The Effect of Instructional Embodiment Designs on Chinese Language Learning: The Use of Embodied Animation for Beginning Learners of Chinese Characters

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ABSTRACT

The Effect of Instructional Embodiment Designs on Chinese Language Learning:
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The focus of this study was an investigation of the effects of embodied animation on the retention outcomes of Chinese character learning (CCL) for beginning learners of Chinese as a Foreign Language (CFL).

Chinese characters have three main features: semantic meaning, pronunciation, and written form. Chinese characters are different from English words in that they are non-alphabetic orthographies. Though popular, they are deemed very hard to learn. However, Chinese character processing is found to be neurologically related to human body movements, or at least the imagination of them. Literature also indicated the importance of embodied cognition, imagination, and technology use in human language memory and learning. The design of embodied animation for a computer-based CCL program is developed which consists of three types of characters.

The study used Between-Subject Post-test Only Control Group experimental design with sixty-nine adults. The study compared five learning conditions: embodied animation learning (EAL), human-image animation learning (HAL), object-image animation learning, no-animation etymology learning, and traditional learning (serving as a control group). Participants in the EAL group perceived the character etymological

animation, and then a video clip depicting the moving actions of human body movements and/or gestures which show the semantic meaning and the written form of the character.

The study found that the EAL group outperformed the other learning groups with medium to large effects. Specifically, after one week of learning, the EAL group outperformed the other groups in terms of learners' free recall of Chinese characters, in characters' meaning-form mappings, and in characters' form-meaning and-sound mappings. Furthermore, the EAL group performed better than the other groups in the retention of all three types of characters (i.e., pictograph, indicative, and ideograph). Therefore, findings revealed the positive effects of embodied animation on CCL. In addition, the HAL group showed promising retention rate by constantly performing the second best in all tasks. The study also revealed that pictographs and indicatives were better learned than ideographs across groups. Drawing from the study, the use of embodied animation in a computer-based program is suggested to be effective on character learning for beginning learners of CFL.

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ACKNOWLEDGEMENTS

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DEDICATION

For my parents, Hon. Kingdom Jing-Jenn Lu and Emily Chun-Luan Lu, who always love, support, and care about me, as well as expect me to accomplish greater self-realization. For Jessica, my wife, who firmly stands by my side whether or not we face storms, tsunamis, or life tests. For Benjamin, my son, whose curiosity and hunger for learning have encouraged my exploration for more knowledge in human world.

CHAPTER I.

INTRODUCTION

> All meaningful and lasting change starts first in
> your imagination and then works its way out.
> Imagination is more important than knowledge.
> -Albert Einstein (1879-1955)

Can learners of Chinese use their imagination to learn Chinese? A critical aspect of Chinese language learning is to learn Chinese words— characters. How can we help individuals learn Chinese characters by using their imagination? And what should learners imagine in order to successfully learn Chinese characters?

Purpose of the Study

The primary aim of my study is to investigate Chinese character learning (CCL) using embodied animation (EA) — an imagination learning tool of body movements, gestures, or actions for learning Chinese characters.

Importance of the Study

The Most Popular Language in the World

Chinese is one of the oldest language systems in the world. In addition, as estimated by *Ethnologue: Languages of the World* (Lewis, 2009), Chinese is currently the most widely spoken language in the world, with over 1.2 billion speakers (an estimated 845 million of whom are native speakers). In terms of the number of native speakers in the world, the second most widely spoken language in the world is Hindi/ Urdu, which has fewer than half of the native speakers of Mandarin Chinese. The third and fourth most widely spoken languages are Spanish and English, which have about one-third of the speakers of Mandarin Chinese. *Figure 1* shows the top nine languages in the world (as measured by the number of native speakers).

