chinese character reading by recruiting neural structures less needed for English words, while Chinese speakers partially assimilate English into the Chinese system. This suggests that character learning requires higher cognitive demands on English speakers compared to English learning by Chinese speakers. In other words, English speakers learning Chinese

must align their neural structures in English with the neural structures required for Chinese (e.g., components representing underlying meaningful features).

Investigations on CFL learners' character learning strategies (including memorization methods and ways coping with instruction requirements) have shown that learners adopt multiple strategies under different circumstances. Sung and Wu (2011) summarized six types of character learning strategies used by beginning-level Chinese learners: practicing naturally, associating, paying attention to the characters, using mechanical techniques (e.g., flashcards), grouping, and paying attention to the pronunciation. Wang (1998) used a 62 strategy inventory to identify strategies used by CFL beginning learners. The researcher found that these learners demonstrated a high-percentage use of some strategies including repetition, memorization, and translation, due to instructions they have received.

Shen (2005; 2008) found that CFL learners at varied Chinese levels are able to use the orthographic knowledge-based cognitive strategies to encode characters. These strategies include component knowledge transfer, combining the semantic information of each constituent character, deriving word meaning based on the semantic information of constituent character, applying knowledge of parts of speech, and using contextual information. These studies are largely in compliance with Williams's (2010; 2013) studies on high-intermediate CFL learners. The results showed that the high-intermediate learners were able to transfer the knowledge of semantic radicals to new characters, but the difference is that their phonetic component transfer was still unreliable. Another study on adult CFL

learners, with many of them having lived in Chinese speaking areas, demonstrated that the participants employed orthographic, phonological, and semantic information of components encoding new characters in a manner largely similar to that of native Chinese readers (Tong & Yip, 2015). These studies may generally reveal development of strategy use for character acquisition among CFL learners of different backgrounds. Again, these studies show that CFL learners at the beginning to intermediate level have not acquired full knowledge to make connections about structures between English and Chinese. At this level, they are still using the acquisition of concepts or semantics to support the surface forms.

As to the factors that influence CFL learners' use of strategies to learn characters, Sung and Wu (2011) examined three independent variables including gender, home background, and previous foreign language experiences. Results showed significant interactive effect between gender and home background (e.g., Chinese heritage) on strategies of using "mechanical" techniques (e.g., using flash cards). Generally, the females tended to use mechanical techniques more than the males with the same background. The results also found significant effect among gender, home background, and previous foreign language learning experiences on strategies of paying attention to the characters. Generally, the males, with the Chinese background who had not studied any other foreign languages, used the strategies of paying attention to characters most frequently compared to all other groups.

The data about the influence of independent factors on character learning are

scarce; however, from the existing studies, it can be suggested that, consistent with previous findings, CFL learners' character learning processes are rooted in their cultural backgrounds and past learning experiences (e.g., English L1) (Kuo & Hooper, 2004). The strategies they use to decode and encode characters may also develop from the L1. As Williams (2010) has found, at a certain learning phase, CFL learners may not use important strategies necessary for character learning (e.g., radical recognition); or, they have not sufficiently developed a viable learning strategy. It is worthwhile exploring the strategies CFL learners use necessary to learn Chinese characters, as well as the factors that may affect their learning. The imagery-based encoding strategy (IBES), which can be taken as a direct semantic pathway for semantic alignment with character meanings and hence meaning-form connections, deserves serious studies on the cognitive underpinnings of character learning by CFL learners. The following section summarizes the findings of IBES use by CFL learners to connect meanings to the surface forms.

The imagery-based encoding strategy by CFL learners. To connect meaning to orthographic forms, L2 learners may use multiple strategies to make the connection (see Sung, & Wu, 2011). Among commonly used memory strategies, imagery and semantic mnemonic strategies have shown a relatively higher positive effect in long-term L1 and L2 vocabulary learning, associating meaning with the form (see Wang & Thomas, 1992; Ellis, 1997). The NLLT points to images as the cognitive components of semantic units or a means of thinking represented by language symbols such as words or characters (Arwood, 2009, 2011). Especially

for the Chinese character, basic scripts or semantic components were the representatives of the mental images of the world (or the icons in Peirce's theory). Recent neuroimaging research also corroborated the use of visual images to learn and encode information into memory. It is believed that visual imagery is generated from a semantic representation that accesses stored visual information in long-term memory (Belardinelli el al., 2011; Kosslyn, 1994). As a matter of fact, the literature reveals that the imagery-based encoding strategy (IBES) was used to study memory effects in various methods and at different levels.

Generally, the methods of using IBES to memorize new information can be divided into deep semantic methods and shallow cuing methods. The deep semantic methods, examining conceptual understanding of a character, may include drawing a picture and creating a story to encode a character with its meaning. These methods were found to produce significantly higher memory effects than all other commonly used methods in character teaching, such as visual coding, verbal coding, and translation (Kuo & Hooper, 2004). The shallow cuing methods focus on cued recall of a word based on making images of certain properties of the word, rather than conceptual understanding of this word; for example, using key words or pictorial information to create mental images mediating between L1 words and the relevant characters (e.g., using the word or image of the *sun* as a cue for the character 早 meaning *early*). Traditional mnemonic techniques using IBES are basically shallow cuing methods. Likewise, some studies have yielded consistently positive results in vocabulary learning,

especially for immediate recall (see Wang & Thomas, 1992). These techniques have also shown long-term benefits in association learning. For example, when examining imagery mediation using a keyword method for meaning-form association[6], one laboratory study revealed that L2 learners substantially learned more associations than a control group using the key word method; and, the advantage was maintained up to six weeks later (Atkinson & Raugh, 1975).

Recent empirical research in the study of IBES focused on learners' capabilities of using the strategy, and has shown varied results. The differences of these results, if looking panoramically, may be attributed to the levels of different research tasks and materials that match or mismatch each learner's conceptual level of generating effective images; or, may reflect some of the limitations of imagery in integrating images into the learner's semantic systems. The following discussions address these two possibilities.

When comparing teacher-supplied and student-generated images in character learning, research showed that students gain more benefits if creating their own mnemonics using the visual and semantic information coded in the characters to generate meaning (Wang, 1998). Wang and Thomas's (1992) study on character retention also confirmed this finding. They found that a reliance on teacher-supplied, imagery-based mnemonics (e.g., pictures) can only produce immediate benefits in the classroom; but, long-term advantages may be unreliable.

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[6] The key word method of imagery strategy is to make images of a familiar key word, e.g., Lincoln, to associate it with the L2 target word, e.g., democracy, so that the target word can be better recalled.

These research results opened questions to the cognitive levels of the pictures having in line with the learner's conceptual level. As the creator's meanings of the pictures may many times mismatch the learner's conceptual level in semantic understanding of the contents of the pictures (Arwood, 2009), there is possibility that the learner's mental images for meaning representation may be interrupted or inhibited.

In addition, there were also studies suggesting that IBES might not work very well in certain circumstances. It was reported that some groups of learners may have difficulties in generating mnemonic images, including learners with disabilities (Swanson, 1988) and young children (Carrier, Karbo, and Kindem, 1983). According to some researchers, creating effective mnemonic images may require considerable effort (or practice) and creativity from the learner (Kuo & Hooper, 2004), as well as the way the learner is taught (Wang, 1998). Furthermore, character types were also reported as a factor restraining CFL learners to self-generate effective images. For example, self-generated images were found less effective for characters with abstract meaning than those with concrete meaning (Kuo & Hooper, 2004). Sham's (2002) study on higher-level Chinese L2 readers delved into cognitive load on learning characters. It was found that when there are high cognitive demands for children or adults, imagery from graphics or pictures seems to increase cognitive loads that compete against the memory tasks. In Sham's study result, reading Chinese characters with English translation produced significantly better learning outcomes than reading them with pictures, because

English meaning could also invoke mental pictures similar to the meaning of simple characters (e.g., pictographs). Kuo and Hooper (2004) confirmed this view. In a survey, it showed that the participants formed mental images to associate the characters with the underlying meanings, even without pictorial or verbal cues. Their conclusion was that dual coding; i.e., verbal and visual coding, may occur spontaneously when learning Chinese characters. Pertaining to verbal coding in this research, the researchers meant that the learner created contexts or key words in English to help relate their self-generated images with relational meanings. In other words, imagery techniques (or IBES) in character learning may need extra supports of increased language; that is, semantic contexts or relations.

To sum up, IBES is theoretically and empirically supported in learning and memory. However, the functions of imagery for semantic encoding still leave a large space for in-depth studies. The following sub-section summarizes some limitations of the IBES use for semantic integration in CFL learning.

Challenges of using IBES for semantic encoding in CFL learning. The NLLT theory points out that visual metacognition (i.e., imagery) is a means of learning and thinking (Arwood, 2009). Evidence from empirical studies has also supported the legitimacy of imagery (especially visual imagery) as the functional representation of cognitive processes (Libby & Eibach, 2013). This is also evidenced in the neuroscientific findings, as discussed in previous sections, in the shared properties and mechanisms between visual perception and imagery, the abilities that humans can manipulate visual images to adapt to new inputs, and

most importantly, the overlaps of images and semantic networks for representing meaning (i.e., images are concepts). Thus far, visual imagery has been used as a cognitive strategy in an array of cognitive functions, such as memory encoding and social cognition (ibid.).

Despite extensive use of the visual cognitive function, using imagery for semantic encoding (IBES) has met challenges. For example, as reported in the last sub-section, several questions were open for discussion in using IBES for Chinese character learning. These questions may include the learner's variations of the abilities in using this strategy, the conceptual levels of the learner to generate effective images, and the cognitive loads of imagery processes that compete with other cognitive functions (e.g., relational meanings). Understanding where these challenges come from may help to bring the imagery function (IBES) to its best strength for effective learning outcomes. The neuro-semantic framework (NLLT) that concerns the relationships of the learner's semantic development and visual metacognition should be a feasible model for investigating the relationships between meaning and the imagery function.

The first challenge in using visuals or pictures to learn characters seemed to come from the discrepancy of the semantic systems between the visual creator and the learner. Images, either physical or mental, represent the language, social, and cognitive development of the creator or interpreter (Arwood, 2009). In other words, images or visuals are not equal in meaning because the creator and interpreter vary in their language, social, and cognitive backgrounds. Judging from the four-tier

meaning levels of the NLLT, sensory inputs of visuals (e.g., pictures indicating character meanings) by a CFL learner may not be equally recognized as the same meaningful pattern by the visual creator, due to discrepancies between the learner and the creator's semantic knowledge of the character meaning. Therefore, the learner most probably generates mental pictures of the meanings of the visuals coded with the character forms based on their own semantic system (the second and third level); or, passively memorizes the visual patterns of the picture separate from the character forms without or with limited access to the semantic system for image generation (the first and second level). As a consequence of the semantic discrepancy, if visuals or pictures closely match the learner's semantic system, IBES are more likely to be used as a cognitive function for meaning-form integration and encoding. In contrast, if the visuals or pictures do not match the learner's semantic system, IBES functions for meaning-form encoding might be interrupted or inhibited. This may be the reason why the traditional assumption of picture effects (or picture superiority) has been found unreliable, due to a lack of consideration of varied cognitive levels among individuals when using pictures to learn (Vaidya & Gabrieli, 2000). To best facilitate IBES use for meaning-form encoding, visuals or pictures had better closely match the learner's cognitive level, not based on the creator's semantic system.

Another challenge of IBES use for character semantic encoding may come from the limitation of images to represent semantic meanings which are absent or unfamiliar in the learner's existing semantic system (e.g., the difference between

time and space in English and Chinese), or the concepts which may implicate multiple neural points for multimodal or amodal processing (e.g., the so-called abstract meanings such as *democracy*) ((Libby & Eibach, 2013). As the neuro-semantic theory indicates, concrete meanings (Level 3 of NLLT) are layered and scaffolded from the sensory and perceptual inputs (Level 1 and 2 of NLLT). For concrete meanings to be developed into a symbolic meaning of a language indicating a multifaceted idea (Level 3 to 4 of NLLT), enough scaffolding and connections from meaningful units (or semantic features) to circuits have to be made before the multifaceted idea emerges. Images may act as meaningful features to access points of meaning to a higher-level conceptual meaning; however, images may not represent the entire construct of the idea. In this case, images need to be supported with semantically relational connections (i.e., the semantic circuits), together with other meaningful features, to form the whole construct of a multifaceted idea. It can be inferred that, in this process, the more connections are made among the layers of meanings, the less cognitive load may be demanded for the representation and access to the symbolic meaning (from Level 3 to Level 4 of NLLT). Therefore, there should be more resources and access points to the meaningful features (e.g., mental images) that represent the idea (IBES). This may be a possible interpretation to the cognitive load competition between semantic processing and imagery cognition. That is, when relational connections increase for representing symbolic meanings (i.e., less cognitive loads), the imagery function should be more effective and robust (or images are better to be generated

and accessed); otherwise, the less relational connections (i.e., more cognitive loads), the harder images can be generated and accessed.

In all, visual metacognition for character semantic encoding (IBES) should be considered a direct semantic pathway for character learning compared to auditory association and visual pattern training. However, the challenges in using IBES for character learning can also be predictable. At present, more evidence needs to be gathered for further understanding of semantic encoding of Chinese characters through the use of IBES. In addition, understanding the influences of other related factors on the use of IBES may also be helpful. This dissertation explored CFL learners' ability in using IBES for character semantic encoding, and examined the impact of three commonly-studied factors, including gender, character type, and proficiency, on the use of the strategy in character learning processes.

Chapter Three: Methodology

The last chapter reviewed the literature that provided theoretical foundations for conducting the current research, and meanwhile shaped the research design presented in this chapter. Specifically, the previous chapter analyzed the deep (semantics) and surface (orthographic forms) structures of the Chinese character from a semiotic viewpoint, and discussed the acquisition process of concepts based on the Neuro-Semantic Language Learning Theory (NLLT). The NLLT and corpus literature in cognitive psychology and neuroscience research have provided insights into the connections between deep semantic meanings and surface orthographic forms, and have informed us that when deep structures are aligned with surface structures, acquisition of the surface forms such as in character writing can be facilitated. Therefore, using the imagery based encoding strategy (IBES), a visual metacognitive function, to encode characters with refined semantic representations may be helpful for all Chinese learners, especially for CFL learners whose oral Chinese has not been fully developed. However, it is still unknown whether or not CFL learners at the beginning to intermediate level are able to align their existing semantic knowledge to character-denoted meanings, and how they employ IBES for character semantic encoding.

This study investigated the ways in which adolescent CFL learners at the beginning to intermediate level of Chinese made mental images of character-denoted

meanings to visually encode and retrieve character forms. Three commonly-used teaching methods were under investigation for measuring the use and effect of IBES on character learning among these learners. The three teaching methods were: characters presented with English translation (i.e,. English), characters presented with pictorial presentation (i.e., pictorial), and characters explained by verbal instruction (i.e., verbal). In detail, this study examined whether or not a commonly-used teaching method resulted in a higher employment rate of IBES and led to better performance in character writing as well as reading. Additionally, this study also examined whether the three factors, i.e. gender, Chinese proficiency, and character type, had impacts on the participants using the strategy.

Research Design

This research used a within-subject experiment design carried out in four phases, i.e., the pre-study phase, main study, one-week follow-up test, and four-week follow-up test. Quantitative data, together with supplementary qualitative data, were collected over the four phases before or after the participants learned twenty-four new characters on computer in the three teaching methods in the main study.

The quantitative data included a baseline survey of the participants' demographic and character learning strategies, writing and reading scores in the main study and follow-up tests, two surveys of IBES use in the main study. The writing scores were triangulated by three independent raters. In order to test the participants' own preferences of using a certain method to learn the characters, the researcher gathered IBES data under two learning conditions in the main study, i.e., a

teacher-select session and a student-select session. The teacher-select session means each of the characters was presented in the teaching method (i.e., English, pictorial or verbal) randomly selected by the researcher. The student-select session allowed the participants to select one their preferred method to learn each character. Two surveys were administered separately in the two conditions, including an Image Making by Teaching Method questionnaire in the teacher-select session and an Image Making by Character questionnaire in the student-select session (see more details in the Measures and Instruments).

The qualitative data came from the participants' character writing scripts (i.e., handwriting shapes), and the commentary responses to the reasons of using a certain method to learn a character. The qualitative data were analyzed and discussed in Chapter Five, Discussion and Conclusion, as the evidence of the participants' cognitive experiences in the IBES use for character semantic encoding.

Participants

Fifty-four students (aged from fourteen to seventeen) from a northwest public high school took part in this study. At the time of the study, the students were enrolled in the first, second, or third-year of a Mandarin class. These students were purposefully selected as the study sample, because the researcher used to teach these classes and had more knowledge of the students' backgrounds of Chinese learning.

All the students were English native speakers and took Chinese as an elective course, three days one week and two days the following week. Each day, the class lasted about ninety minutes. Complying with a district stipulation, the students were

required to complete fifty-five credit hours in a foreign language class each semester for at least two years. At the time of the study, the first-year students had not completed learning characters in a systematic manner (i.e., acquired knowledge of character structures and basic radicals). According to the ACTFL description of Chinese proficiency (ACTFL, 2012), the students' Chinese reading and writing levels ranged from novice low to intermediate low (consistently used in this dissertation as beginning to intermediate level).

All the students took part in the study as an in-class project. Only the students who met the inclusion criteria were included as the participants of the study. The inclusion criteria were: 1) students must have normal or corrected-to-normal vision; 2) students do not have any mental disorder or learning disability (e.g., unable to draw); 3) students' heritage language is not Chinese (or any Chinese varieties) and Chinese was not used at home. Hence, three students were excluded in the study due to their Chinese heritage background. Qualified participants of the study (n=51) were later divided into two groups of a higher or lower character proficiency level based on the score of a character proficiency test administered before the main study (see Chapter Four: Results in detail). Two students withdrew in the main study, and later one student withdrew in the two follow-up tests. Altogether, forty-nine students participated in the main study, including twenty-six males, twenty-two females, and three others (i.e., self-identified neither male nor female). Forty-eight students completed the first follow-up test and the second follow-up test.

Role of the Researcher

The researcher was granted permissions from the school district and principals to cooperate with two classroom teachers from the Confucius Institute while conducting the study. Both the classroom teachers were Chinese natives, assigned by the Confucius Institute Headquarters (Hanban) in China for a two-year Mandarin teaching program in America. One month before the study, both the classroom teachers received instructions from the researcher in a thirty-minute meeting about the study purpose of using IBES to learn characters, and the procedures carried out in the four phases. One week before the study, the classroom teachers received another thirty-minute training from the researcher on character writing evaluations based on a writing grading scheme developed by the researcher (see Grading Analysis of Character Writing). In the main and follow-up studies, the researcher took primary responsibilities at each study phase during class hours, with the assistance of the teachers. The researcher and the teachers were all native Chinese speakers. They independently evaluated students' character writing scores for each study session.

Materials

Three types of materials had been prepared before the study was conducted, including a database of 30 new characters, the learning material used in the main study, and participants' writing samples for writing evaluation.

Character database. A 30-character database (see Appendix A) was created by the researcher, and used to construct the learning material for the main study. Thirty new characters which did not appear in the participants' curriculum book were

selected from five Chinese character picture books (Gu, 2006; Matthews & Matthews, 2007; Tan, 1998; Wang & Zheng, 2005; Zhang, 2005). Along with the characters, the information which was also entered into the database included each of these characters' English translation, pictorial illustration (i.e., picture), and Chinese meaning explanation in text and audio formats. This information was later used as the three teaching methods randomly selected by the researcher for character presentation in the main study. The reason to select 30 characters was due to two considerations: 1) Learning 30 new characters fit the 90-minute time frame for the majority of the participants in the study and was determined based on the learning pace in a sample test (the sample test will be discussed in Methods); 2) 20 to 30 were the average numbers of new characters in a typical lesson in the participants' curriculum book, so the number was considered suitable for the participants' cognitive capacity of learning new characters at their current Chinese level.

The characters selected must meet the criteria for the specified character types, stroke numbers, and frequency counts of their English translation. To study character type as a factor on the use of IBES, the characters selected were either integral ideographs (e.g. 血/blood) or left-right compounds (e.g. 犯/criminal), and evenly divided into three groups: ideographs, compounds with concrete meaning (i.e., the meaning that can be perceived through senses), and compounds with abstract meaning (i.e., the meaning that cannot be perceived through senses). To reduce confounding factors from structural complexity and meaning familiarity to the participants, these 30 characters met another two conditions: 1) stroke numbers

ranged from four to eight, matching the participants' reading level of Chinese (see Lu, 2011); 2) English translation was at a medium frequency scale from 1,000 to 10,000 frequency count (see Brysbaert & New, 2009; Chang et al., 2014).

Considering that some participants had not had the experience of using pictures to learn, and some of the pictures might not effectively deliver meanings of the character, some pictures were minimally adapted. For example, arrows were added between the components of the characters (e.g., left and right components in the compounds) and the relevant picture components. This adaptation was made to help reduce possible interruptions from unrelated components contained in a picture to enhance meaning and character form association. An example chart of the database is shown in Appendix A.

The learning material. After construction of the database, the thirty characters were grouped in there categories aligning with the three character types, and presented three in a block, each from a character-type group, on Google PowerPoint slides. For each character block, the researcher randomly selected a teaching method as the instruction for each character in the teacher-select session. The randomization of the teaching methods was intended to reduce possible impression on the participants of any priority of the methods due to order fixation. In the student-select session, each character was provided with three teaching methods, so that the participants could select a preferred method on their own to learn the character. Between each character block, text instructions for completing the writing and reading tasks and answering the questionnaires were provided on the slides for the

participants to follow the study instructions. The google slides were used as the learning material in the main study.

Character writing samples. The character writing samples (see Appendix B) were collected from the participants' homework and in-class tests. These writing samples were used as the baseline writing data for character writing evaluation in the later writing tests (see the details in Methods, Character Writing Evaluation).

Methods

This section describes the methods used in this study to collect quantitative data (i.e., questionnaires, reading tests, and writing scores), and qualitative data (i.e., commentary responses and writing scripts) that were used for analyses to address each research question. The section also includes information of a sample study which was administered before the main study to obtain feedback on the learning material, tests, and questionnaires.

Character writing evaluation. Previous grading criteria of CFL writing mainly targeted for higher-level writing in discourse, so character errors were basically a simple right-or-wrong judgment (e.g., Kang, 2011; Shi, 2012). Law and Caramazza (1995) adopted a comparative approach to examining cognitive processes of character writing on Chinese patients with dyslexia and dysgraphia. This approach found four types of character writing errors at component level: substitution, deletion, addition, and transposition. The current study referred to this approach as *character writing by component*, and broke down to the stroke level of a character. Based on the comparative approach, this study developed a new

grading scheme for character writing by comparing the participants' writing samples collected from their homework and in-class writing tests. Table 3.1 outlines the grading scheme for component-based character writing evaluated on a 5-point scale. Using the 5-point scale to evaluate character writing, starting from 1 point rather than 0 point, was considered a better match with cognitive processes of character writing, compared to evaluations based on behavioral outcomes, and should be more suitable for the participants' current level of Chinese.

Table 3.1.
Grading Scheme for Character Writing by Component

Grade	Description	Examples
5	Accurate character; or close to accurate character with small errors at intersections or loosely positioned components	 （少）;  （时）
4	The character has **all the components** or all recognizable components, but the positions may be wrong, or there are a small number of deleted or added strokes which do not inhibit identification.	（具）; （等）
3	The character has **combined accurate components** or combined recognizable components while the positions may be wrong or the rest of the strokes are replaced, ill-formed or deleted.	（旅）; （别）
2	The character has **one** accurate component or a recognizable target component, while the rest of the strokes are replaced by irrelevant components, ill-formed or deleted.	（吃）;  （忙）
1	Blank; random strokes or non-target components	 （间）

Note. Components (or logographemes) are the basic written units of a character, higher than strokes. They may or may not carry meanings. The intended characters are in parentheses.

In this grading scheme, each character was analyzed by three categories: stroke, component, and position of the component. Stroke errors were marked by

the degree of comprehensibility to the reader, from a scale of random strokes, to ill-formed strokes, to the number of deleted or added strokes within a component. Component errors include substitution and addition errors, number of target components, and comprehensibility. Position errors were basically right or wrong judgment.

The inter-rater reliability of this grading scheme was later tested to examine the agreement of independent evaluators on the five scales of the grading scheme. Eighty writing scripts (nearly one-fifth of a total of 440 scripts) were randomly drawn by the researcher from the participants' baseline writing samples, and were copied on a sample sheet (Appendix B). The three native Chinese teachers (including the researcher and two classroom teachers) independently rated the eighty scripts based on the grading scheme. Statistical results of the ratings are shown in Table 3.2.

Table 3.2.
Spearman's rho Correlation Analysis of Inter-rater Reliability of Character Writing Evaluation Based on Character Writing by Component Scheme

	Rater 1	Rater 2	Rater 3
Rater 1 n=80	--	.91**	.89**
Rater 2 n=80	.91**	--	.85**
Rater 3 n=80	.89**	.85**	--

Note. **Correlation is significant at the 0.01 level (Two-tailed).

Spearman's rho correlation analysis showed significantly high correlation relationships among the ratings of the three raters, $r_{1,2}$(n=80)=.91, $r_{1,3}$(n=80)=.89, $r_{2,3}$(n=80)=.85. That is to say, the grading scheme had high inter-rater reliability.

The participants' writing evaluations in the later studies in this research were based on this grading scheme. The scores of each writing script by the participants were the average scores rated by the three evaluators.

Measures and instruments. The measures that were designed to collect data consisted of three types, i.e., questionnaires, writing recall tests, and reading tests. Correspondingly, the data mainly measures IBES perceptions (i.e., questionnaires), character form retention (i.e., writing recall tests), and semantic understanding of the characters (i.e., reading tests). In order to address the research questions from different facets, and as well, observe the changes in the four study phases, multiple instruments were used as the measures for data collection. As aforementioned, the IBES use was examined in two questionnaires used separately in two sessions of the main study: a teacher-select session of the methods and a student-select session of the methods. The questionnaire used in the teacher-select session was to gather information about the participants' overall perceptions of IBES use by teaching methods (i.e., Image Making by Teaching Method questionnaire). Differently, the questionnaire used in the student-select session was to gather focused information about the participants' IBES use during learning each character (i.e., Image Making by Character questionnaire). A tabulation of the measures and instruments selected to answer each research question is listed in Table 3.3.

Table 3.3.

Summary Chart of the Research Questions and Measures for Data Collection

	Research Questions	Instruments	Purposes	Appendix#
1	Did any of the three methods, i.e., English, pictorial, and verbal, lead to better performance in character writing and semantic understanding?	Demographic and Strategy Use (DSU) Questionnaire	Baseline data of strategy use	C
		Image Making by Teaching Method (IMTM) Questionnaire	Data of IBES perception and experience by three teaching methods in the teacher-select session of the main study	E
		Image Making by Character (IMC) Questionnaire	Data of IBES perception and experience by character in the student-select session of the main study	F
2	Did any of the three methods，i.e., English, pictorial, and verbal, lead to better performance in character writing and semantic understanding?	Writing recall tests	Writing scripts and scores over four phases	G
		Semantic Judgment Test	Reading scores in the main study and one-week follow-up study	H
		Old-New Character Identification Test	Reading scores in the four-week follow-up study	I
3	Did the three factors, i.e., gender, Chinese proficiency, and character type, affect student-perceived use of the imagery-based encoding strategy?	Demographic and Strategy Use Questionnaire	Independent variable: gender	C
		Character Proficiency Test	Independent variable: proficiency groups	D
		Image Making by Teaching Method (IMTM) Questionnaire	Dependent variable: IBES perception	E

In general, to measure the impacts of the three teaching methods on IBES use (i.e., research question 1), the IMTM and IMC questionnaires were used in the

main study to collect data of the participants' use of IBES to learn characters presented in three teaching methods; comparatively, baseline data of the IBES use by the participants was collected through the DSU questionnaire. To measure the impacts of the three teaching methods on character learning performances over the phases (i.e., research question 2), the writing scripts were collected at each phase for character writing evaluation; in addition, the reading data were collected through the semantic judgment test and old-new character identification test as the measurements of the levels of character semantic understanding. To measure the impacts of three independent factors on IBES use (i.e., research question 3), data from the IMTM questionnaire was used as the dependent variable. The independent variables of gender, proficiency, and character types were nominal data determined through the DSU questionnaire, the character proficiency test, and researcher-categorized character types. The information of the instruments used as the measures for data collection is detailed in the following.

The Demographic and Strategy Use (DSU) questionnaire (Appendix C) was designed by the researcher and pretested in a sample study before the enrollment of the participants. The questionnaire was composed of fourteen closed-ended questions and one open-ended drawing question. It was an instrument not only to select participants but also measure independent variables such as gender difference. The questions about strategy use measured the proportion of the participants' IBES use on a daily basis compared to other strategies (see Chapter Four: Results for detail). The last question asked the participants to draw an animal

and an object from memory. The drawing was considered a reference to their abilities to make mental images of a concept and the related features of the concept. The result of the questionnaire showed that all the participants could draw the animal and object from their memory according to the instruction.

The character proficiency test (Appendix D) was designed by the researcher based on the vocabulary list on the participants' curriculum book. The test selected thirty vocabularies (including single characters and two-character phrases) and asked the participants to write their phonetics and translation. The participants were also required to write five Chinese characters from the English equivalents. The proficiency test was intended to measure the participants' character proficiency at their current level. Based on this test, the participants were divided into a lower-level and a higher-level proficiency groups (see Chapter Four: Results for detail), and the group differences on the use of IBES were evaluated later.

The Image Making by Teaching Method (IMTM) questionnaire (Appendix E) was designed by the researcher based on Wyra, Lawson, and Hungi's (2007) Ability to Make Images Questionnaire. The IMTM questionnaire served to measure the participants' self-perceived performance and experience of image making by teaching methods for encoding and retrieval of eighteen characters during the teacher-select session. The questionnaire consisted of three sections with a total of twelve questions rated on a 5-point scale, from having not at all made any images, not very good images, reasonably good images, good images, to made very good images. The three sections gathered information about the performance of IBES by

teaching methods, respectively, on learning characters, components, and on the reading and writing tests.

The Image Making by Character (IMC) questionnaire (Appendix F) was a researcher-designed character-by-character questionnaire. The questionnaire served multiple purposes to gather information about the participants' preferred teaching methods and their IBES experience in learning each character. It included one closed-ended question for the method the participant selected for learning the character, and an open-ended question for the reasons of selecting the method (i.e., the commentary data). If image making was experienced, the participants rated their self-perceived performance of using images to learn the character on a 5-point scale.

The writing scripts were collected on a researcher-designed character writing sheet (Appendix G). To minimize practice effects, the participants were allowed to write a maximum of four times in boxes for each character. Each character was cued by the teaching method presented in the teacher-select session in the main study.

The semantic judgment test (Appendix H) was one of the researcher-designed reading tests to measure the level of the participants' semantic understanding of the twenty-four characters presented in the main study. Each character was tested by three judgment questions in English word pairs, with the correct answer in each question matching or related to the meanings of the character. Unlike many other semantic judgment tests which were required to judge only the correct translation, this study intended to test the participants' cognitive levels of understanding the characters. Therefore, the three judgment questions were to test three types of

semantic understanding of a character: 1) an English equivalent to the character, 2) a semantic component of the character, and 3) a semantic context that the character can be related to (e.g., between *tear* and *sugar*, the answer for the character 甘/sweet is the latter). Each correct judgment by the participant rated 1 point, and 0 for each incorrect judgment. The total score for the twenty-four characters was 72, 3 points for each character. In order to avoid any semantic confusion between the answer choices in each question, all the word pairs were neither synonyms to each other nor the synonyms to other characters on the learning list.

The old-new character identification test (Appendix I) was previously used by Chang et al. (2015) to test retention rates of character forms. The current research borrowed the method from Chang et al. (2015) to collect data on a recognition rate of the characters presented in the teacher-select session in the main study. Besides testing the recognition rate of previously-presented characters, this test was used as a source to examine the ability of the participants to identify different characters with the same components. The test was composed of thirty-six characters. Eighteen were the characters presented in the teacher-select session, and eighteen were new characters containing shared components with the old characters. The participants were instructed to judge whether the characters were previously-presented characters in this study. 1 point was given to a correct answer, and 0 to an incorrect answer.

The sample study. Before the study was officially launched, a sample study was conducted outside of class on two students who were the former students of the Chinese program. The two students voluntarily agreed to participate in the sample

study. The purpose of the sample study was to obtain feedback on the instruments and determine the time allocation needed for each character during the main study. The two students were orally instructed by the researcher the purpose, procedures, and definition of IBES before the sample study. Nine characters were randomly chosen from the character database, and administered in the same format and procedures of the main study to the two students. The whole procedure took 35 minutes. All the sessions were timed. Based on the time used in this study, a 30-second computer fixation period for character display was set up in the main study to control time allocation for each character.

The two students expressed full understanding (i.e., no difficulties in carrying out judgments in the tasks) of the question items (and answer choices, if there were) in the IMTM questionnaires, the IMC questionnaires, the writing recall test, and the semantic judgment test. Only some adaptions were made on the Demographic and Strategy Use (DSU) questionnaire based on the feedback from the two students. The original version of the questionnaire had six answer choices in the strategy use questions (Questions 13 and 14; Appendix C). The revised version used only five choices (one was deleted) due to unclear boundaries between two choices.

Procedures

This section describes how the study at each phase was administered. Figure 3.1 illustrates the overall procedures of the study in chronological order. For convenience, the four study phases (i.e., the pre-study phase, main study, one-week follow-up study, and four-week follow-up study) were named Phase I, II, III and IV,

respectively. The overall study took seven weeks in the fall semester of 2015. Altogether, the researcher met the participants five times during class hours.