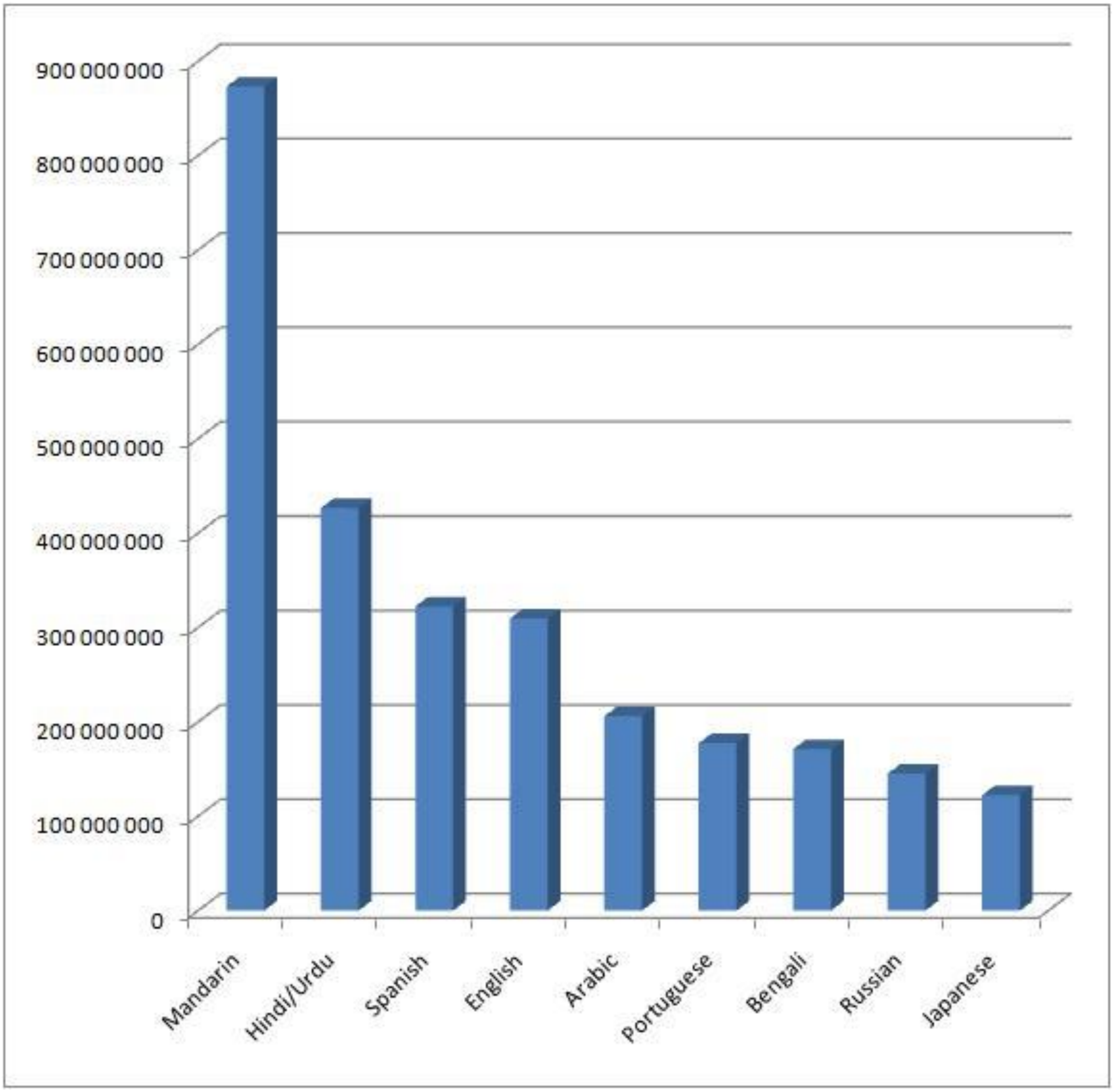

Figure 1. Bar Chart of the Top Nine Native Speaking Languages in the World (Lewis, 2009)

In the United States, Chinese is growing more popular as well. From several reports and stories in *The New York Times* (2008, 2010), Chinese language classes offered in K-12 schools have expanded rapidly in recent years, while the number of other foreign language classes has declined. According to a national K-12 foreign language survey conducted by the Center for Applied Linguistics from September 2006 to August 2009, the growth of Chinese language courses has allowed Chinese to outpace all other foreign languages offered in K-12 schools across the nation (Rhodes & Pufahl, 2009). *Figure 2* illustrates the growth of Chinese language courses.