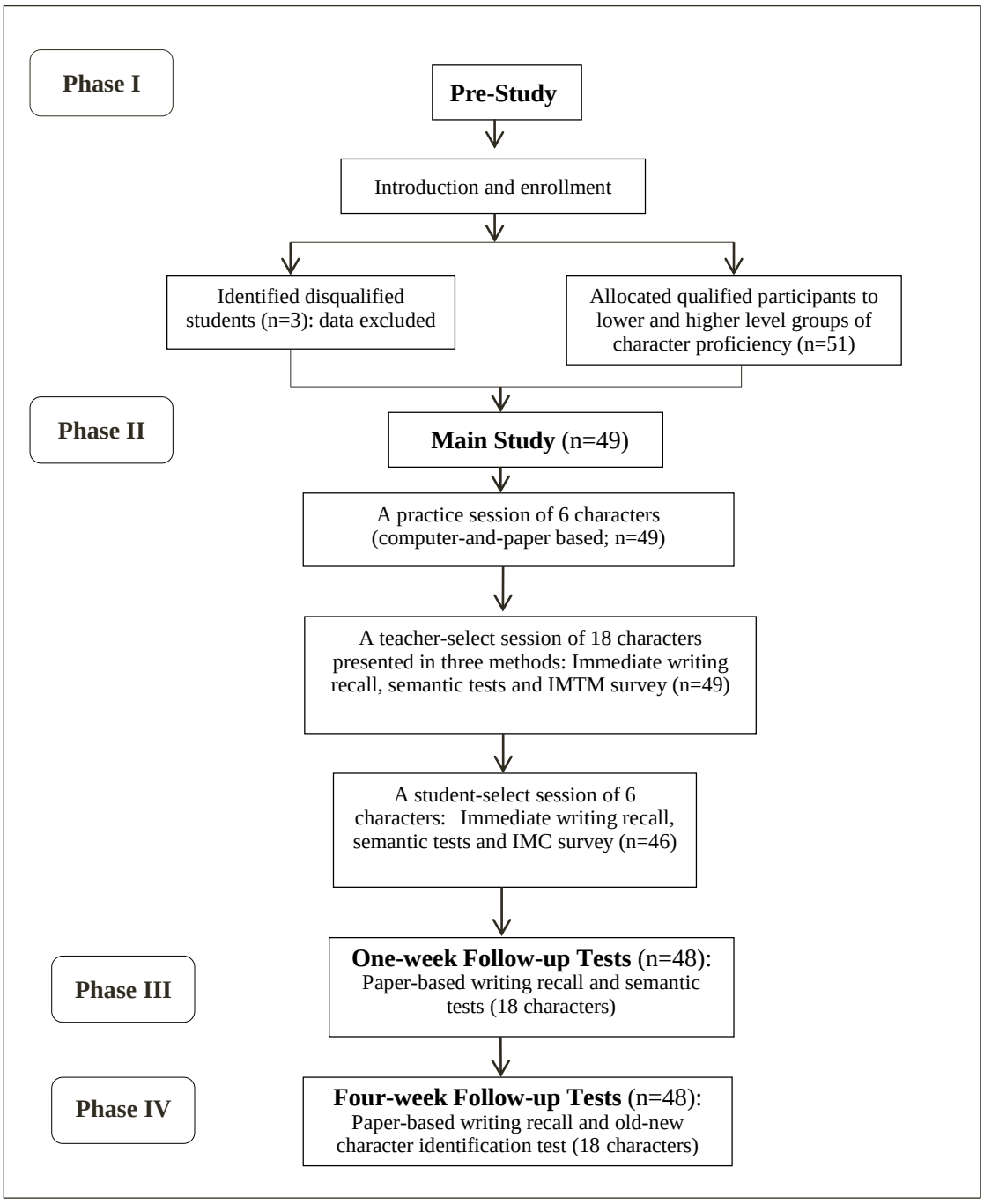

Figure 3.1. Summary and flow of the study procedures. IMTM=Image Making by Teaching Method questionnaire; IMC=Image Making by Character questionnaire

Phase I procedures. The pre-study phase took two weeks, during which introduction of the study and enrolling the participants were completed. In this phase, two instruments were used for enrolling and grouping the participants.

The official introduction took twenty minutes in class in the first week. In the introduction, all the current students in the program (n=54) were introduced to the purpose and procedures of the study, as well as the definition of IBES. The introduction was orally presented by the researcher with the assistance of PowerPoint slides. The definition of IBES was illustrated with a character-picture presentation to show an example of how a mental image may be associated with the character. The students unanimously reported understanding of making mental images of character meanings by giving a hand up to the researcher to indicate understanding; so, the researcher knew that no further explanations were needed for individual students. At the end of the twenty- minute introduction in the first week, the students were given consent forms for parental consent to the study, and asked to bring back the parent signed forms the next week.

The enrollment session was scheduled in the second week in class for about twenty minutes. Signed consent forms were collected by the researcher with the aid of the teachers. All the students completed a Demographic and Strategy Use questionnaire (DSU; Appendix C) and a character proficiency test (Appendix D) during the class session. According to the enrollment criteria, 3 students were disqualified due to their Chinese background. Therefore, the pre-study enrolled 51 students as the participants whose data were used in the study. The participants were

divided into two groups of lower and higher character proficiency based on the character proficiency test (see Chapter Four, Results).

Phase II procedures. The main study was conducted in the third week in a school computer lab over a regular class period of 90 minutes. It consisted of three study sessions, including a practice session of six characters, the teacher-select session of eighteen characters, and the student-select session of six characters. Character learning and task instructions in the main study were carried out on Google PowerPoint 2010. All the tests were in paper-and-pen format. Figure 3.2 illustrates details of character learning and testing procedures of the thirty characters in the main study.

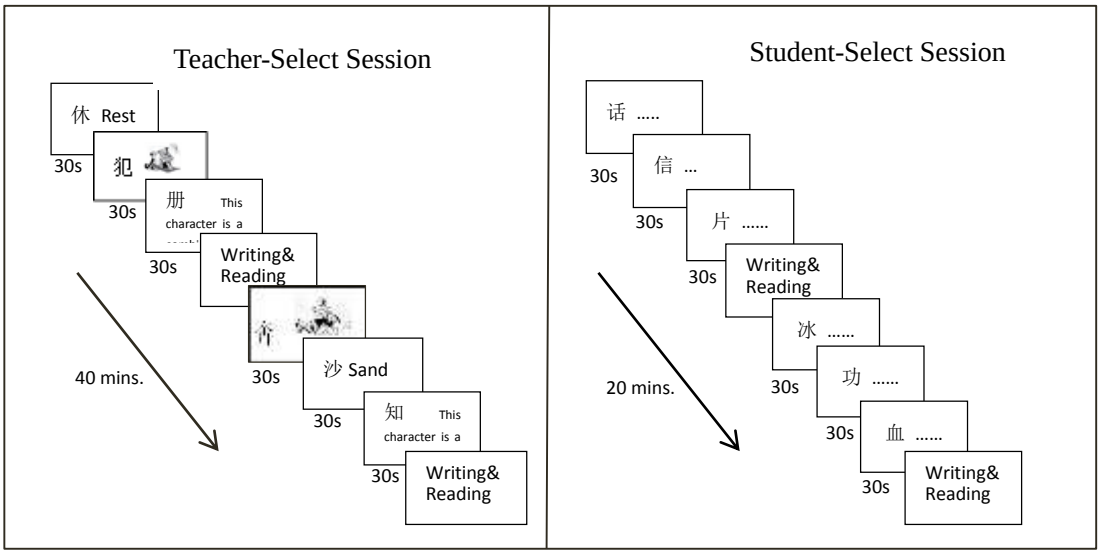

Figure 3.2. Schematic of learning, writing, and reading tests of 24 characters. The teacher-select session included 18 characters in 6 blocks. The learning method was randomly chosen by the researcher in advance. The student-select session included 6 characters in 2 blocks. The learning method was chosen by the participant. All the characters were displayed in 30 seconds (30s).

To familiarize the study procedures and formats, a practice session of six characters was first administered before the teacher-select session with the same

procedures and formats. The teacher-select session took about forty minutes. In this session, eighteen characters were equally distributed in six blocks. Each character was allotted thirty-second learning period, during which the participants were required to memorize the form and meanings related to each character. At the intervals between the blocks, the participants were asked to write the three characters from recall. After the writing task was completed, the participants completed the reading test (i.e., semantic judgment test; Appendix H) for each three characters. The feedback of the judgments was given on the back page of the reading sheet. There was no time limit in the writing and reading tasks. At the end of the teacher-select session, the participants completed Image Making by Teaching Method (IMTM) questionnaire (Appendix E).

The student-select session took about twenty minutes after the teacher-select session. The student-select session was the same as the teacher-select session in the presentation of another six characters (2 blocks) and the test formats (i.e., writing and reading tests). The difference was that the participants could choose one preferred teaching method to learn each character. After learning each three characters in a block, they completed the writing and reading tests for the three characters, and then the Image Making by Character (IMC) questionnaire (Appendix F). In the questionnaire, the participants were asked to report the method they had chosen to learn each character, make comments on the reasons why they chose the method to learn that character, and their experience of IBES during learning that character.

Phase III procedures. The first follow-up tests were administered one week after the main study during class. The tests in this phase were used to measure the one-week retention rates and semantic memory of the characters presented in the main study, compared to the performances in the immediate tests. The one-week follow-up tests included two parts, both administered on a paper-and-pen format. The participants were first required to complete a writing recall of the eighteen characters presented in the teacher-select session, and then a reading test of the twenty-four characters in the teacher-select and student-select sessions.

During the writing recall, the participants were prompted to write each character by the teaching method presented in the teacher-select session. Due to limited time to prepare for the overall twenty-four characters in the main study (six were learned in the student-preferred methods), only eighteen characters in the teacher-select session were chosen in this recall test.

The reading test was the same as the semantic judgment test administered in the main study sessions. The character order and answer choices of each character were randomly shuffled by the researcher before the administration of the test. The purpose was to reduce possible sequential memory of the answer choices from the last recall. The participants were allowed as much time as they needed for these writing and reading tasks.

Phase IV procedures. The second follow-up tests were administered four weeks after the main study during class. Due to a longer interval between the first follow-up tests and the second follow-up tests, these tests were mainly used to test

and compare the retention rates of the characters with the previous tests. In this phase, the participants were first asked to complete a writing recall of the eighteen characters learned in the teacher-select session, and then an old-new character identification test (Appendix I) of these characters. The writing recall was the same as the task administered in the first follow-up tests. The participants were given as much time as they needed for the two tasks.

Data Analysis

This study adopted a mixed method of quantitative and qualitative data analysis. In the quantitative statistical analysis, the independent variables included teaching methods, character types, gender, and character proficiency. The dependent variables were participants' performance scores on character writing and reading tests (including semantic judgment and old-new character identification tests). The software tool, SPSS 18.0, was used to compute the statistical data. Specifically, to address research question 1, statistical descriptive analyses were used to reveal the percentages of the participants employing IBES in learning the characters. To address research question 2, a within-subject one-way ANOVA was run to test the impacts of the methods on writing and reading performances across study phases. To address research question 3, a non-parametric test was conducted for testing the impacts of other variables (i.e., gender, proficiency level, and character type) on the participants' perceived use of IBES.

The qualitative data included the participants' comments about selecting the preferred methods to learn the six characters in the student-select session, and their

writing scripts in the follow-up tests. The qualitative data were used as the supplementary materials for quantitative data analyses to further address the research questions in Chapter Four, Results. For the commentary data, content analysis method was adopted to analyze why the participants selected certain methods, as well as the relationship of the method selection and IBES use (see Merriam, 2009). When analyzing the writing scripts, characters that gained the highest and lowest scores were compared in relationship to the character type.

The content analysis of the commentary data involved opening coding of the phrases pertaining to reasons, purposes, and feelings of the participants while using their preferred method to learn each of the six character in the student-select session. Comments which included similar phrases or messages were categorized; and then, the category theme was summarized in relationship to the reasons and purposes of selecting the methods to learn the characters. This process generated four categories of themes (see Appendix J). The four categories included those comments emphasizing only meaning, making images for meaning, understanding meaning and making images for character memorization, and other reasons. Examples of the four categories, representing the thinking of the participants in character learning, were used as the evidence for quantitative data analyses. The qualitative data were later analyzed, with the support of the literature, to explore the participants' cognitive processes in character learning in Chapter Five, Conclusion and Discussion.

Chapter Four: Results

The previous chapter described the research methodology and design of the study sessions. This chapter provides the results of the data obtained from the four study phases. Measurements for statistical analyses included baseline data of the participant information and their use of strategies to learn characters, the self-perceived rating of image making experiences in the main study, as well as the writing and reading scores in the main and two follow-up studies. Besides the results of statistical analyses of the above measurements, the results from non-statistical analyses (e.g., analyses of the participants' writing scripts and comments) are also presented under the corresponding research questions.

To be detailed about what was evaluated in relation to the research questions, it is better to recall the methods which were used to compare the differences of the measurements. As described in Chapter One, comparisons were made by measuring the differences of the use and effect of the imagery-based encoding strategy (IBES) in three commonly-used teaching methods: Characters presented with English translation (i.e., English), characters presented with pictorial presentation (i.e., pictorial), and characters explained by verbal interpretation (i.e.,verbal). In addition, differences were also compared to test three independent factors in the student-perceived IBES; i.e., gender, Chinese proficiency, and character type.

The chapter is composed of four sections in relation to the research questions. Section 1 presents the baseline data of the participants' demographic and strategy use information, followed by section 2 which presents the results of the participants' perceived use of IBES (research question 1). Section 3 provides the results of the effects of the three teaching methods in the writing and reading tests (research question 2). Section 4 gives details about the effects of the three independent factors in student-perceived IBES (research question 3). Considering that each research question entails multiple variables, sections 2, 3 and 4 are further divided into sub-sections guided by individual directional questions.

Section 1: Demographic Information and Chinese Learning Strategies

Table 4.1 presents a summary of the data generated from the Participants' Demographic and Strategy Use questionnaire (Appendix C) and character proficiency test (Appendix D). Descriptive analyses were conducted on the data. The numbers and percentages of the participants in two Chinese proficiency levels, as well as the frequency (i.e., counts) and percent rates of the choices of the survey questions about gender, character learning background, and strategies used on a daily basis in memorizing characters and recognizing meanings are presented in Table 4.1. These results serve as the baseline data for comparisons of the IBES strategy use addressing research question 1, and factor analyses addressing research question 3.

Table 4.1.

Summary of the Participants' Demographic and Strategy Use

Variable	Category	Count n	Total N	Percentage %
Proficiency	Lower	26	51	.51
	Higher	25	51	.49
Gender	Male	26	51	.51
	Female	22	51	.43
	Other[a]	3	51	.06
Learned to write	Lower	12	26	.46
	Higher	21	25	.84
Methods to memorize new characters[b]	Pinyin	32	51	.64
	English	26	51	.52
	Imagery	18	51	.36
	Form photograph	24	51	.48
	Other	3	51	.06
Methods to recognize meanings[b]	Pinyin	30	51	.60
	English	28	51	.56
	Imagery	9	51	.18
	Form match	21	51	.42
	Other	0	51	.00

Note. [a]*Other* (Gender)=Missing value or choices by the participants who believed themselves to be neither male nor female. [b]*Methods to memorize new characters* and *Methods to recognize meanings* were multiple response questions.

Considering the participants' similar learning backgrounds and uneven number of students in the three classes, this study did not simply assign the participants into different groups of Chinese proficiency based on the number of years learning. They were assigned into two groups of higher and lower proficiency based on a vocabulary test from their curriculum book (Appendix D). Among 51 students who were enrolled and completed the proficiency test, 26 (51%) were assigned to the lower-level group and 25 (49%) to the higher-level group by

the median score. Therefore, the participants were nearly evenly distributed into the higher and lower groups.

As revealed from the demographic questionnaire, 33 participants (64% of all the participants) reported that they had systematically learned to write characters (i.e., acquired some knowledge about character structures and some basic radicals), and 18 (36% of all the participants) reported they had not, which included 4 at the higher level character proficiency and 14 at the lower level. That is to say, a majority of the higher-level group (n=21; 84%) acknowledged that they had received systematic writing instructions prior to the study, while more than half of the lower-level group (n=14; 54%) acknowledged that they had not.

In the demographic questionnaire, the participants also answered questions about their Chinese learning strategies they normally employed to memorize new characters and recall meanings. Among the given five answer choices, the participants were allowed to pick more than one choice according to their own learning experiences. For example, a participant may pick Pinyin and making a mental photograph of the character forms (i.e., form photograph)as the strategies that he or she used to memorize a new character on a daily basis; or, using the English meaning and matching to a memorized character form (i.e., form match) to recall the meaning of the character.

The results in Table 4.2 show that the Pinyin and English strategies were the top two primary methods used in their character learning for both character form memorization and meaning recall. From 52% to 64% of the participants recognized

that they used these two strategies to learn characters. The structural strategy, i.e., form photograph or form match, was the third method they used to learn characters for form memorization (48%) and meaning recall (42%), respectively. The imagery strategy (i.e., making mental images of character meanings) placed the fourth in the learners' choices. It is interesting to note that the participants either did not use this strategy at all, or mostly used this strategy for memorization of character form (36%), whereas very few of them (18%) acknowledged that they used this strategy to recall character meanings.

Section 2: The Use of IBES in the Teacher-Select and Student-Select Sessions in the Main Study

The results in this section address research question 1: *Did any of the three commonly-used methods (i.e. English, pictorial and verbal) result in a higher employment rate of IBES by adolescent leaners of CFL?* Using images to teach characters has been a commonly studied mnemonic method, but the results have not been very consistent. Due to this reason, the pictorial method was selected to compare with the other two teaching methods in this current study. To address the first research question, three sub-questions (questions 1.1, 1.2, 1.3) were generated as the measurements for statistical analysis under two study conditions – the teacher select and student select sessions. The participants' commentary data were also summarized in the sub-question 1.3 to provide further evidence for research question 1.

Sub-question 1.1: Did the participants perceive the pictorial method to be the best method for the use of IBES when learning the 18 characters and the components in the teacher-select session? Table 4.2 summarizes the means, standard deviations, and percent rates of the participants' perceived IBES use in three teaching methods. Statistical significance of the differences among the teaching methods is also presented. The data were drawn from the ratings of the Image Making by Teaching Method questionnaire (IMTM; Appendix E) after learning 18 characters and their components in the teacher-select session.

Table 4.2.

Summary of Means, Standard Deviations, p-Value, and Percentages for the Participants' Perceived Use of IBES by Teaching

Category	Method	M (n=49)	*SD* (n=49)	*p*-value (F)	Percentage[a] %
Character				.002*	
	English	2.90	1.07		.63
	Pictorial	3.65	.95		.86
	Verbal	3.35	1.11		.78
Component				.10	
	English	3.02	1.12		.65
	Pictorial	3.49	1.00		.88
	Verbal	3.31	1.14		.73
General Experience	English	12.08	3.51		.68
	Pictorial	14.00	3.15		.83
	Verbal	13.39	3.59		.78
Average	English	6.24	1.90		.65
	Pictorial	7.05	1.70		.86
	Verbal	6.68	1.95		.76
Overall				.03*	.76
	English-Pictorial			.03*	
	English-Verbal			.19	
	Verbal-Pictorial			1.00	

Note. *The mean difference is significant at the .05 level. [a]Percentages were the percent rates of the participants who perceived making mental images of the character meanings and rated from reasonably good to very good on the Image Making by Teaching Method Questionnaire.

Generally, the results show that 49 participants who took part in the main study rated using IBES the best in the pictorial method for character (M=3.65, SD=.95) and component (M=3.49, SD=1.00) learning, as well as for the general experience (M=14.00, SD=3.15). Statistical significance was found in the effects of methods on the overall perception of IBES, F (49, 2)=3.71, *p*=.03. Among each method, the mean difference reached a significant level between the pictorial and English methods in the learning of the characters (*p*=0.02), but not in the components (*p*=.10). The second method that was perceived to invoke better use of IBES was the verbal method. The English method rated the lowest for the use of IBES. These results also can be seen in the percent rates of the participants who perceived making mental images of the character and component meanings. The highest percent rate was in the pictorial method for component learning (88%), followed by the same method for character learning (86%). The lowest was in the English method for character learning (63%), and then the same method for component learning (65%).

One with greater discernment might argue that using student-perceived rating as the measurement of their experience and quality of image making does not seem to be the most convincing. However, considering mounting evidence of persistent consistency in the reports of subject perception and imagery experiences from empirical and neuroimaging studies (e.g., Belardinelli et al., 2011; Klein et al. 2004; Zwaan, Stanfield, & Yaxley, 2002) and the consistent participant reports of IBES experience across two learning conditions in this study (which will be

discussed later), it is proposed that the perception of IBES use rated by the participants did in large measure reflect their experiences and quality of image making in character learning. Therefore, the percent rates of the participants who rated making mental images of the character and component meanings from reasonably good to very good were considered acceptable to measure the use of IBES.

The results did not show any distinct advantage between the characters and components as to invoking a better use of IBES. A tendency was that teaching methods had an effect on the use of IBES. The more participants who perceived using IBES in that method, the better they felt the quality of making mental images of the character or component meanings. However, an interesting finding was that in the pictorial method, more participants perceived using IBES for component learning than for character learning (88% versus 86%), but the quality of perceived image making was slightly lower (M=3.49 versus M=3.65). As the difference was very small, rather than concluding that characters can invoke better quality of mental images for meaning than components can, this difference may also be speculated to just happen by chance.

Regarding sub-question 1.1 – Did the participants perceive the pictorial method to be the best method for the use of IBES when learning the 18 characters and the components in the teacher-select session – the null hypothesis was rejected. We can at the moment accept that the participants perceived the pictorial method to be the best method for the use of IBES among all the three methods, and this perception

was true for both character and component learning.

Sub-question 1.2: Was there an overall participants' preferred method to learn the 6 characters in the student-select session? Figure 4.1 displays the percent rate differences of the participants' choices of using one teaching method to learn each six characters in the student-select session. The data were drawn from the Image Making by Character questionnaire (IMC; Appendix F) after learning each of the six characters in the student-select session. Figure 4.1, also drawn from the IMC questionnaire, presents the percent rates of the participants' perceived experience or inexperience (i.e., self-report to have not made mental images while learning the character) in using IBES to learn each of the six characters. Of the 49 participants who took part in the main study, 46 of them finished both the teacher-select and student-select sessions. Three didn't finish the student-select session, so their data were not included in the analysis of the student-select session.

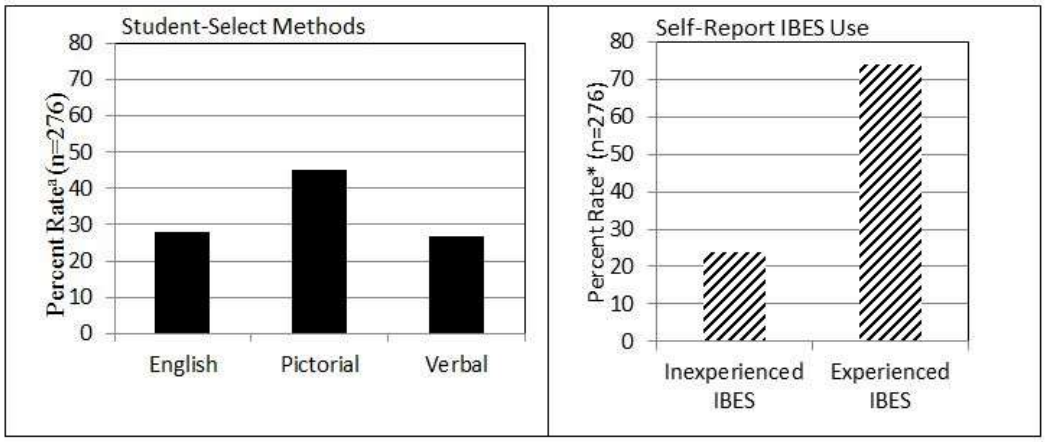

Figure 4.1. Student-select methods of learning 6 characters and self-report IBES Use. [a] The percent rates for the experienced IBES/inexperienced IBES were the rates of the characters checked by the participants who perceived having/not having made mental images of the character meanings during learning 6 characters.

The results show that for the method selected for each character by the 46 participants (n=276), 28% of the selections were made to learn the characters in the English method, 45% were learned in the pictorial method, and 27% in the verbal method. These results further support the hypothesis on an overall preferred method among the participants to learn new characters. The pictorial method was much more used by the participants to learn the 6 characters based on their experiences in the previous study sessions. The two other methods combined made up the rest of the selections, and were almost equal to be selected. Therefore, the result corroborated the previous assumption that the pictorial method seemed to be the overall preferred method for the participants in character learning.

The results of individual character learning in the student-select session showed that 74 percent of the cases on character learning were experienced by the participants to have made mental images of the meanings of the character; and, 26 percent of the cases were reported having not experienced IBES. These results were very close to the average percent of the participants who reported to have made mental images of character meanings on the IMTM questionnaire (76%, see Table 4.2). Though the learning conditions were different, e.g., 18 characters in the teacher-select methods and 6 characters in the student-select methods, the results of characters with controlled variables learned by the same group of the participants in the same environment are parallel. Therefore, it can be concluded that the participants' perceptions of IBES use were consistent across different learning conditions.

Sub-question 1.3: Did the participants select the preferred method because they can use IBES to learn the 6 characters in the student-select session? In this sub-section, the statistical results in the last two questions were compared and analyzed to address sub-question 1.3. In addition, commentary data were summarized to give further evidence to the results from the participants' own points of view. The commentary data were collected from the IMC questionnaire (Appendix F) after learning each of the six characters in the student-select session in response to a commentary question concerning the reasons to choose a certain method to learn a particular character.

The responses in the last two questions indicate that the reason for having the overall preferred method (i.e., the pictorial method) was not directly related to the use of IBES, though IBES was predominantly experienced during learning. This inference was made through comparing the selections of the English method with the verbal method in two different learning conditions. Though the English method (65%) ranked lower than the verbal method (76%) in the number of the participants who used IBES to learn the previous 18 characters in the teacher-select session (see Table 4.2), it was similar with the verbal method (English=28%; Verbal=27%) when the participants chose their own methods to learn the six characters in the student-select session (see Figure 4.1). That is to say, if IBES was the direct cause, the participants should have chosen the verbal method more than the English method to learn the six characters in the student-select session. However, this was not the case.

Additionally, the IBES experience survey results of learning each of the six characters in the student-select session confirmed that IBES use was not a direct reason for the participants to select the methods to learn. The mean scores of the survey questions were computed from the participants' responses to the rating of the quality of IBES use on the IMC questionnaire. Corresponding to the methods they selected to learn each character, the pictorial method (M = 3.39, SD = 1.63) was rated the highest on the participants' perceived quality of using IBES; the verbal method (M = 3.35, SD = 1.88) closely ranked behind the pictorial method; and, the English method (M = 2.56, SD = 2.08) ranked relatively lower than the other two methods. Again, these results were consistent with those revealed in the teacher-select session for the use of IBES by method. The consistent results demonstrate the participants' perceived quality of using IBES to learn characters by the three methods, but cannot justify the reason that the English method was selected the same as the verbal method in learning the six characters. Therefore, the assumption that using IBES was the reason of method selection cannot find support at the moment.

The participants' on-site comments on the reasons that they selected a certain method to learn each character on the IMC questionnaire serves as further evidence to answer sub-question 1.3 (i.e., Was IBES the reason for selecting the preferred method?). 46 participants made their comments on the six character learning. Some frequent words and phrases can be identified, such as *meaning*, *remember*, *images*, *radicals*, and *easy*. These words or phrases were representative of the

participants' thinking as to what was important for them in character learning. Generally, these reasons can be categorized into three groups, in relation to the three methods. Some of the comments with over-general words, such as *remember* and *easy*, didn't mention reasons or strategies for learning, and were included in the fourth group. The three groups were those comments which indicated: 1) knowing the meaning and translation; 2) seeing the images for meaning;3) knowing the Chinese meaning so as to have the images and remember the structure. The categorization and commentary examples can be found in Appendix J.

The comments in the first category predominantly indicated the needs to know meanings directly and quickly, or mentioned that the supplied pictures were hard to understand. This group mainly represented those who selected the English method. For example, some commented, "Because I wanted to know the meaning first." Exceptions, in this category, were the participants who used the English method to focus on the radicals since they were already familiar with many radicals or wanted to make their own images by using the English meaning. The second group mentioned pictures or photos, often followed by an intention to understand the meanings of the character. A typical comment was, "Pictures are easier for my mind to understand." This group mainly used the pictorial method because the participants wanted to have mental pictures to learn, and there were also some who mentioned that they chose pictures because it was hard to make their own pictures. The third group represented those concerned about meanings, images, and character structures. A representative comment was, "Knowing why a

character looks a certain way is helpful." This group mainly used the verbal method, and also included those who chose the pictorial method to use pictures to see the components. The fourth group represented those occasional situations when the participants had no clear thoughts as to how to learn the characters. For example, some mentioned that they just wanted to try a different method. Giving an overview of these commentary data, it can be safe to say that the reasons to choose the methods to learn new characters were various. However, it is obvious that there was a growing tendency in the participants to use IBES as a mediating method for understanding Chinese meanings, or for memorizing the character structures, compared to the baseline data.

To summarize this section, the research question 1 (i.e., Did any teaching method result in better IBES?) may be first settled. The answer is positive under the current conditions. It seemed that the pictorial method resulted in a better employment rate of IBES than the other two methods. However, these conditions are only limited to the participants whose Chinese levels were from beginning to emerging intermediate and to the learning results immediately after showing pictures. Furthermore, the results showed in this section indicated that although the pictorial method was recognized the overall preferred method in character learning by these participants, using IBES to learn was not supported as the direct reason for the preferred method. Commentary data predominantly pointed to knowing more meanings of the characters, either in English or Chinese, as the reason for selecting the preferred teaching method; and, using IBES to learn the Chinese

meanings was gaining growing awareness.

Section 3: **Performance of Writing and Reading Tests by Method across Studies**

The results in this section addresses research question 2: *Did any of the three methods lead to better performance in character writing and reading?* The data were from the writing and reading scores obtained across three phases: immediate tests in the main study, one-week follow-up tests, and four-week follow-up tests. Forty-eight participants completed all the tests after one student withdrew from the follow-up tests. Therefore, the data from 48 participants were included in the analysis. A descriptive analysis offered the means and standard errors of the writing and reading scores that can be compared across three phases. Statistical significance of the effect of method on performance was run through repeated measures ANOVA, and pairwise comparisons of statistical significance were further conducted among the three methods. The research question was addressed through three sub-questions (sub-question 2.1, 2.2 and 2.3).

Sub-question 2.1: Did the pictorial method produce higher scores than the English and verbal methods in the immediate and follow-up writing tests of the 18 characters learned in the teacher-select session? Figure 4.2 presents the means and standard errors of the writing performance by method across study phases. To maintain consistency for the writing across the study phases, only 18 characters in the teacher-select session were included in the analysis. The writing scores were evaluated by three evaluators.

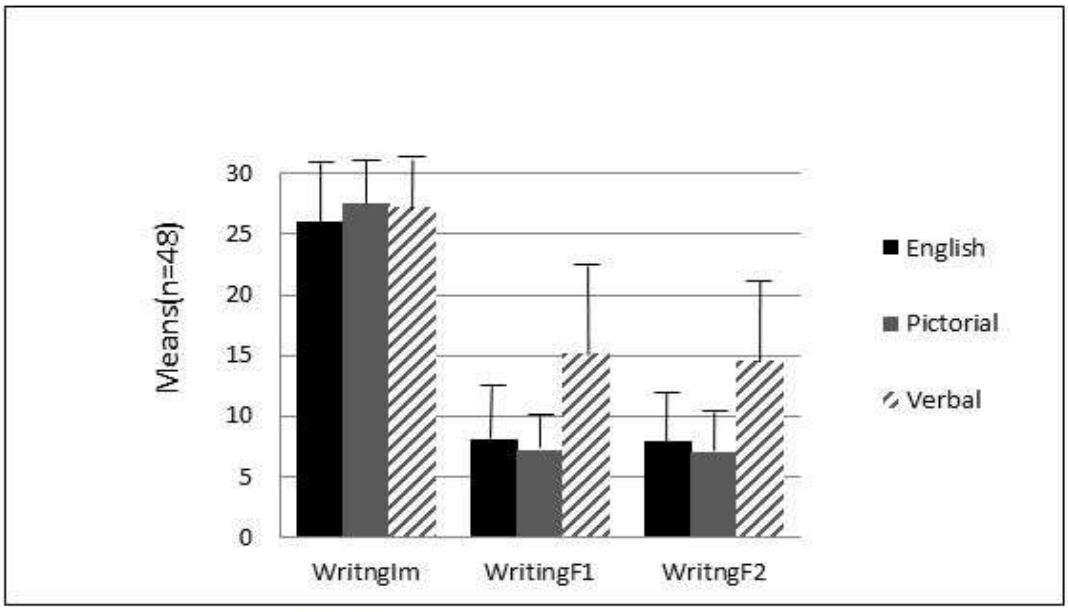

Figure 4.2. Performance of writing across phases for 18 characters shown in the teacher-select session. *Note:* Im=Scores from immediate test. F1=Scores from follow-up test 1(one week); F2=Scores from follow-up test 2 (four weeks).

The result shows that the writing scores generated from the pictorial method achieved the highest among the three methods, averaged 27.49 (SE=.45), in the immediate recall. The verbal method scored closely behind (M=27.35, SE=.46), and the English method (M=25.98, SE=.66) scored relatively lower than the other two methods. These results align with the participants' perceptions of IBES use and their behavioral responses discussed in the last research question, indicating accuracy of the participants' perceptions of their abilities to immediately recall character writing.

However, their perceptions did not seem to apply to the retention tests. The two follow-up writing tests yielded almost the same results in the writing retention rates. The means dropped to 8.11 (SE=.46) and 7.95(SE=.50) in the one-week and four-week follow-up tests, respectively, in the English method, with an average

decrease of 69% across phases. In the pictorial method, the means dropped to 7.23 (SE=.26) and 7.07 (SE=.33) in the two follow-up tests, the highest average decrease of 74%. The verbal method showed the least decrease, with the means hit 15.16 (SE=.82) and 14.57 (SE=.76), a 46% decrease. However, what is interesting to notice are the relatively larger standard errors in the verbal method. The errors may indicate that there may be a greater variability in the participants' abilities to take advantage of the verbal method for character learning and memorization. The inconsistency of the performance in the pictorial method between the immediate writing and two follow-up writing results suggest that the pictorial method worked the best only for character immediate recalls; the effect attenuated sharply in the retention tests.

Table 4.3 shows statistical significance results of the effect of method on writing performance across three phases. Specific information about differences between each method is also presented.

Table 4.3.
Repeated Measures ANOVA and Bonferroni Pairwise Comparisons of the Effect of Method on the Writing Performance across Three Study Phases

		Immediate			Follow-up 1			Follow-up 2		
Task	Method	*df*	*F*	*p*	*df*	*F*	*p*	*df*	*F*	*p*
Writing	Overall	2	5.93	.00*	2	84.65	.00*	2	79.38	.00*
	E-P			.01*			.17			.11
	E-V			.63			.00*			.00*
	P-V			1.00			.00*			.00*

Note. * The mean difference is significant at the .05 level. E=English method; P=pictorial method; V=verbal method.

The results show that methods significantly impacted the participants' writing performance at all three phases, $F(2, 48)=5.93, 94.65, 79.38$, $p<.01$. Comparatively, methods had a higher significant effect in the retention of writing than immediate writing. To be more specific, in the immediate writing recall, there was a significantly different effect between the pictorial method and the English method ($p<=.01$) on the writing performance, but the effect was not significant between the English method and the verbal method. There was no significant difference between the pictorial and verbal methods. However, both the follow-up writing tests showed a significant difference between the verbal method and the other two methods ($p<.01$).