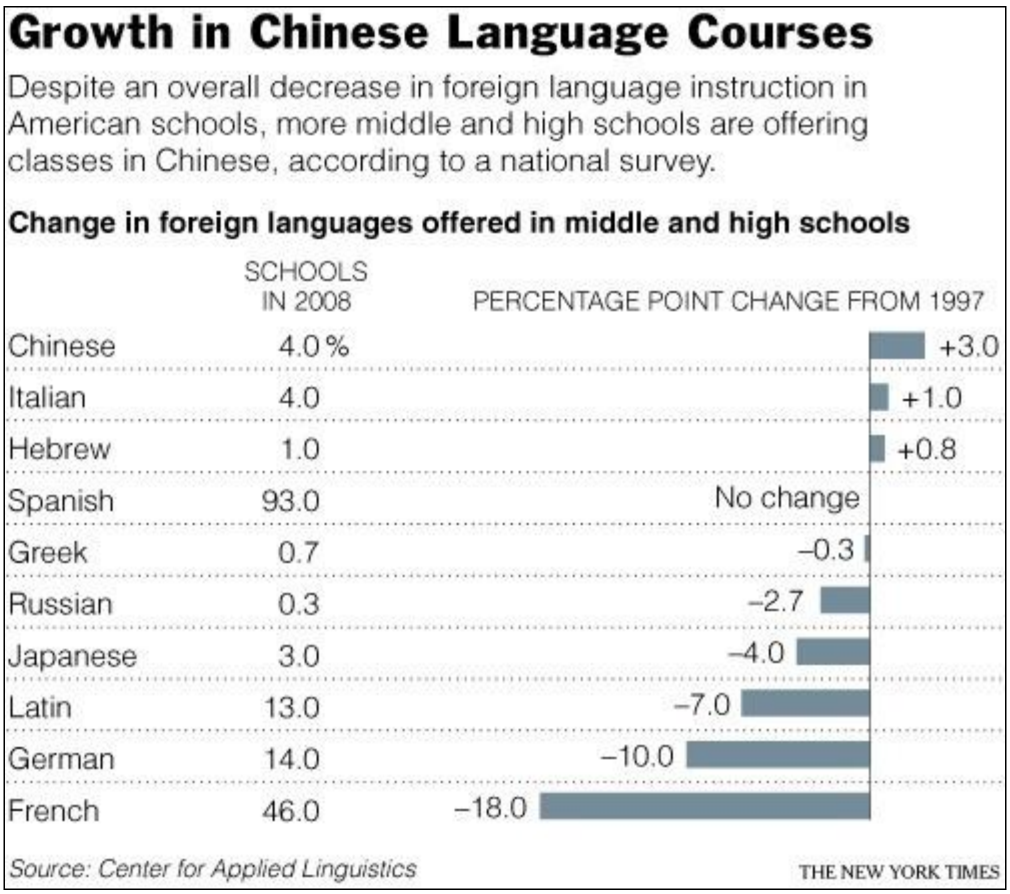

Figure 2. Growth in Chinese Language Courses in Middle and High Schools (*The New York Times*, 2010)

In fact, several years ago, school districts of numerous parts of Connecticut, New

Jersey, and New York have begun to hire many teachers of Chinese (*The New York Times*, 2008). What has been happening in these regions reflects a national trend. The number of Chinese language programs in pre-K through 12th grade in the U.S. has risen by almost 200 percent since 2004, according to the Asia Society (*The New York Times*, 2008).

Also, Chinese was expected to be the third-most popular Advanced Placement language exam in 2010 (*The New York Times*, 2010), according to Trevor Packer, the vice president of the College Board: "Other indicators point to the same trend. The number of students taking the Advanced Placement test in Chinese, introduced in 2007, has grown so fast that it is likely to pass German this year as the third most-tested A.P. language, after Spanish and French." He also stated that "We've all been surprised that in such a short time Chinese would grow to surpass A.P. German" (Dillon, S. *The New York Times*, 2010).

Similarly, Chinese has become a very popular choice for U.S. college students. The Modern Language Association (MLA) found that Chinese language course enrollment rose 51 percent from 2002 to 2006 (Furman, Goldberg, & Lusin, 2007). The MLA found in its survey of 2,795 institutions of higher learning, representing about two-thirds of all such institutions in the United States of America, 34,153 students were studying the Chinese language at colleges and universities in 2002, and that this number had grown to 51,582 students in 2006 (Furman, Goldberg, & Lusin, 2007). This makes Chinese the second fastest-growing foreign language, behind only Arabic, in college enrollment. *Table 1* shows the top 10 most-studied foreign languages in U.S.

universities and their ranks by percent change from 2002 to 2006.

Table 1. Most Studied Foreign Languages in U.S. Universities

Language		**Fall 2006 enrollments**	**% change from 2002**	**Rank by % change**
1.	Spanish	822,985	10.3 %	6
2.	French	206,426	2.2 %	10
3.	German	94,264	3.5 %	9
4.	ASL	78,829	29.7 %	3
5.	Italian	78,368	22.6 %	5
6.	Japanese	66,605	27.5 %	4
7.	Chinese	51,582	51.0 %	2
8.	Latin	32,191	7.9 %	7
9.	Russian	24,845	3.9 %	8
10.	Arabic	23,974	126.5 %	1

Source: Association of Department of Foreign Languages at the Modern Language Association, *Foreign Language Enrollments in United States Institutions of Higher Education, Fall 2006*

In addition to this upward trend of Chinese language learning in K-12 schools and U.S. colleges (Furman, Goldberg & Lusin, 2007), Chinese language learning is also being emphasized by U.S. policymakers (e.g., The White House, 2009) and the American Council on the Teaching of Foreign Language (1999). The executive director of the

MLA, Rosemary G. Feal, has also said, “This [Chinese language learning] has just exploded all over the country” (*The New York Times*, 2008). Clearly, the popularity of Chinese language learning is obvious and indisputable.

The Difficulty of Learning Chinese

Despite the fact that over one-fifth of the world’s population, or over one billion people, speak some form of Chinese as their native language, Chinese is widely considered a language that is both hard to learn and hard to teach (Baxter, 2006; Moser, 1991; DeFrancis, 1966; Lu, Wu, Fadjo & Black, 2010). Moreover, although Mandarin Chinese is the world’s most widely spoken language (Lewis, 2009), many people believe that Chinese is one of the most challenging languages in the world, especially for native speakers of English (e.g., Baxter, 2006; Moser, 1991), most probably due to its irregular morphology and unsystematic morphophonemics (Everson, 1998). For example, the Defense Language Institute in Monterey, California, categorizes the languages it teaches into four groups as measured by the time of instruction required to bring learners to a certain level of proficiency. Chinese is categorized as one of the hardest languages: it is estimated that 1,320 hours of instruction are required for a student with average language aptitude to reach level 2 proficiency, whereas other languages, such as Dutch, French, and Swedish, require only 480 hours of instruction for a student with average language aptitude to reach the same level of proficiency. Furthermore, after 720 hours of instruction, a student with superior language aptitude would attain level 3 proficiency in these languages – but only level 1 in Chinese (Baxter, 2006).

Many researchers and learners of Chinese as a Foreign Language (CFL) have acknowledged the difficulty of the Chinese language. It is not only hard for non-native speakers of Chinese, but also for native Chinese people in terms of the teaching and learning of Chinese characters (Moser, 1991). For example, DeFrancis' (1984) Chinese colleagues estimated that "it takes 7-8 years for a native Mandarin speaker to learn to read and write three thousand characters," whereas his French and Spanish colleagues estimated that "learners can achieve comparable levels in 3-4 years" (Moser, 1991, p. 60). In general, Chinese is hard because the writing system is complex; the language consists of intricate strokes that resemble calligraphy; the writing system is not very phonetic; cognates are vague, unhelpful and uncommon; looking up words in the dictionary is complicated; classical Chinese (as opposed to modern and simplified) is often used; there are too many different Romanization methods; there are five tones in Mandarin Chinese (but eight in Taiwanese and nine in Cantonese); memorizing Chinese characters is hard; and a cultural barrier often exists for would-be learners (Moser, 1991; DeFrancis, 1966, 1984, & 1989; Mair, 1986; Kennedy, 1964). Indeed, when it comes to the issue of why Chinese is so hard, many of the reasons are closely-related to its logographic writing system and its difficult-to-recognize characters.

Due to the difficulty of learning Chinese characters, learners of CFL show a motivational decline in their learning after their first semester and/or when Chinese characters are introduced (as opposed to Pinyin, which are Chinese characters transliterated into the Latin alphabet) (Branner, 2009; Li, 1996). Thus, there is a clear need to develop more effective systems for learning Chinese characters.

Traditionally, in regard to CFL learning, rote memorization or constant repetition has been emphasized to master the target language. Therefore, CFL learners have had to do a lot of repetitive writing and dictation, which make Chinese learning "very mechanical, uninteresting, and stressful" (Ki, et al., 2003, p. 54). In addition, learners of CFL may have learned some Pinyin, so they may be able to speak some Chinese. But they cannot read or write Chinese. For example, a learner of CFL, after learning some pinyin, may express the sentences "How are you?" and "Thank you" (in "Ni hao ma?" and "Xie xie," respectively), but he or she may not be able to read or write "你好嗎?" and "謝謝, " respectively, or even recognize these words in print or on a computer screen. Therefore, designing and developing good programs that help beginning learners of CFL better learn Chinese characters seems essential.

A New Approach to Chinese Character Learning

To tackle the issue of learners' inability to learn Chinese characters well in the early stages, I propose a new approach to Chinese character learning (CLL) for beginning learners of CFL. I have developed a computer-based CCL program that seeks to use what I call "embodied animation" (EA) to help beginning learners of CFL better learn Chinese characters.

Animation, in this context, refers to the display of a sequence of images that creates an optical illusion of movement. Embodiment is a cognitive term meant to emphasize the role of the body and imagination in learning, cognition, and the shaping of the mind. "Embodied Animation" is thus animation that contains bodily movements, gestures, or expressions in a motion picture or video. In this study, EA for CCL is developed and designed to depict the written form and semantic meaning of given characters.

Overview of Dissertation

This dissertation is organized into five chapters. Chapter II provides a review of the literature relevant to my dissertation. I first introduce Chinese characters. Concepts and related theories of instructional embodiment in Embodied Cognition are then presented. The designs of existing computer-assisted language learning programs for Chinese characters are also discussed. Then I reveal neurological evidence for the use of embodied animation for CCL. I also describe the design of embodied animation for the CCL program, before concluding with two research questions on the effect of using different types of instructional support to aid in the learning of Chinese characters.

Chapter III describes the pilot study and its results. The experiment compared EA to two other learning conditions. The pilot study helped develop measures and improve main study designs.

Chapter IV describes the main study itself and its findings. The experiment investigated the effect of the use of embodied animation in CCL by comparing it to four other learning conditions. The main study reveals that the use of embodied animation is a superior method for learning Chinese characters in that students learn characters best through perceiving embodied animations and through the imagination of body movements, gestures, or actions. The chapter provides a summary of the main study results and relates the empirical findings to the research questions. The limitations of the study are discussed.

Chapter V discusses the theoretical implications and practical applications of the findings. The chapter concludes by offering possible directions for future research.

CHAPTER II.

LITERATURE REVIEW

This chapter reviews related literature and consists of five sections:

Section 1. Chinese Characters: In this section, I discuss language acquisition and second language (L2) learning, introduce Chinese characters, and provide arguments for elements that should be included in the computer-assisted language learning (CALL) program for CCL.