To sum up, the descriptive and significance tests revealed that the pictorial method only had significantly better effect than the English method in the immediate writing recall. However, this advantage dropped dramatically in the two follow-up tests, down to the lowest writing recall rates compared to the other two methods. In contrast, the verbal method showed significantly better effect on character retention than the other two methods, and the effect lasted for three weeks.

Sub-question 2.2: Did the pictorial method produce higher scores than the English and verbal methods in the immediate and follow-up semantic tests of the 18 characters learned in the teacher-select session？ Figure 4.3 demonstrates the means and standard errors of reading performance for 18 characters by each method across two study phases, i.e., the main study and

one-week follow-up study. The reading scores were obtained from the semantic tests used in the main and the first follow-up studies (Appendix H). Considering a different test used in the second follow-up study, the reading scores in the third phase were not included in the descriptive analysis.

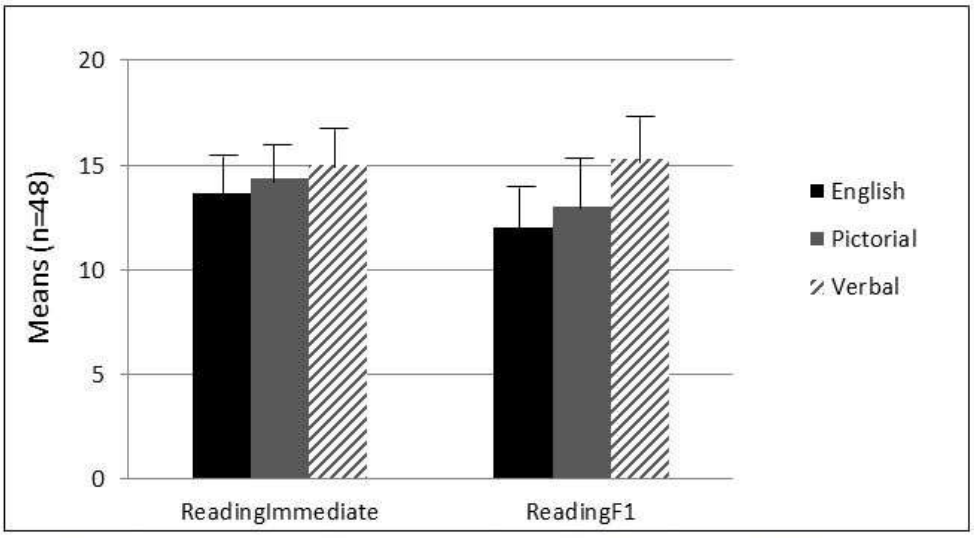

Figure 4.3 . Performance of reading across two phases for 18 characters. Im=Scores from the immediate test. F1=Scores from the follow-up 1 test (one week)

The results in Figure 4.3 show consistent differences in reading performance in the three methods and across study phases. The means in the two phases ranged from 13.67 (SE=.42) to 12.02 (SE=.47) in the English method, an average accuracy rate of 71% with a 12% decrease; and, from 14.38 (SE=.41) to 13.02 (SE=.52) in the pictorial method, an average accuracy rate of 76% with a 9% decrease. The verbal method, interestingly, experienced a very slight increase from 15.02 (SE=.39) to 15.32 (SE=.49), an average accuracy rate of 84% with a 2% increase.

Table 4.4 shows statistical significance results of the effect of the method on reading performance across three phases. Meanwhile, specific information about

differences between each method is also presented. The results in the second follow-up reading test were from the scores of the old-new character identification test (Appendix I) on 18 characters learned in the teacher-select session. The results in the second follow-up test are used to address sub-question 2.3 (i.e., Did the pictorial method produce higher scores than the other two methods in the old-new character identification test?).

Table 4.4.
Repeated Measures ANOVA and Bonferroni Pairwise Comparisons of the Effect of Method on the Reading Scores across Three Study Phases

		Immediate			Follow-up 1			Follow-up 2 [a]		
Task	Method	*df*	*F*	*p*	*df*	*F*	*p*	*df*	*F*	*p*
Reading	Overall	2	8.13	.00*	2	25.31	.00*	2	11.74	.00*
	E-P			.09			.11			.44
	E-V			.00*			.00*			.00*
	P-V			.28			.00*			.00*

Note. * The mean difference is significant at the .05 level. E=English method; P=pictorial method; V=verbal method; [a] The follow-up reading 2 was the results from the old-new character identification test on 18 characters learned from the teacher-select session.

Significance analysis showed that methods also had a significant impact on reading performance in the main and first follow-up tests, F(2, 48)=8.13, 25.31, p<.01. Pairwise comparisons further testified that the verbal method was significantly different from the English method on immediate reading (p<.01), but not significantly different from the pictorial method (p=.28). The English and pictorial methods did not show significant difference during immediate reading (p=.09). However, in the one-week follow-up reading, the verbal method showed significant higher scores than both the English and pictorial methods (p<.01).

Again, similar to the writing results, the reading results rejected the hypothesis that the pictorial method might produce higher reading scores than the other methods. The verbal method actually had significant advantages over the other two methods in character reading performance, even shown from the immediate reading test.

Sub-question 2.3: Did the pictorial method produce higher scores than the English and verbal methods in the follow-up old-new character identification test of the 18 characters learned in teacher-select session? The old-new character identification test served to further examine the effect of methods on character retention rates across phases. In Table 4.4, significance analysis shows that methods had significant effects on performance in this test ($p<.01$). Specifically, the verbal method produced significantly higher scores than the English and pictorial method ($p<.01$). What was surprising was that though the verbal method rated higher than the other methods, the average accuracy rates of the three methods were far lower than the previous reading tests, 31% for English method, 26% for pictorial method, and 38% for verbal method. A previous assumption was that the identification test should be easier than character writing recall, but it was not supported.

Likewise, the results did not support the hypothesis in sub-question 2.3. The pictorial method did not produce higher scores in the old-new character identification test; conversely, the verbal method consistently showed significantly

better effect on reading performance in this test than the other two methods, though accurate recall was limited across methods.

Therefore, to summarize for this section, research question 2 can be settled by combining the results from the three sub-questions. The results showed that methods in general had significant effects on the participants' performance in writing and reading across study phases. Among the three methods, the verbal method demonstrated better effects in both writing and reading performances than the other two methods, and the effects were even more distinguished in the retention tests. Although the pictorial method showed significant effects in the immediate writing recall, the effect attenuated in the retention tests. The English method seemed to have the least advantage in both reading and writing performance.

Section 4: Factor Analyses of the Use of the Imagery-Based Encoding Strategy

This section mainly addresses the third research question: Did the three factors, i.e. gender, Chinese proficiency, and character type, affect student-perceived use of IBES? Before addressing the main research question, a correlation test was run to determine the relationships between the perceived use of IBES and writing-reading performance. Although the purpose of the correlation test was not to reveal the effect of IBES on performance due to uncontrolled conditions in the study, it was believed that the linear relationship between the participants' perceived use of IBES and test results may provide additional

evidence to the participants' ability and performance in employing the strategy to complete character learning and related tasks.

Table 4.5 gives an overview of the association strengths between perceived use of IBES and writing-reading performance. The IBES perception data was based on the participants' responses to IBES use for the learning of 18 characters in the teacher-select session. The writing and reading scores of one-week follow-up tests were used in the analysis. Using the one week follow-up test scores in the correlation test, instead of the immediate test scores in the main study, was due to two reasons: 1) the writing and reading tests used in the one-week follow-up study were the same as in the main study; 2) the writing and reading performance in the follow-up tests were considerably more stable, compared to the immediate tests in the main study which might be heavily influenced by factors such as working memory effects in the immediate recall. Based on the above reasoning, the researcher had confidence to believe that the performance in the follow-up tests should better represent the abilities of student visual-semantic learning.

Table 4.5.
Spearman's rho Correlation Coefficients of the Strengths between IBES Perception and Writing/Reading Performance

Variable	n	IBES	Writing	Reading
IBES[a]	48	--	.33*	.07
Writing[b]	48	.33*	--	.57**
Reading	48	.07	.57**	--

Note. *. Correlation is significant at the 0.05 level (2-tailed).**. Correlation is significant at the 0.01 level (2-tailed). [a]IBES values were the total scores on the *Image Making by Teaching Method* questionnaire. [b] Writing and reading values came from the total scores of the one-week follow-up writing and reading tests.

The results in Table 4.5 show highly significant associations between the writing and reading performances, r=.57, p<.01. That is to say, the higher the writing score was, the higher the reading score, or vice versa; the participants' writing and reading performance was consistent. However, it seemed that the perceived use of IBES only significantly associated with the writing performance (r=.33, p<.05), but not reading (r=.07). Some possible explanations will be discussed in Chapter Five.

Table 4.6 demonstrates the three specified variables and the effects of these variables on the participants' perceived use of IBES. The data about gender and Chinese proficiency were baseline data drawn from the demographic questionnaire and proficiency test (see Table 4.1). Character types were categorical data of the characters learned in the main study, which had been evenly assigned by the researcher based on the character structure and meaning into three categories: compound characters with concrete meanings, compound characters with abstract meanings, and integral ideologies (see Materials in Chapter Three). The

measurement of IBES experience used the ratings from Image Making by Teaching Method questionnaire for the factor analyses of gender and proficiency. For the factor analysis of character type which required disaggregation of data into individual characters, IBES experience used the responses from Image Making by Character questionnaire. A Kruskal Wallis non-parametric test was run to analyze the effects. The three sub-questions (sub-question 3.1, 3.2, and 3.3) related to the three possible factors are addressed one by one.

Table 4.6.

Chi-square Values of IBES Perception Related to Gender, Proficiency and Character Type

Variable	*n*	*df*	χ^2	*p*	η^2
Gender	48(26/22)[a]	1	0.01	.92	.00
Proficiency	49(26/23)	1	1.15	.28	.02
Character Type[b]	276(92/92/92)	2	3.71	.16	.01

Note. [a]IBES values of character type came from the participants' self-perceived rates of image making for each character in the *Image Making by Character* questionnaire. [b]The numbers of males and females, high and low proficiency, and three character types are in parenthesis.

Sub-question 3.1: Did boys perceive more use of IBES than girls? In Table 4.6, the results show that gender difference had the least impact on perceived use of IBES, $\chi^2 = 0.01$, p= .92, $\eta^2 = .00$, an almost zero effect size. The test also showed a mean rank comparison of 24.69 versus 24.26 for boys and girls, respectively. The mean ranks also indicate that there was no difference between boys and girls in the perceived use of IBES for character learning. That is, boys and girls equally perceived the same level of the use of IBES during character learning in the teacher-select session. Up to now, there have no other reports of

gender difference concerning the use of imagery strategy for boys and girls in Chinese character learning.

Sub-question 3.2: Did the students with higher character proficiency measured by the proficiency test perceive more use of IBES than those with lower character proficiency? Table 4.6 also showed that proficiency level of Chinese characters did not have significant effect on the participant perceived use of IBES, χ^2 = 1.15, p= .28, η^2=.02, a small effect size. A detailed look at the mean rank difference found that the lower-level group (22.94) ranked lower than the higher-level group (27.33) in relation to the experiences of IBES use in the teacher-select session. The mean ranks indicate that the participants with higher proficiency may have experienced a relatively higher degree of IBES during character learning in the teacher-select session, but the difference did not reach a significant level.

Something interesting appeared in this subject sample when probing the relationship between Chinese levels and IBES use into the data set. It was found that the students from the second-year class tended to more consistently report their experienced IBES use during character learning (n=25; mean rank=26.56), which was higher than the students from the first (n=13; mean rank=20.73), and even the third-year class (n=11; mean rank=26.50). This might suggest that the teacher's instructions about IBES use in character learning could also be a possible factor affecting students' use of IBES, interacting with the proficiency variable. More of the related discussions will be carried out in Chapter Five.

Sub-question 3.3: Did the ideographs selected for character learning lead to a higher student-perceived use of IBES than the compound characters with concrete meanings and the compound characters with abstract meanings?

Table 4.6 showed the results of the effect of character type on perceived use of IBES, $\chi^2 = 3.71$, p= .16, η^2=.01, a small effect size. This means that statistical significance of the impact of character type was not found among the three types of the characters. Judging from the statistical test results, the null hypothesis can be accepted at the moment; that is, the result did not find significant differences in the effect of character on student-perceived use of IBES. More detailed studies of the effect of character types on perceived use of IBES, including in the mean rank differences or the writing-reading results, also corroborated this conclusion. These results are summarized in the following.

The mean rank study within the three types of the characters learned in the student-select session revealed a surprising result. The mean rank of the ideographs (122.88) was the lowest than the other two types, while the compounds with concrete meanings (143.78) ranking the highest and the compounds with abstract meanings (135.34) the second highest. This result contradicted previous research on the impact of character type on character learning (see Sham, 2002; Wang, 1998). The previous research found that pictographs or ideographs were the easiest for CFL learners to remember the character and meaning because these characters were usually self-explanatory. It seemed that the data from this study showed a different aspect of ideographs in the effect of character learning.

A further study of the writing and reading scores also failed to justify the participants' performance on the ideographs which were assumed to invoke better images. Means and standard deviations were computed and compared on each type of the characters drawn from the one-week follow-up tests. The study revealed consistent results in the compounds, in which the characters with concrete meanings (M=1.51, SD=.59 in writing; M=2.35, SD= .52 in reading) scored higher for each character than compounds with abstract meanings (M=1.34, SD=.48 in writing; M=2.09, SD=.52 in reading) in both the writing and reading tests. However, the results in the ideographs were various, M=2.13, SD=.77 in writing and M=2.29, SD=.60 in reading. The mean scores indicate that the writing of the ideographs scored much higher than all the compounds, but the reading ranked just in between the two types of compounds. Furthermore, a detailed look at the individual ideographs in the writing test showed that the ideographs could either produce the highest accuracy rate (86%) or the lowest accuracy rate (20%), comparing to the average accuracy rate of the compounds 28%. All the above results suggest that character type or categorization of characters was not a factor or direct factor impacting the participants' use of IBES.

To summarize the results for this section, statistical analyses of the three possible factors; i.e., gender, Chinese proficiency, and character type, all showed insignificant effects on the participant-perceived use of IBES. That is to say, there was no evidence in this study to prove that these factors impacted the participants' perceived use of IBES, or at least they were not direct causes. Therefore, research

question 3 (Did the three factors significantly affect student-perceived use of IBES?) was not supported in the current study.

Summary

This study used quantitative methods along with qualitative data to analyze the use and effect of the semantic-imagery strategy (i.e., IBES) among adolescent CFL learners at the beginning to b intermediate levels of Chinese. The results were presented by addressing three research questions and the corresponding sub-questions.

The major findings were three-fold. Regarding the use of the strategy, the participants in general reported the least frequency in using IBES to learn Chinese characters on a daily basis, compared to using English and form memorization. When comparing the three commonly-used teaching methods to learn 24 new characters, the pictorial method was reported the easiest method to employ IBES and learn the new characters. This method was also the most frequently selected by the participants in student-select session. The English and verbal methods were rated similar frequencies, ranking significantly behind the pictorial method to be as the participants' preferred methods. Though IBES were gaining more popularity, the results did not support IBES to be the direct cause of selecting the methods.

When analyzing the effect of using IBES in three teaching methods to learn the new characters, the results were almost reversed from the results of the participants' use of the strategy. Although the pictorial method led to significantly higher scores than the English method in the immediate reading and writing, the

verbal method, which ranked the lowest in the participants' preferred methods, showed significantly better effects in both reading and writing recalls relative to the other two methods, and the memory effect lasted for three weeks through the first to the second retention tests. Interestingly, participants in the second follow-up tests scored much lower in the identification test for all the methods than in the semantic judgment tests. The scores showed consistency with the writing recall test, rather than the reading test.

Factor analyses were also conducted to investigate possible factors that may be involved in the participants' perceived use of IBES. The three factors specified in the research questions, including gender, proficiency and character type, all showed insignificant effects; that is, gender, Chinese character proficiency and character type had no evidence in this study to prove that they were the factors impacting the participants' perceived use of IBES, or at least they were not direct causes. More detailed investigations into the data sets and individual characters may have revealed interesting results. A study of the relationships of the perceived use of IBES and the writing-reading performance showed that writing, rather than reading, was significantly correlated with the use of IBES. Conclusions and their discussions will be provided in Chapter Five.

Chapter Five: Conclusion and Discussion

The previous chapter presented results in relationship to the research questions and corresponding subordinate questions. This chapter discusses the current results as they are linked to the literature discussed in Chapter Two. In addition, some discussions are also made regarding findings based on evidence from the qualitative data; i.e., writing scripts and the participants' commentary texts. The findings and discussions are related to the purposes and hypothesis of the research.

For the sake of convenience and clarity, it is better to restate the research purposes and main hypothesis herein. The current research aimed to investigate the use and effect of the imagery-based encoding strategy (IBES) on Chinese character learning by adolescent CFL learners at the novice to intermediate level, with the hope that the learners' visual-semantic abilities are understood so as to help with appropriate instructions and better experiences in Chinese character learning. The main hypothesis prefaced the research was that the CFL learner's ability to align meanings with the Chinese character through IBES use should predict a better performance in character writing and reading.

This research is different from previous similar research in Chinese character learning in the way to analyze the problem under neuro-semantic framework, characterized by triangulation of the literature from interdisciplinary modules in language, cognitive psychology, and neuroscience. Particularly in this research, the

literature is heavily grounded in the theories and findings of the three main areas – semantic knowledge and networks, visual-semantic pathways, and memory – which have established the theoretical foundation examined in Chapter Two.