Section 2. Embodied Cognition: In this section, I review the literature about grounded and embodied cognition, imagination in learning contexts, and the notion of instructional embodiment. I then examine the connection between embodied cognition and language learning, and present empirical evidence for embodied cognition.

Section 3. CALL and Other Technological Designs for CCL: In this section, I review what CALL entails and examine previous designs of computer-based programs using animations for CCL.

Section 4. Neurological Evidence for the Use of Embodied Animations in CCL: In this section, I review neuro-imaging studies in Chinese processing and provide evidence for the use of embodied animations in CCL.

Section 5. Design of Embodied Animations for CCL: In this section, I describe the construct of embodied animation and illustrate the design of embodied animations for CCL in a CALL program. At last, I summarize the literature review.

Section 1. Chinese Characters

Language Acquisition and L2 Learning

Language can be viewed as an organized means of word combinations for use in human communication (Tomasello, 1999; Sternberg & Ben-Zeev, 2001). From a cognitive viewpoint, a language is a system that encodes and decodes information, and achieves the purpose of human communication. Many researchers mutually agree upon six principal properties of language: "communicative; arbitrarily symbolic; regularly structured; structured at multiple levels; productive; and evolving" (Brown, 1965; Clark & Clark, 1977; Clucksberg & Dank, 1975; cited in Sternberg & Ben-Zeev, 2001, p 197). Language is communicative because it allows people to transmit ideas with others who share the same language. The arbitrary symbols of a language can refer to a certain thing, idea, thought, or description. Language has a structure in which certain arrangements of symbols create certain meanings. Language is also structured at multiple levels in that meaning utterance can be analyzed at several levels. Lastly, people can produce language, create new words and meanings, and modify language usage (Sternberg & Ben-Zeev, 2001).

Chomsky (1965, 1972) has proposed an innate language-acquisition device (LAD) that humans have for acquiring language. Humans are naturally able to learn languages through many different processing mechanisms. For example, when we learn a language, we can do hypothesis testing, which suggests the integration of nature and nurture. Humans acquire language "by mentally forming tentative hypotheses regarding language on the basis of their inherited facility for language acquisition (nature) and then testing these hypotheses in the environment (nurture)" (Sternberg & Ben-Zeev, 2001, p. 212). To form hypotheses, we follow certain operating principles: 1. patterns of changes in word forms; 2. morphemic inflections that inform changes in meaning, especially suffixes in English; and, 3. sequences of morphemes, including both the affixes and roots and the sequences of words in sentences (Sternberg & Ben-Zeev, 2001). We then test our hypotheses by using the language in the real world.

However, unlike the natural acquisition of a primary or first language where a human being usually progresses through stages of cooing, babbling, holophrases, two-word utterances, and basic adult sentence structure, a human individual learns a second language (L2) or a foreign language (FL) with his or her first language (L1) as a foundation (Nunan, 1987). L1 is an important external factor that influences the "development of language proficiency" (Nunan, 1987, p. 47). Based on what we, as humans, know about our first language, we subsequently try to learn a new target language. Therefore, when our L1 and the L2 are very different in nature, language learning or teaching becomes a challenge. Specifically, the fact that the writing system of Chinese characters, a logographic system, is vastly different from that of most other human languages, which are either a syllabic system (e.g., Korean or Japanese) or an individual sounds system (e.g., German, French, or English), has made the teaching of Chinese a challenge for educators, and language acquisition and learning for learners difficult. As CFL learning and English as a Foreign Language (EFL) learning are different in nature, teachers teaching Chinese characters should be aware of their uniqueness and think of effective ways to teach them (Lu, Wu, Fadjo, & Black, 2010).

Knowing a Word

When learning a word, it is necessary to first know what "knowing a word" means. Researchers have different definitions for lexical knowledge. The earliest definition of knowing a word comes from Cronbach's (1942) discussion of the dimensions of knowing a word: generalization, application, breadth, precision, and availability. Generalization is a learner's capability of defining a word. Application refers to the ability to recognize situations appropriate to the word. Breadth refers to the knowledge of multiple meanings. To be able to apply a word correctly to all situations is precision. The ability to use the word in thinking and discourse is availability. Therefore, knowing a word is more complex than merely knowing its definition. In L2 vocabulary learning research, researchers provide a fundamental and comprehensive definition of vocabulary knowledge where several attributes are included: frequency of occurrence, word register, word collocation, word morphology, word semantics, word polysemy, the relationship of sound to spelling, and knowledge of the equivalency of the word in the mother tongue (Richards, 1976; Taylor, 1990; Nation, 1990).

Nevertheless, a generally accepted understanding of the concept of knowing a word has moved from being able to receptively recognize a word to being able to productively use it (Laufer, 1990; Palmberg, 1987; Corson, 1983). This active/ productive and passive/ receptive distinction is made by almost all the lexicologists and lexical knowledge models in linguistics (Ortapisirici, 2007). Researchers also generally agree that a learner's receptive lexical knowledge develops before productive lexical knowledge; a learner's receptive vocabulary is larger than his or her controlled productive vocabulary; when the number of receptive vocabulary increases, the number of productive vocabulary also increases; receptive vocabulary is needed for listening and reading whereas productive vocabulary is needed for speaking and writing; and the free usage of learners' known vocabulary items takes place later after their acquisition phase of these items (e.g., Laufer, 1990; Laufer & Paribakht, 1998; Schmitt, 2000; Schmitt, N. & Schmitt, D., 1995; Schmitt & Zimmerman, 2002; Nation, 2001).

In CFL, knowing a character is therefore two-folds. Receptively speaking, a learner should be able to recognize and understand at least some features of the target character when presented with its form, meaning, or sound. Productively speaking, a learner should be able to write down the character's written form, pronounce the character, or use the character correctly in context. Both types of knowledge are important to CCL. For example, in terms of written form, a learner should be able to answer both the receptive question of "what does the character look like?" and the productive question of "how is the character written?" Similarly, for the use of grammatical functions as another example, a successful learner should be able to possess both the receptive knowledge of what patterns this character occurs in and the productive knowledge of what patterns s/he must use this character in.

As receptive knowledge comes before productive knowledge in vocabulary learning, beginning learners of CCL first learn characters in isolation before in context. Beginning CCL learners in the initial learning phase focus more on the features of a character and encode them in a more isolated way, which is different from actively using those features of a character or even known characters in a later, more contextual learning phase. For example, in terms of form and meaning, it would be difficult and not-so-reasonable for beginning learners of CCL to first acquire the productive knowledge (i.e., what word form can be used to express this meaning?) if they do not even carry the receptive knowledge of the word (i.e., what meaning does this word form signal?) (Nation, 2001). In addition, CFL learners do not have the sufficient amount of exposure and opportunity to experience language input in terms of both quantity and quality, and this may be regarded as a constraint in the contextual transfer phase of learning. Therefore, for beginning learners' CCL in their initial learning phase, placing emphasis on each isolated characters and their features seems to be practical and necessary.

Chinese Characters

To design effective computer-assisted language learning (CALL) programs for beginning learners of Chinese characters, one has to know the basics of Chinese characters. For example, what constitutes a Chinese character? Why are Chinese characters so different from other words or writing systems? How many Chinese characters are there? And among the characters, what characters should be first introduced to beginning learners of CFL in the program? Which types of characters are the most important and valuable for beginners to learn?

What is a Chinese Character?

The basic unit of written Chinese is a *character* or *zi* (字). A written Chinese word can consist of one or more characters, with the typical word consisting of two characters. Chinese characters are nonalphabetic orthography words that are formed and written in a specific logographic format. A Chinese character is also called and known as a *Han word* or *Han character* (i.e., 汉字 in Simplified Chinese, or 漢字 in Standard Traditional Chinese; both are written and pronounced [*Hànzì*] in Pinyin). Each Chinese character corresponds to one syllable and one morpheme. A character is a logograph used in written Taiwanese (*Hanji*), written Chinese (*Hanzi*), written Japanese (*Kanji*), written Korean (*Hanja*), and written Vietnamese (*hán tự*). A logograph, or logogram, is a grapheme which represents a word or one or more morphemes. Since it is a written or pictorial symbol that is used to represent an entire word, it is therefore unlike a phonogram, which represents phonemes, or phonetic sounds. Thus, as a logographic writing system, Chinese characters are very different from other writing systems, such as a syllabic system (e.g., Korean or Japanese) or an individual sounds system (e.g., French, Spanish, or English). Chinese characters are also known as sinographs, and the Chinese writing system as sinography (DeFrancis, 1989; Li, 1993; Li, 1977; Norman, 1988).

Number of Chinese Characters

Through surveying glossaries, corpora, thesauri, and dictionaries from past to present, we see there has been an increase in the number of characters due to the need of communication and evolution of language use (Norman, 1988; see Table 2 below).

Though the oldest extant Chinese glossary is the *Erya* (or *Erh-ya;* 爾雅) from the 3rd century BC with 2,094 entries, about 4,300 words, and a total of 13,113 characters (Karlgren, 1931), the first dictionary that analyzes the structure of characters and defines the words represented by them is Xu Shen's (Shu Shen) (100 A.D.) *Shuowen Jiezi* (or *Shuo-wen chieh-tzu*; 說文解字), "Explaining Simple and Analyzing Compound Characters," which contains 9,353 characters (Coblin, 1978; Serruys, 1984). It is the first book that provides rationales and describes the etymologies of the characters. In addition, it is the first to use the principle of organization by semantically meaningful parts of shared components, which are also known as *radicals, significances, or Bu-shou* (部首) (Boltz, 1993). In *Shuowen Jiezi*, there are 540 radicals in total (see Appendix 0). *Yupian* (玉篇) contains 12,158 character entries under 542 radicals, and *Qieyun* (切韻) includes 16,917 characters. The number of characters increased dramatically in *Guangyun* (廣韻), *Jiyun* (集韻), *Zihui* (字彙; with 214 radicals), *Kangxi Zidian* (康熙字典; with 214 radicals), *Zhonghua Da Zidian* (中華大字典; with 214 radicals), *Hanyu Da Zidian* (漢語大字典), *Zhonghua Zihai* (中華字海), and *Yitizi Zidian* (異體字字典).