Thus, in this chapter, the literature of the three areas is again utilized to provide interpretations to the current results and findings. To assist with a review of the literature, a neuro-educational model is developed. The model summarizes the prominent theories and research in the three areas pertaining to the current problem, and meanwhile shows a dynamic potential in using these areas for data analyses. Based on the findings of this research as they are linked to the literature, implications in language research and pedagogies in teaching Chinese characters are suggested.

This chapter includes: a neuro-educational model of character learning, discussions on the use of IBES, the effects of IBES in character learning, implications of the research, and limitations.

A Neuro-Educational Model in CFL Learning and Research

This research explored the semantic abilities of the CFL learners to use the visual imagery strategy for character semantic encoding and retrieval. Different from previous research which only reported behavioral results of the IBES use in character learning, the researcher attempted to draw upon the literature from language theories, cognitive psychology and neuroscience to analyze the current research results and discuss the cognitive processes of character learning in the current study contexts. By triangulating the three areas of research and findings,

specifically in semantic knowledge and networks, visual image pathways, and memory, it is believed that the research can be validated with more scientifically-based explanations for understanding a complicated cognitive function: Character learning by CFL learners.

The above thought about triangulation of the literature came up out of several considerations, due to observable limitations of the research and application models used in the language-based education. First, the traditional application research in education mainly relies on generalized theories and behavioral models of empirical research to seek explanations so as to guide teaching methodologies. The learners' conceptual abilities in their learning processes are typically disvalued or neglected. As a result, learning becomes an outcome-driven behavior or skill set. This is opposite to the educational tenet that emphasizes learner-centered learning. Second, traditional psychology research, including numerous studies on cognition, mainly seeks answers from empirical approaches which are still behavioral oriented and lack of data to understand cognitive processes involved in higher order learning. Third, emerging neurobiology and neuroimaging studies may have examined brain activities and cognition, but a majority of these studies only focuses on narrowed areas of the brain or isolated mechanisms that do not suffice to explain cognitive operations requiring brain-wise areas to perform a language function. Fourth, language theories may provide a foundation to examine language functions, but need data to support the validity so as to apply the theories to everyday educational environments.

Taking all these considerations into account, the researcher utilized the triangulation method of analysis based on the literature from the three disciplines, and believed that integrating the literature from interdisciplinary fields should complement in some degree the limitations derived singularly from each of these fields and provide a more comprehensive approach that fits the study of a complicated cognitive function, visual-semantic learning of characters. Hence, based on this approach, a neuro-educational model for conducting the current research and analyzing the results through literature was developed (see Figure 5.1).

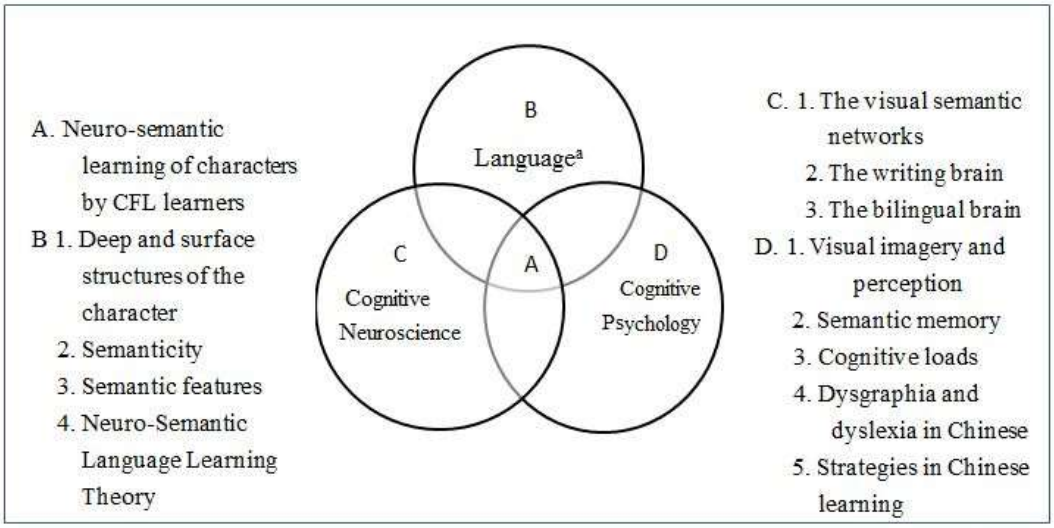

Figure 5.1. A neuro-educational model for the study of Chinese character acquisition by CFL Learners. [a] Language here refers to the language function that a learner maps meaning to a sign and scaffolds the information for expanded use of the sign in his or her daily life.

The neuro-educational model illustrated in Figure 5.1, summarizes the primary theories and research areas relevant in this study, which served as the foundations for result analyses and discussions. In general, the model illustrates the triangulation approach to studying a language function (A) in a neuro-semantic direction, which is a theoretically supported semantic-based process (B) that relies

on the integrated operation between the learner's brain (C) and mind (D) to serve the purpose for everyday use of the language. The three lenses, constituted by individual sub-topics juxtaposed to offer discussions and evidence for the study, are in an interactive relationship: neuroscience and psychology complement each other with data from both brain activities and behavioral results; these results further give evidence to confirm/disconfirm language theories to be used to analyze a learning function, which in turn guides the research in cognitive neuroscience and psychology toward a direction that reveals functional human capabilities.

The neuro-educational model developed herein may be taken as an example, if possible, to expand it into wider contexts in research and application in education. In fact, as long as a study or application is dedicated to understanding learners' learning and thinking processes, a triangulation of the literature about language functions, brain activities and mechanisms, and the psychological outcomes should be considered necessary in studying a real classroom problem.

Guided by the neuro-educational approach, the following discussions on the findings of this research – the use and effect of IBES for semantic learning of Chinese characters – are carried out with a triangulation of the literature. The findings are analyzed in alignment with the language theories for semantic interpretations, mainly under the Neuro-Education Language Learning theory (NLLT), and then related to relevant scientific findings in cognitive psychology and neuroscience for further analyses.

The Use of IBES in Character Semantic Encoding

The use of IBES in the baseline data. The baseline data revealed the participants' use of IBES for character learning on a daily basis. Comparing IBES to Pinyin, English translation, and form memorization, IBES was used the least frequently. For those used the strategy on a daily basis, the imagery strategy was used to memorize character forms (especially component shapes), but less for recalling and integrating the characters with their meanings. These results seemed to be consistent with the results in previous studies. As aforementioned, Shen (2005) and Sung and Wu (2015) found that the most frequently used strategies by the beginning learners of Chinese were practicing, translation, and receiving ideas quickly, while cognitive strategies such as imagery, mapping and associating were used less.

This study data could indicate that most these CFL learners at the beginning to intermediate level of Chinese had not (or not sufficiently) developed abilities in using IBES to learn characters on a daily basis, partly due to a lack of knowledge, or were not taught, of the connections between character forms and the underlying meanings. This is evidenced in the commentary data, suggesting that the participants did not know the connections and were looking for underlying meanings to make images; e.g., "Knowing the components in meaning gives me a mental image." There were also some participants who were able to use this strategy, but their limited knowledge of associating conceptual meanings to characters could only be used for some characters or parts of the characters. So

most of the time, they would prefer using the English translation as a crystal clear method to assist with partial meaning-form association. In this case, IBES for character semantic encoding could not play a full role, as the character-related semantic path to access images stored in long-term memory was not fully established (Gardini et al., 2005; Kosslyn, 1994; Lloyd-Jones & Vernon, 2003).

The insufficient knowledge of associating underlying meanings to characters might directly come from the ways in which students at the beginning level were taught. From this study data, it showed that the students at the beginning level needed to deal with a large quantity of information through pattern overlapping, an easy way for them to quickly produce learning outcomes where the teachers taught and required. The pattern-overlapping strategies (e.g., Pinyin and English associations with characters) may be considered necessary for what is expected at this stage, or the result of a learning habit.

By examining the baseline study results under the NLLT framework regarding language acquisition processes, the participants at the beginning level of Chinese demonstrated initial stages of language learning from the sensory to perceptual levels (Level 1 to Level 2). They could see character patterns, and quickly reproduce the characters, but these patterns were not integrated with the learner's conceptual meaning networks; that is, most of character learning on a daily basis did not reach the third level of NLLT (concepts). Without conceptual integration of the characters with the underlying meanings, the participants had to resort to their existing English system to associate sounds and patterns with English meanings.

As a consequence, Chinese characters became additional new patterns for which frequent copings, repetitions, and associations were required, and these learning strategies could be continuing if students were not given sufficient training in connecting the patterns with the underlying Chinese meanings.

Foreign language learning theories and cross-cultural neuroscience have informed us that universal language systems are widely shared among languages, with some differentiations, representing language specificities, usually appearing on the surface levels (i.e., sounds and structures) (Dehaene & Cohen, 2007; Perfetti et al., 2007). In this case, we can infer that, in this study, the participants' own semantic systems (i.e., the system including the semantic features for Chinese meaning construction) had not been adequately used, or required to use, to be connected into the whole networks for character learning (Level 3 and 4 in NLLT). This may be the reason why memorizing characters had been reported a very challenging task for CLF learners. Especially for the beginning learners, if the new patterns cannot be directly integrated with the learner's conceptual networks, the memory of the patterns and the associated English meanings are mostly limited or restrained in a short-term memory. Cognitive psychology identifies the short-term memory as working memory, which is different from the semantic memory, a relative long-term memory (Squire, 1987).

To summarize, the use of IBES was very limited on a daily basis in the participants to learn character-denoted meanings for character form encoding and retrieval. The reason may mainly come from the teacher's instructions and learners'

habits of learning. The literature advises that what the learners at the beginning level of Chinese could do was to use their existing semantic systems to associate with the new patterns. Images can be generated from the semantic networks to adapt to the new patterns for character semantic encoding. However, the participants could not use the IBES strategy maybe because they were experiencing a developmental stage of pattern overlapping for quick memorization outcomes, which were believed to be represented mostly in the short-term memory.

The use of IBES in the main study. In the main study, the participants reported that the pictorial method was the easiest method to carry out IBES and learn new characters. This method was also selected the most frequently by the participants in the student-select session. These results indicated that the pictorial method was a widely-accepted preferred method perceived by the participants for character meaning-form association (while not necessarily a semantic memory). The survey data of the participants' on-site comments collected in the student-select session qualified the results, but the reasons for selecting methods to learn were various. Using IBES to learn was not supported in the data to be a direct cause for selecting the pictorial method. The participants may make mental images of the Chinese meanings in all the three teaching methods. Whether or not they used IBES to learn, or chose a method to learn individual characters, depended on different circumstances or factors; e.g., the participants' previous knowledge of radicals and character structures, the clarity of the supplied pictures for the learner's understanding, the structural complexity of a character, and the

participants' previous learning experiences. However, a majority of these self-reported reasons pointed to an overall reason that the participants were attempting to gain semantic understanding of the characters; and, understanding the Chinese underlying meanings of the character with the component relationships may be considered the dominant reason for selecting the pictorial method as the best method. Compared to the baseline data, the participants started to consciously use IBES as a mediating tool to access character meanings for character semantic encoding.

To examine these results within the NLLT framework, the participants were attempting to reach from the second perceptual level of pattern memorization, as shown in the baseline data, to the third level of conceptual understanding of the character meanings. Based on the concepts they learned in English, they intended to incorporate the new information into their acquired semantic systems for the association of existing concepts with character surface structures. This is in line with the literature in the cognitive processes for language acquisition (e.g., pragmaticism); and, also supported by the neuroimaging data about cross-language studies stated earlier.

However, with different learning backgrounds in both English and Chinese (i.e., meanings are assigned based on previous learning), they had to adopt different learning strategies (e.g., IBES, semantic relationships, or pattern overlapping) to learn or memorize new information in relationship to the previously acquired systems. For example, some participants with better knowledge of radicals

commented the English method to be the best method, because they could utilize the established semantic relationships of the components to learn new characters; some participants at the beginning level may find using IBES without contextual supports to be difficult, so they had to resort to image perceptions from the pictures to recognize meanings or images to associate with the characters. Therefore, the results showed that the participants used various strategies and looked for multiple access points to learn the characters, depending on their previously acquired concepts and experiences from which meanings were assigned to the new inputs (Arwood, 2009, 2011).

Comparing to the other teaching methods, pictures or visuals provide multiple semantic points to access the learner's semantic system (Arwood, 2009). That is to say, the pictures provided in this study offered more contextual and relational information that had accesses to the participants' learning systems. This could be especially important for the beginning learners, whose relational or contextual meanings in Chinese had not yet established and who had just been provided with some pieces of Chinese. These learners could interpret the pictures based on their own conceptual levels and associate the perceived meanings or images with the characters and components; and even, could attach the components with the perceived semantic or image features in the pictures for a relational or spatial recall of the components. One participant commented, "I can use the picture to memorize the placement scene that the components are supposed to make." However, the attachment of the components to perceived meanings or images may not be

necessarily encoded into the semantic networks for semantic memory. If the character components can only be attached to the perceived image places, while the conceptual meanings of the character were not surfaced as a result of insufficient picture interpretations, the character might not or shallowly be encoded into the semantic long-term memory. According to the NLLT's levels of meanings, pictures also have meanings that can be interpreted at different levels. If a picture matches the learner's semantic system, it helps the interpretation to reach conceptual levels (Level 3 or 4); otherwise, pictures may maximally create perceptual meanings in the learner (Level 2) (Arwood, 2009). Without semantic or conceptual interpretation, characters that were attached to the perceptual meanings in the pictures might be perceived, but could not be recruited into the learner's semantic system.

Compared to the pictorial method, the English method did not offer enough contextual information for the participants to conceptually understand character meanings and relationships. The verbal method, however, might contain some contextual information about the relationships of character components; but, the participants might find it difficult to generate their own images for character semantic encoding based on the new and limited information presented in this study. For the images or concepts to appear at the third level of NLLT, overlapping of perceptual meanings from the second level in the learner's own system is necessary (ibid.).

Cognitive psychology and neuroimaging studies may also offer some insights

in imagery processes. Compared to seeing the images with the eyes (i.e., imagery versus perception), image making based on understanding did not always seem to be easy. Increasing evidence showed that imagery processes recruit more extensive neural networks, assumedly the semantic networks, than perception processes (Mazard, et al., 2005; Olivetti Belardinelli et al., 2009); that is, less or lower levels of meaning, less imagery representations; and vice versa. In this sense, also bearing in mind the brain economy principle, it would be demanding in the current study that all the participants generate their own images while at the same time learning much new information. Due to the limitation of the learners' knowledge of Chinese, it would be difficult for them in a short time to recognize new components that were away from their understanding, and integrate them with their conceptual networks immediately. Therefore, for some of the characters, making mental images were difficult compared to seeing the images and figuring out the meaning. This may be one of the reasons that the pictorial method was selected as the overall preferred method. A number of the participants mentioned, "Pictures are easy"; or, "I don't have to make my own images."

In the main study session, the results showed growing favorability in the participants to use IBES for new character learning. Their use of the strategy may have occurred in all the three teaching methods depending on different circumstances. The pictorial method, however, was considered the easiest method, and selected as the preferred method in character learning. The primary reason was that the participants were attempting to gain character semantic meanings with the

relationships to the components. Perceived or self-made images were used as mediating tools for character semantic encoding; however, it seemed that making images at present were not easy probably due to competition with the demanding semantic information. At the participants' current Chinese level, their use of the IBES seemed to have to be supported by other sources such as semantic contextual meanings for conceptual understanding of the character.

The use of IBES by Chinese proficiency. Chinese proficiency has not been previously reported to be an impact in the use of imagery strategies in Chinese learning. The current research found insignificant effect of Chinese proficiency on IBES use. A possible explanation may be that proficiency does not perform an important role in using IBES. The participants in different proficiency could equally experience using the strategy, given the same learning task and situation. Or, the insignificant result might be attributed to type-II errors, due to involvement of other factors with proficiency, such as the teacher's instructions of the IBES use (see sub-question 3.2); or, the construct validity of the proficiency test that was assumed to divide the participants into two distinct proficiency groups. To testify this issue, stricter enrollment rules of the participants and measurements should be required. From this current result, if the null hypothesis is true, that proficiency does not impact the use of IBES, it implies that it would be equally beneficial for the lower-level and higher-level learners to use this strategy for meaning-form integration.

The use of IBES by character type. In this research, the character type factor also showed no significant effect on the use of IBES. That is to say, ideographs are the same as other characters types such as compounds in the participants' use of IBES. Conversely, previous assumptions believed that stroke numbers and character types may be important factors in character learning (see Ke, 1996; Lu et al., 2010; Sham, 2002; Wang, 1998). Such surprising differences in the learning of ideographs may be attributed to a tendency of overgeneralization of character types and structures on the surface, while disregarding the meanings of individual characters which were interpreted by the learner.

The current study controlled stroke numbers and studied individual characters of different types. It found that the learners processed character information based on their brain capacities to integrate visual inputs with their existing or refined semantic knowledge. Rather than relying on stroke numbers and categorizing characters, the learners in this research did not seem to have noticed this information or depended on the surface structures (e.g., integral or left-right structures) to find strategies to learn. Instead, they looked for familiar structures (e.g., contours, chunks, or symmetrical structures) that made sense to them (i.e., semantic components) and then built new knowledge onto old knowledge. Any information that did not make sense to them was more easily forgotten or more difficult to recall. For example, the characters with the highest recall rates in the ideographs (回=back；交=cross) were in the same stroke-number range as two others with the lowest recall rates in the ideographs (甘=sweet;奔=rush). It was

obvious that the participants recalled the former the best due to the combined images of meaning and the form which were provided in verbal interpretation, while the latter were presented with the pictorial method from which a direct linkage between the meaning and form was not built up. Another case in point was between two compounds. The current study categorized them as one with concrete meaning (休=rest) and the other with abstract meaning (协=join). However, the participants had one of the highest recalls for *join*, and almost no recalls for *rest*. Again, the verbal interpretations for *join* matched the participants' semantic understanding of the relationships of the component units, while the English translation of *rest* did not match their understanding of the relationships of the component units, even though they had learned each component previously. These results indicate that not all the abstract or concrete words (or characters) are the same. The learner acquires words or characters based on the level or amount of meaning which the learner's environments or past experiences have assigned to him or her.