Year	Name of Dictionary	Number of Characters
100	*Shuowen Jiezi*	9,353
543	*Yupian*	12,158
601	*Qieyun*	16,917
1011	*Guangyun*	26,194
1039	*Jiyun*	53,525
1615	*Zihui*	33,179
1716	*Kangxi Zidian*	47,035
1915	*Zhonghua Da Zidian*	48,000
1989	*Hanyu Da Zidian*	54,678
1994	*Zhonghua Zihai*	85,568
2004	*Yitizi Zidian*	106,230

Table 2- Number of Characters in Different Dictionaries

Depending on how one counts variants, there are approximately 100,000 characters that are currently in use. However, there are only numbered at about 4,000 to 5,000 commonly used characters. In the People's Republic of China, the *Xiàndài Hànyǔ Chángyòng Zìbiǎo* (现代汉语常用字表; Chart of Common Characters of the Modern Han Language) lists 2,500 common characters and 1,000 less-than-common characters, while the *Xiàndài Hànyǔ Tōngyòng Zìbiǎo* (现代汉语通用字表; Chart of Generally Utilized Characters of the Modern Han Language) lists 7,000 characters, including the 3,500 characters already listed above. In Taiwan, the Ministry of Education's *Chángyòng Guózì Biāozhǔn Zìtǐ Biǎo* (常用國字標準字體表; Chart of

Standard Forms of Common National Characters) lists 4,808 characters; the *Cì Chángyòng Guózì Biāozhŭn Zìtĭ Biăo* (次常用國字標準字體表; Chart of Standard Forms of Less-Than-Common National Characters) lists another 6,341 characters. In Hong Kong, the Education and Manpower Bureau's *Soengjung Zi Zijing Biu* (常用字字形表, Chart of Common Characters' Forms) lists a total of 4,759 characters for use in elementary school and junior high school education.

Chinese Orthography

Each Chinese character usually takes up roughly the same amount of space, due to a character's block-like, square-shape nature. Beginning learners therefore typically learn by practicing writing with a grid as a guide (Chen, 2005). In addition to strictness in the amount of space a character takes up, Chinese characters are written with precise rules in traditional Chinese language education. The three most important rules in traditional learning were the strokes employed, stroke placement, and the stroke order.

According to the orthographic depth hypothesis (Katz & Feldman, 1983; Katz & Frost, 1992), which postulates orthographic depth as an index of the degree to which orthographies can regularly and systematically represent script-to-phoneme correspondence, Chinese has a deeper orthographic system than English does in that Chinese is more inconsistent and irregular in how the characters map speech onto print. It is therefore more difficult to support word recognition processes that involve Chinese phonology. English words, on the other hand, have more easily recoverable phonological representations and can mediate more efficiently between print and lexicon.

Thus, a language with more orthographic depth, like Chinese, requires more attention to a printed word's visual orthographic structure than Spanish or English due to its inconsistencies and irregularities between spelling and pronunciation (Everson, 1998).

Chinese is considered a logography, in which characters represent words or morphemes. If we look into Chinese characters, we see that many exist with irregular morphology and unsystematic morphophonemics (Everson, 1998). However, DeFrancis (1989) argues that the term is misleading and suggests that Chinese be termed *logographic-phonetic* since pictographic characters comprise a small percentage of Chinese characters in use today (Everson, 1998). Zhu (1987; quoted in Everson, 1989) estimates that approximately 90% of Chinese characters are compound characters because these characters consist of two elements, one of which represents meaning (i.e., a "radical" or "significant") and the other of which shows pronunciation clues (i.e., a "phonetic"). Nevertheless, only "26 % of [these] compound characters are pronounced just like their phonetic elements" (Zhu, 1987, cited in Everson, 1989, p. 197). In fact, the approximated 90% of logographic-phonetic Chinese characters that DeFrancis (1989) and Zhu (1987) propose fall into the category of semantic-phonetic compound type of characters, and the semantic component of these characters comes from the categories of pictographs, indicatives, and ideographs.

Types of Chinese Characters

As far as Chinese character types are concerned, the characters were first classified by the Chinese linguist Xu Shen, whose etymological dictionary *Shuowen*

Jiezi divides the script into six categories, namely the *liùshū* (六書) (Boltz, 1994; Gou, 1986). These six types of characters are:

(1) Pictographs (pictograms; hieroglyphs): Pictographs are characters that were created from images or pictures of objects. Pictographs are derived from images of nature, animals, and humans. Examples include wood/ tree (木), fire (火), mountain (山), heart (心), human (人), eye (目), fish (魚), sun (日), moon (月), knife (刀), dog (犬)… etc. Pictographs represent fewer than 5% of modern characters (Chen, 2005), as Xu Shen estimated that 4% of characters fall into this category.