In short, this research rejected previous assumptions about some commonly-studied factors which were thought to impact learners' character learning, including stroke numbers and character type categorization. Instead, it supported a semantic-configuration hypothesis of character learning in the CFL students; that is, the learning of semantic features or components and the relationships among them. This means that the images that helped with the learner's character learning should be integrated with the structural configurations

of the characters, so that structural units can be recruited into semantic networks at the conceptual level and encoded into long-term memory (Level 3 of NLLT).

The Effects of IBES on Character Semantic Encoding

The effects of IBES on writing performance. Investigations of IBES experience through comparisons of CFL learners' performances in different teaching methods have been conducted in several previous studies (e.g., Kuo & Hooper, 2004; Wang & Thomas, 1992). Generalizability of this approach has been established in their rigorous research design and consistent findings. Especially in the writing studies, cognitive/mental processes were summarized in abundant research on the writings of Chinese patients with dyslexia and dysgraphia (e.g., Law & Caramazza, 1995; Law & Leung, 2000; Leung et al., 2012). Therefore, the researcher believed that by analyzing the participants' writing and reading performances, their experiences of IBES use as an effect on learning could be largely summarized. To increase the validity of the analysis, in this research the relationships between IBES use and performances were also examined in the triangulation with other data sources, including their perceived IBES ratings and self-introspective comments.

In this research, the results of the writing performance showed consistent advantages in the verbal method throughout phases. The advantage was even more distinct in the retention recalls (54% average retention), reaching significantly high over the other two methods. However, the performance of using this method had the greatest variability among the participants. The English method produced lower

writing scores across phases (31% average retention). Although the pictorial method hit the highest in the immediate test, the performance using this method dropped dramatically to the lowest in the retention tests (26% average retention). Moreover, significant correlations were found between the participants' perceived IBES use and overall writing performances. The writing scores produced in the English and verbal methods showed consistently positive relationships to the ratings of IBES use perceived by the participants.

The writing performances reflected not only the effects of using these methods, but also the cognitive processes of meaning representations and the IBES use in both the encoding and retrieval processes of character learning. In general, the results revealed, in consistency with the analysis in the last section, that the more meanings matched the learner's semantic system, the better performances in the writing recall. If putting the writing results under the NLLT's meaning equation, the verbal method offered more recognized meanings, and helped the participants to access their acquired systems to form the character concepts, or making images of the character meanings, integrated with the character forms. On the NLLT equation, character learning using the verbal method may be the closest to the third level of NLLT, the level of conceptual meanings. In comparison, character learning in the English and pictorial methods in this study most likely stayed at the second level of NLLT, the level of perceptual meanings or patterns, which requires more meaning overlapping to reach the conceptual level to successfully memorize and recall characters.

To give a detailed look at the messages contained in the verbal method, this method offered three units of meanings relevant to the character, including the English concept, the semantic components, and the relational or spatial relationships of the components to form the concept. Although the information was not as much as the information contained in the pictorial method, this information may be likely to have created more points of access to the participants' existing semantic networks for character semantic encoding and retrieval. These units of meanings may be especially beneficial for the participants who had acquired basic radicals or semantic components. As long as they could recognize the semantic components embedded in the verbal interpretation, they could write the components from recall.

Besides offering more access points to the semantic networks, the verbal method may also be helpful to invoke effective mental images (with component positions) of the characters or components overlapped with the semantic meanings. As discussed in the last section, the more meanings can be recognized, the more chances of concepts of the characters or the images can be surfaced. This is evidenced in some of the written scripts of the characters with new components or shapes which the participants had not learned before the study. For example, new characters or components with higher recalls in the verbal method included the character 交 (cross), and relative higher recalls of the right parts of 协 (join) and 犯 (criminal). Comparatively, new characters and components did not show such high recall rates in the other two methods. A logical explanation may be that the

recognized meanings or meaningful features invoked the images stored in memory; in these character cases, for example, the images of people joining hands in the character *join*, and a criminal sitting on the ground in the character *criminal*, as the verbal method interpreted. It may be that the meaningful features and the invoked images overlapped to form a "story" of the character concepts (Level 3 of NLLT); and meanwhile, encoded the whole entity of the character and components into the learners' semantic system. Therefore, retrieval from the semantic networks with the images of the entire story, encoded with the character forms (including the new components), would be easier. Recent neuroimaging data has found that using the verbal method for character learning may invoke in the learner audiovisual integrations to form cross-model concepts (Campbell, 2008; Stevenson et al., 2011); or, to form auditory concepts in the NLLT framework (see Arwood, 2011). In other words, IBES could work as the mediating tool to associate semantic meanings with the corresponding forms. Though the ability in audiovisual integration to form concepts seemed to vary among the participants, substantial evidence could be found in some of their own comments; e.g., "It (i.e., the verbal method) makes a verbal picture and gives me an imagination."

In general, the participants' demonstrated abilities to use IBES to learn in the verbal method, as evidenced in their self-perceived ratings, comments, and writing results, confirmed that the participants at the beginning to intermediate level have started to have the ability, through the use of IBES, to align their understanding with character-denoted meanings for character interpretation and memory. This is

consistent with William's (2010; 2013) research in which the results found that above-intermediate CFL learners have already had developed semantic knowledge of Chinese characters to relate character forms with semantic components. However, as to what degree their use of IBES can be as an effect on character writing is still a question.

Compared to the verbal method, the English method did not offer enough information to access the learner's semantic system (except the English concept) for encoding and retrieving the characters; thereby, invoking less mental images of the character meanings and less recall rates.

The effects of the pictorial method seemed to be more complex. A fundamental explanation is that pictures also have meanings at various levels (Levels 1-4 of NLLT) that may have caused variations in the interpretation and memory performance. The sharp decrease of the performance from the immediate to retention writing recalls in the pictorial method confirmed the analyses of the distinctions in perceiving and conceptual understanding of the pictures. The results indicate that the participants only recognized the perceptual meanings in most of the pictures based on their past experiences; thus, resulted in perceptual patterns of the pictures (Level 2 of NLLT) (maybe attached with character forms) represented or stored temporarily in the working memory, but not encoded in the semantic networks for an access to the images stored in long-term memory. According to the NLLT's meaning level interpretation, not all pictures are the same, because the creator of the pictures and the interpreters (the participants) were not at the same

level of assigning their meanings to the pictures (Arwood, 2009). The designers who created the pictures were at independent language (Chinese versus English languages), social (ancient Chinese culture versus modern American culture), and cognitive levels (knowledge of the character meanings) from the participants who interpreted the pictures. Therefore, it would be reasonable to infer that there were meaning discrepancies between the creators and the learners who interpreted the pictures. As a result, unsuccessful interpretations of the pictures, heavy cognitive load, attenuated attention to encoding characters through concepts or images, and loss of the linkages of the pictures to the characters might all occur.

To put it simply, the images that were perceived by the participants were not the images or the concepts of themselves, or not integrated in their own sematic circuits or networks. This may be the reason why self-generated images of the characters reported in previous research had better effects on memory than the pictures supplied by teachers (see Kuo & Hooper, 2004). These perceptual images could last for a while, but could not be encoded into the long-term memory unless overlaps of the images were available to reach the conceptual level of the characters. Moreover, due to heavy cognitive load relative to the learners' own meanings, using the same pictures to recall the characters via the perceptual images could also be heavily interrupted by unrelated information in the pictures relevant to the meanings of the characters. This may explain why the pictorial method resulted in the least retention recalls. The limited picture effects in the immediate recall were also reported in another research (see Wang & Thomas, 1992).

By interpreting the writing, commentary, and image making data of the current study within the NLLT framework, it can be safe to say that the effects of IBES use were closely linked to the levels of meaning the participants had for the meanings of the characters. The results indicate that, at the participants' current of level of Chinese, character semantic encoding through the use of IBES had to be supported with more increased meanings related to the characters; for example, using the verbal language (the verbal method used in this study) to help with the interpretation of the pictures to increase access points to the stored mental images; or, adjusting the verbal language and visuals to the levels of meanings acquired by the participants.

The effects of IBES on reading performance. The reading results drawn from the semantic judgment and character identification tests also showed consistent effects of the verbal method over the other two methods across phases. However, these results seemed different from previous research (e.g., Kuo & Hooper, 2004) which found that pictures had a better effect than English and verbal methods in the immediate and long-term recall in meaning-form association. The argument may be resolved if considering the different study conditions between this research and the previous research, including differences in characters and pictures used in the research, test contents, and subject groups. The current study used characters of various types on the participants at the beginning to intermediate level of Chinese, while previous research used mostly pictographs on the subjects without any Chinese background. In addition, the current research

especially tested the participants' cognitive processes of learning, so the knowledge and use of sematic features were included in the reading tests. Due to these reasons, the effect of the verbal method, which demonstrated significant advantages over the other two methods in semantic understanding of the characters, was not surprising because the semantic features were clearly embedded and supported in the contexts in the verbal interpretation of the characters. Therefore, it was positive that semantic alignment with character-denoted meanings also played an important role in the semantic judgment test as in the writing test. However, as to whether IBES was involved and the degree to which it had an effect on semantic understanding during the reading process, these tests did not seem to reveal confirmative information.

The correlation effect between the participants' perceived IBES use and reading performance in the semantic judgment test did not find significance, which is different from the correlation found between the rates of IBES perception and writing performance. An explanation for the insignificant association between IBES use and semantic reading performance may be that the participants did not make sufficient images during the reading process. Instead, they employed multiple strategies to complete the semantic judgment tasks. For example, the participants may be able to grossly make semantic judgments based on their knowledge of learned semantic components, perceived character patterns, and English word-pair distinctions; or, using these skills interactively. Therefore, imagery activities for the characters were not deemed necessary to complete the

semantic judgment test. These results may support the neuroimaging finding that imagery activates more extensive visual networks than character perceptions (Cui et al., 2007; Heikkila et al., 2015; Olivetti Belardinelli et al., 2009), probably associated more with character reading. So, imagery may be an important strategy used for writing recall, but less in the semantic judgment tasks. As to the associations of IBES use and character reading, studies of different reading tasks are suggested in the future.

The character identification test showed surprising results as to the relatively low identification rates among all the three methods compared to the judgment tests. However, the results seemed to accord with the writing performance in the performance accuracy rates among the three teaching methods. An explanation for the overall low identification rates may be largely attributed to the structural similarity of the new and previously-presented characters in which the same semantic components were used. In the previous semantic judgment tests, which required mostly gross judgments for character and component meanings based on English word comparisons, the participants were able to choose correct meanings related to these characters. However, when characters contained the same components and looked much similar, the participants' judgment abilities were affected. These results may prove that the participants at the beginning to intermediate level of Chinese relied heavily on the semantic components (or familiar parts) which they had memorized for character recognition, but the recognition or judgments were still partial and gross. A possibility was that they

saw the familiar parts, but they did not relate them to meanings and carry over to infer character meanings (Level 2 of NLLT). In other words, their abilities to make finer distinctions of character forms and meanings have not been fully developed, or their abilities to displace or carry over semantic features (the components) to different contexts were still developing. Like the semantic judgment test, the participants may mainly rely on perceptual familiarity, rather than learning concepts or using imagery strategy to finely distinguish the nuances of component forms in relation to character meanings.

Another reason that may have led to the overall low accuracy rates in the writing and identification tests may be ascribed to limited imagery functions in linking images with forms and in representing concepts (e.g., the idea of a character) as an entire entity at different conceptual levels. Cognitive psychology believed that images invoke mostly concepts of basic or concrete meanings, while higher-level meanings do not depend on imagery, though imagery could be involved (Libby & Eibach, 2013). A detailed study of the character writing scripts may conform to this theory. For example, the character 休 (meaning *rest* shown in English method) had the lowest recall rates in spite of its simple and common semantic components (i.e., 亻= people; 木=tree). The participants seemed unable to connect the left component (people) with the right one (tree) to form the meaning *rest*, which means people were resting under a tree. So, the meaning-form disconnection also affected them to distinguish this character from the new character 体（body=the root of a person）in the identification test. In this case, the

individual semantic features or images did not seem to be adequate to represent an idea or concept for *rest*, thereby recall of the internal relationships and structure forms being affected. The literature in language (e.g., the semanticity theories) suggests that probably a better way to map lower-level meanings or images to higher-level concepts may be to connect the meaning or images with contextual information; or scaffolding information in the NLLT theory. A good example might be to let the learner draw or write the concept out with images or semantic features connected in contexts (e.g., using language like why a “tree” is there?) to make up the “story” (similar to the “story” method in the Viconic Learning Methods; Arwood, 2009, 2011).

Generally speaking, the English and pictorial methods may provide perceptual or categorical meanings to the characters. However, to connect character forms with the meanings for writing and recall, it is necessary that the participants should have been informed with the Chinese contextual meanings so as to help develop abilities in fine distinctions in meanings and forms. Again, it seemed that the verbal method might work better to provide more of this information.

Language theories and neuro-semantic findings in cognitive neuroscience support that semanticity occurs at all four learning levels proposed in NLLT and may involve brain-wise activities for cognitive processing (Level 3). The results from the semantic judgment and character identification tests conform to the theories and scientific findings. The learners at the beginning to intermediate level of Chinese were able to judge grossly the meanings with the character forms and

depended on their previously learned knowledge to recall stored information. However, they suffered in fine distinctions of both the meaning features and corresponding forms due to a lack of enough meaning overlapping; thus, unable to flexibly carry over their acquired knowledge to new contexts. Again, if more supported information such as the contextual relationships among semantic features were offered to form a whole conceptual idea, the meaning-form integration for recall may be enhanced. These reading results further verified that the effect of IBES was rather limited in representing a multifaceted idea or concept. For a better effect of mental images on encoding and accessing characters, the mental images had to be supported with contextual information.

Summary of the Hypothesis

This research found that the participants at the beginning to intermediate levels of Chinese started to develop the ability to align their existing semantic knowledge with the Chinese character learning through the use of IBES. However, the alignment and use of the strategy were limited and may be easily affected by semantic understanding of the character, cognitive load during encoding and retrieval, interruptions of unrelated information, and character presentation effects. The analyses of the data were in line with the literature in terms of the use of IBES; that is, making mental images for character learning was preferred, but not easy compared to perceptual processes for recognizing meaning. Visual imagery for character meaning representation needs to be supported with sufficient semantic information, such as the contextual meanings between semantic components, to

build a semantic network of a whole character concept.

Analyzed from the performances, semantic alignment with character-denoted meanings has become a fundamental ability for completing the performances in both writing and reading. However, IBES for semantic alignments has been seen used more in the writing recall tasks, while the reading tasks were found to involve more perceptual recognition, interactively used with multiple strategies. Thus, the main hypothesis can only be partially supported in the current research. That is, the learners' abilities in semantic alignment with the characters through the use of IBES predicted better performances, most evidently in writing; however, the abilities of using IBES to learn were still underdeveloped, and needed to be supported with sufficient contextual information to facilitate a better effect for character semantic encoding.

Based on the above conclusions and discussions about the CFL learners' abilities in semantically learning characters, this dissertation proposes the following implications for teaching pedagogies in CFL classrooms and other language-based teaching practices.

Implications of the Research

As to the long-time argument whether or not character teaching should be incorporated at the beginning level of Chinese in the CFL classroom, the answer from the current research results was largely positive. Although the logographic writing system may be very different from the learners' L1 writing in English, compared to the alphabetic Pinyin system, the Chinese character was not beyond

their grasps at the beginning level. The current research showed that the participants tended to incorporate new information into their existing semantic systems and preferred to use IBES or semantic features to refine meaning networks for character semantic encoding and recall. The consistent reports of the difficulties in character learning may mainly come from the way characters were taught independently in isolated parts, while overlapping of the meaningful parts was not sufficient to recruit new information into the semantic networks.

Considering the benefits of learning characters in the long run in cultural awareness and literacy development, the general implication of the current research in CFL teaching is that character learning, including writing, can be initiated at a very early stage, paralleling or immediately after the Pinyin system is introduced. However, to incorporate character teaching into the curriculum, learner abilities should be exclusively considered, such as learners' cognitive abilities in visual-semantic learning. There are five implications drawn from the current research in this regard.

First, teachers should realize that character learning could be daunting to students if perceptual ways of teaching are mostly emphasized; for example, copying, following stroke orders, recognition, etc. Teachers should also know that although pattern training may be useful at the early stage, these ways of teaching could only produce fast and immediate outcomes which are available mostly in the short-term memory. For a longer memory to appear, characters should be encoded into the semantic systems for flexible use and recall. Therefore, students may be

reminded of the limitations of the fast and shallow styles of learning strategy, while being encouraged with more in-depth learning of the character. Suggested teaching methods may include establishing the relationships among semantic features or components to form the concept or idea of a character.

Second, in view of the discrepancy between student preferences and effects of learning in using different teaching methods, teachers may consider balancing the two by encouraging self-made mental images with a consideration of the students' current semantic abilities. To reduce the effects of students' variations in their backgrounds in both English and Chinese, teachers may consider offering more contextual information or access points to connect to the students' semantic systems, especially for characters carrying multifaceted ideas or symbolic meanings. For example, for lower-level learners, new characters had better be presented with character-relevant physical images (i.e., the pictorial method) and also encourage mental images of the learner through writing with verbal contexts (i.e., the verbal method).

Third, teachers should be careful to select or design visuals or pictures for character learning. The visuals ought to match the learner's level of cognitive, language, and social development for conceptual understanding of the character. Visuals which are beyond the learner's experiences might bring in more cogitative loads that inhibit understanding and character learning. Teachers had better emphasize viewing a visual or reading a character as a complete concept or idea so as to make linkage for individual components; that is, from whole to parts.

Students should be reminded that only knowing or recognizing the parts of a picture or character may not be very helpful to learn the character as a complete concept and memorize the character forms.

Fourth, IBES can be taken as a mediating tool to connect character meanings with the forms for a longer memory, and maybe especially useful at the early learning stage. However, CFL students may not automatically use this strategy for character learning mostly due to a lack of understanding of the character meanings. Teachers may find various ways that are the most meaningful to explicitly teach using IBES to learn and meanwhile boost students' preferences in the Chinese class. Typical ways of using IBES to learn maybe like using students' drawings, acting performances, or stories to connect the images (static or motion) with character forms.

Fifth, teachers should be aware of the differences in cognitive demands between the reading and writing tasks at the beginning level. In view of the limitations in character reading and recognition as well as the learner's inadequate abilities in imagery and fine-grained distinctions of the character, teachers may incorporate writing for contextual understanding as a complementary task to facilitate a better encoding and fine-grained learning. To enhance the function of imagery, contextual relationships of multiple components or features within or among characters had better be explicitly explained so that more semantic points are available for the students to access the character meaning and form.

The above five implications of the current research are pedagogical

suggestions addressed to the teachers for CFL classroom teaching. Another implication may be addressed to those educators or researchers who are interested in the field of language learning and education. Traditional language teaching and learning studies resort to students' behavior or teaching outcomes to find answers to solve a problem. For example, in character learning, structural complexity and character types have been considered important factors influencing acquisition of the character. This behavior-oriented study model stayed on the surface of the problem. The current research revealed that the learner's semantic abilities to interpret characters are the main reason for acquisition. Future studies in language learning or perhaps in general learning may be predicted to shift to the learner-centered model which examines their cognitive abilities and processes. The emerging cognitive neuroscience and psychology have paved the way to provide increasing findings toward cognitive analysis of classroom applications. Educators and researchers should predict more of the similar kinds of research methods to come along.

Limitations

As this dissertation has come to an end, the researcher would like to take the opportunity to outline the major limitations of this research for the purpose to encourage future studies in this area with a better and more rigorous research design. The researcher realized that a genuine classroom research with a large scale of research procedures such as this one is very difficult to control every situation and variable. Some of the uncontrolled situations may have involved in this

research and affected validity of the research results. The following limitations reflect this concern, and are addressed here for the reader's consideration in future research.

First, the researcher realized that this study had a small sample size for a quantitative study. As the study phases lasted for seven weeks in five class sessions, the sample size continued to shrink and some missing values occurred in the data. Although the final sample size maintained above 45 participants, the results could be more trustable if there was a bigger sample size, especially for addressing the questions examining group differences. If possible, future studies may need to recruit participants at different locations if they meet the enrolling requirements.

Second, three participants in the first-year class did not finish the writing and reading tasks in the self-select session in the main study, because they needed more than 90 minutes in one class session to learn 30 characters. Though the time allocation for the 30 characters was determined based on the result of a sample study, the participants' Chinese level in the main study was not considered in the timeframe. In future studies within class sessions, it had better consider about different time allocation to participants of different levels to complete the tasks.

Third, the pictures used in this research seemed to have produced confounding results of learning performance. From the analysis, this may be due to presentation of the pictures with uncontrolled cognitive levels to the participants with different levels of Chinese (or, probably with different levels of English). Future research may be especially needed in the effects of pictures on character

learning. For example, research may just focus on the cognitive levels of pictures and examine the effects of pictures with controlled cognitive levels on a group of learners with controlled learning backgrounds.

Fourth, the internal validity of the current study might face threats from the research procedure. One threat might be from the study of proficiency impact on IBES use, which found no significance in the result. However, detailed studies on the participants' demographic information found a possible confounding variable on this issue; that is, the participants from different classes might be taught with different strategies. Though the current study could not allow control of this condition, internal validity of the study might be affected in answering the question about proficiency impact on IBES use. Future studies may find participants taught by using the same strategy at different levels. The other threats that might have caused reduced validity might be from the old-new character identification test. The test was designed to further measure character retention rates along with the writing recall, but it seemed confusing to the participants because the 36 old and new characters were all presented at one time, thus increasing interruptions from unrelated characters. Though this way might also reveal some interesting results, the construct validity of this test may be reduced. Future reading tests may consider more rigorous methods to present characters so as to reduce interruptions from unrelated information; or, to study about reading for conceptual understanding of the characters.

Fifth, this limitation might happen upon all the research conducted in

everyday classrooms; that is, investigating cognitive processes by using data from students' self-perceived experiences. Although literature has found overlaps between imagery and perception, it was still uncontrollable as to what happened in the participants' brain during learning and completing the tasks. That was the reason why this dissertation used data from other resources, e.g., writing scripts and commentary data, to triangulate data and support analyses. Future studies of investigating cognitive processes in an educational setting may come up with more rigorous study design; for example, collecting more data for triangulation, or finding supporting data from rigorous neuroscience and psychology studies.

Being aware of these limitations, the researcher believed that the current research did serve its purposes to provide relevant data and useful findings in the field, and hoped that this research can set an example for more cognitive studies of student learning in ordinary classroom settings.

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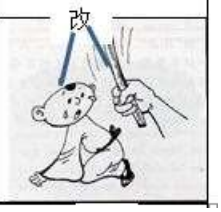
Appendices

Appendix A

Examples of the Character Database

Note: Stroke No.=stroke number; English Trans FreCount=English translation frequency count; Abs=abstract meaning; Conc=concrete meaning

Character	English Trans	Stroke No.	English Trans FreCount	Abs: 1 Conc: 2	Verbal meaning	Pictorial meaning
Compound Character with Abstract Meaning						
私	Private	7	3874	2	This character contains the grain on the left, valuable as money in the past, but only a small part of it on the right is left for personal possession.	
改	To correct	7	2292	2	This character contains a child on the left and a stick beating the child on the right, suggesting a child corrects his behavior after a punishment.	
Compound Character with Concrete Meaning						
冰	ice	6	4057	1	This character is a combination of ice with cracks on the left and cold water on the right.	
沙	Sand	7	1035	1	This character contains water on the left, meaning sands are shown in shallow water.	
Ideographs						
交	Cross	5	2807	1	This character is in the shape of a man sitting cross-legged.	 交
奔	rush	8	1602	1	The character shows a man running with swaying arms and rapid movements of his legs.	

Appendix B

Baseline Writing Samples

Note: The correct characters are in print beneath each written script.

	1	2	3	4	5	6	7	8
1	又 问	用 用	让 让	等 等	站 站	想 想	亲斤 新	帮 帮
2	冂 常	犬 太	旧 旧	夭 太	方文 放	快 快	具 具	想 想
3	票 票	先 先	时 时	甬 再	奶 奶	来 来	不 不	拿 拿
4	忄子 忙	叫 叫	亲 新	所 所	妹 妹	次 次	至 至	常 常
5	我 我	具 具	愁 想	来 来	少 少	矢 知	爷 爷	慢 慢
6	他 他	先 先	姐 姐	是 是	冢 家	别 别	弟 弟	我 我
7	禾 菜	道 道	茶 茶	星 星	蓝 蓝	刃 汤	这 这	夠 购
8	苗 菜	来 来	面 面	艹 菜	游 游	吃 吃	以 以	原 原
9	吸 吃	让 让	玩 玩	鱼 鱼	生 生	便 便	汤 汤	旅 旅
10	兄 吃	对 对	朋 朋	包 包	书 书	叽 吃	友 友	为 为

Appendix C

Demographic and Strategy Use Questionnaire (DSU)

1. How old are you?
   - ☐ 14
   - ☐ 15
   - ☐ 16
   - ☐ 17
2. Which grade are you in?
   - ☐ 9th
   - ☐ 10th
   - ☐ 11th
   - ☐ 12th
3. What is your gender?
   - ☐ Male
   - ☐ Female
   - ☐ Other
4. Is English your first language?
   - ☐ Yes
   - ☐ No

   If no, indicate your first language: _____
5. Is Chinese a foreign language to you?
   - ☐ Yes
   - ☐ No
6. Do you use Chinese or any variety of Chinese (including Japanese Kanji) at home or at other places?
   - ☐ Yes
   - ☐ No
7. How many years have you learned Chinese as a foreign or second language?
   - ☐ Less than one year
   - ☐ One year
   - ☐ Two years
   - ☐ Three years
   - ☐ More than three years
8. Are you taking Chinese courses at another place?
   - ☐ Yes
   - ☐ No
9. Have you systematically learned Chinese characters?

   Please mark YES if you have learned stroke types, stroke orders, character structures (e.g. left-right/inside-outside structures)，and radicals.
   - ☐ Yes
   - ☐ No
10. How much do you think characters are important in Chinese learning?
    - ☐ Extremely important
    - ☐ Very important

- ☐ Somewhat important
- ☐ Slightly important
- ☐ Not at all important

11. How much are you comfortable learning characters?
    - ☐ Very comfortable
    - ☐ Somewhat comfortable
    - ☐ Neither comfortable nor uncomfortable
    - ☐ Somewhat uncomfortable
    - ☐ Very uncomfortable
12. Which of the following is the most difficult for you during character learning?
    - ☐ Naming
    - ☐ Meaning
    - ☐ Copying
    - ☐ Writing from recall
13. Which of the following ways do you **usually use to memorize** a new character? **Please mark all that apply.**
    - ☐ Reading Pinyin
    - ☐ Connecting to English translation
    - ☐ Memorizing character forms
    - ☐ Making mental images
    - ☐ Others _____
14. Which of the following ways do you **usually use to recognize the meaning** of a character? Please mark all that apply.
    - ☐ Pinyin
    - ☐ English translation
    - ☐ Matching to a memorized visual image of the character forms
    - ☐ Seeing images for meaning
    - ☐ Others _____
15. Please draw **a cat with tail** and **a chair with four legs**.

Appendix D

Character Proficiency Test[7]

[7] The vocabularies used in this test are from the curriculum book for the subjects: *Learn Chinese with Me-Book 1.*

A． Please write the Pinyin and English translation for the following 30 characters or words. Example: 狗 __gǒu_/_dog____

1. 家 _____
2. 明天 _____
3. 风 _____
4. 朋友 _____
5. 学 _____
6. 可是 _____
7. 几 _____
8. 时间 _____
9. 和 _____
10. 中文 _____
11. 好 _____
12. 面包 _____
13. 看 _____
14. 睡觉 _____
15. 你 _____
16. 中国_____
17. 钱 _____
18. 我们 _____
19. 是 _____
20. 没有 _____
21. 女 _____
22. 节日 _____
23. 来 _____
24. 打算 _____
25. 冷 _____
26. 开车 _____
27. 玩 _____
28. 喜欢 _____
29. 月 _____
30. 打球 _____

B． Please write five Chinese characters or words according to the English meaning.

1. To eat 2. To go 5. Very 3. Birthday 4. Teacher

Appendix E

Image Making by Teaching Method[a] Questionnaire (IMTM)

The questions below are about making mental images you may have experienced when learning the characters. Indicate how well you felt about making mental images. Rate from 1-5 on the card.

Character imaging performance	Not at all	Not so good	Reasonably good	Good	Very good
	1	2	3	4	5
Did you make mental images[b] about the **character meaning** in the **English** translation method?	____	____	____	____	____
Did you make images about the **character meaning** in the **pictorial** method?	____	____	____	____	____
Did you make mental images about **the character meaning** in the **verbal** interpretation method?	____	____	____	____	____

Component imaging performance	Not at all	Not so good	Reasonably good	Good	Very good
	1	2	3	4	5
Did you imagine things about the **parts of the characters**[c] in the **English** translation method?	____	____	____	____	____
Did you imagine things about the **parts of the characters** in the **pictorial** method?	____	____	____	____	____
Did you imagine things about the **parts of the characters** in the **verbal** interpretation method?	____	____	____	____	____

Imaging experience	Not at all	Not so well	Reasonably well	Well	Very well
	1	2	3	4	5
Are the mental images made by you from the **English** translation method helpful for **writing** these characters?	____	____	____	____	____
Are the pictures in the **pictorial** method helpful for **writing** these characters?	____	____	____	____	____
Are the mental images made by you from the **verbal** interpretation method helpful for **writing** these characters?	____	____	____	____	____
Are the mental images made by you from the **English** translation method helpful for **understanding** the Chinese meaning of these characters?	____	____	____	____	___
Are the pictures in **the pictorial** method helpful for **understanding** the Chinese meaning of these characters?	____	____	____	____	___
Are the mental images made by you from **verbal** interpretation method helpful for **understanding** the Chinese meaning of these characters?	____	____	____	____	____

Note: a. The characters are shown in three teaching methods: character presented with English translation, character presented with a picture of the character meaning, character interpreted with verbal instruction of the character meaning. b. Making mental images about characters may be like imagining a tree when seeing the character 木. c. A part of a character may be like the part 木（tree）in the character 校 (school).

Appendix F

Image Making by Character Questionnaire (Example)

Please answer three questions about the character you just learned.

Character	Questions
19 话	1. Which method did you choose to learn this character? (Please select one) ☐ English translation method ☐ Pictorial method ☐ Verbal interpretation method 2. Why did you choose this method to learn this character? (Please write your reason below.） _____ _____ _____ 3. Did you make mental images of the meaning of the character or parts of the character? ☐ Yes ☐ No If Yes please answer #3.1. If No please don't answer #3.1.

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
3.1 Making mental images of the meaning of the character helped me learn the character.	☐	☐	☐	☐	☐

Appendix G:

Character Writing Sheet (Example)

Please write the 18 characters learned in the study session based on the method used. You can write a maximum of 4 times for each character. Write whatever you remember.

Character 1: Rest

Character 2: 

Character 3:

Character 4:

This character is in the shape of circling water, meaning back.

Character 5: Fear

Character 6:

The character is formed by adding a longer stroke on the upper part of a tree, indicating the tip of the tree.

Appendix H

Semantic Test (Example)

Please compare *a* and *b* in each item. Circle *a* or *b* that better matches the meaning of the character.

1.印

1.1 a. hand b. shake
1.2 a. greet b. print
1. 3 a. paper b. friendly

2. 怕

2.1 a. mouse b. past
2.2 a. memory b. heart
2.3 a. recall b. fear

3.末

3.1 a. earth b. tree
3.2 a. tip b. root
3.3 a. grow b. top

4. 沙

4.1 a. lonely b. river
4.2 a. water b. small
4.3 a. sand b. island

5. 协

5.1 a. ten b. service
5.2 a. govern b. join
5.3 a. office b. group

6. 甘

6.1 a. sugar b. tear
6.2 a. mouth b. sad
6.3 a. sweet b. disaster

7. 冰

7.1 a. ice b. lake
7.2 a. fridge b. drink
7.3 a. water b. clean

8. 功

8.1 a. tool b. laugh
8.2 a. credit b. beauty
8.3 a. work b. humor

9. 血

9.1 a. boil b. drop
9.2 a. cover b. container
9.3 a. blood b. wok

Appendix I

Old-New Character Identification Test

The following are 18 old characters and 18 new characters in random order. Please write YES down below if they are characters that appeared in the experiment (old characters), and write NO if they are characters that didn’t appear in the experiment (new characters).

1. 劫	2. 怕	3 任	4. 沙	5. 秒	6. 刊	7. 甘	8. 困	9. 改
10. 拍	11. 私	12. 犯	13. 却	14. 删	15. 夸	16. 价	17. 伴	18. 形
19. 江	20. 协	21. 内	22. 攻	23. 体	24. 交	25. 回	26. 收	27. 利
28. 介	29. 印	30. 末	31. 册	32. 忆	33. 犹	34. 杉	35. 休	36. 奔

Appendix J

Example Comments in Category (from IMC Questionnaire)

Category	Example Comments	Learning Method
Meaning	· I thought it would be easier to translate it directly from English.	English
	· I learn best through the English translation method.	English
	· The picture sometimes didn't make sense to me.	English
	· I know the right part means water, so I wanted to know the meaning.	English
Image for meaning	· I thought I'd understand the meaning better through a photo.	Pictorial
	· Knowing it in English gives me a mental image.	English
	· It seemed like a character I wouldn't be able to make image of my own.	Pictorial
	· It makes a verbal picture and gives me an imagination.	Verbal
Meaning and image for structure	· I chose this method because it gives me an idea of the meaning and it helps me remember the character.	Verbal
	· Because I can use the picture to memorize the placement scene that the components are supposed to make.	Pictorial
	· Knowing the meaning of both components is very helpful.	Verbal
	· It explains the parts of the character and I'm able to remember it as long as I remember what the verbal said.	Verbal
Others*	· Because it is easier.	Pictorial
	· I randomly chose one.	Pictorial
	· It's the hardest method, so I wanted to see if I could do it.	English
	· Decided to change things up and not go with the English meaning	Verbal

Note. All the comments that did not fit in the first three categories belong to the Other category.