(2) Indicatives (simple indicatives; simple ideographs): Indicatives are characters formed with indicating symbols or indicating functions. They are usually composed of a pictograph and a symbol for complete indication. Examples include 中 (in the middle), 上 (above; on the top), 下 (below; underneath), 大 (big; large; huge), 小 (small; little), 刃 (blade)… etc. There are only a few characters that fall into this category.

(3) Ideographs (ideograms; compound ideographs; ideogrammic compounds; logical aggregates): Ideographs "denote the elements in an event or complex idea" (Chen, 2005, p. 11). These characters usually combine two pictographs or one pictograph and one simple ideograph to symbolically create a third character. For instance, doubling the pictograph 木 (wood; tree) produces 林 (forest; grove). Similarly, combining 日 (sun) and 月 (moon), the two natural sources of light, makes the character 明, which means "bright." Examples in this category include 比 (to compare; comparison), 看 (to watch; to view; to see), 告 (to tell; to speak; to say), 長 (long;

length), 去 (to leave; to go); 舟 (boat; ship); 林 (forest; grove; woods); 尖 (sharp) and so forth. Xu Shen estimated that 13% of characters fall into this category.

(4) Semantic-phonetic compound characters (phono-semantic compounds; pictophonetic compounds): These characters are generally composed of two parts: a radical component that suggests the general meaning of the character, and a phonetic component that provides pronunciation information for the target character (Li, 1977; Taylor & Taylor, 1995). In most cases, the radical component "entails the conceptual category of the character" (Chen, 2005, p. 11). For example, 踢 (kick), 跑 (run), and 跳 (jump) are among the many characters that contain the foot radical 足 (foot; feet; leg) on the left hand side of the character. In addition, the phonetic components 易 [yi4], 包 [bao1], 兆 [chao4] provide clues for the pronunciation of the characters 踢 [ti1], 跑 [pao3], and 跳 [tiao4], respectively. Similarly, all of these 炒 (to stir-fry), 炸 (to fry; to deep-fry; to explode; to bomb), and 炮 (firecracker; cannon; roast; bake) characters have a radical 火 of four short strokes on the left, which is a simplified pictograph for fire, indicating that the character has a semantic connection with fire. The right-hand side in each case is a phonetic indicator. Therefore, these phonetics, 少 [shao3], 乍 [cha4], and 包[bao1] provide pronunciation clue to the characters 炒 [chao3], 炸 [cha4], and 炮 [bao1; pao4; pao2], respectively. Xu Shen estimated approximately 82% of characters fall into this category, while in the Kangxi Dictionary (Kangxi Zidian; Zhang, 1979) the number is closer to 90%, due to the productive use of this semantic-phonetic technique to extend the Chinese vocabulary over the centuries. Many chemistry- and radiation-related characters are formed as semantic-phonetic compounds

as this method is still used to create new modern characters. For example, the chemistry-related character 鋰 (lithium) is the metal radical 金 plus the phonetic component 里 [li], which shows both its meaning and its pronunciation. A similar radiation-related character 鈾 (uranium) also has the same word-forming structure. It should be noted that a small percentage of characters in this category are irregular characters in which the radical provides no information about the character's semantic meaning. In addition, Yin (1991) finds that of all the phonetic components in Chinese characters, only 36% indicate clear information about a character's pronunciation, while 48% indicate partial information, and 16% indicate no relevant information.

(5) Transformed Cognates (Analogous characters): Transformed cognates are usually transformed from old characters and carry a similar meaning. They originally did not represent the same meaning but have bifurcated through orthographic reform and/ or semantic drift. For example, 項 [dieng3] and 顛 [dian1] both mean "top"; and 考 [kao3](to verify) and 老 [lao3](old) were once the same character, meaning "elderly person". Characters in this category are very rare.

(6) Loan characters (rebuses; phonetic loans; borrowings): When an existing character is used to represent an unrelated word with similar pronunciation and the old meaning is then lost completely, the character is categorized as a loan. A loan character is sometimes formed by adopting some part of an existing character. For example, the character 八 [ba1](eight) is detached from the top part of the character 分 [fen1](apart) (Cheng & Tien, 1992). In addition, characters such as 自 [*zì4*], which originally meant "nose" but now exclusively means "self" or "oneself", or 萬 [*wàn4*],

which originally meant “scorpion” but now means “ten thousand” are both loans. However, characters in this category are also very rare.

According to Li (1993), modern Chinese characters can be dichotomously categorized into either simple characters or complex characters. Simple characters cannot be meaningfully divided into sublexical units but can serve as components for constructing complex characters whereas complex characters can be further divided into sublexical units. Examples of simple characters are pictographs and indicatives, such as 口 [kou3] (mouth), 土 [tu3] (earth; soil), and 上 [shang4] (above; on the top). Examples of complex characters are compound ideographs and semantic-phonetic compound characters, such as 森 [sen1] (forest), 城 [cheng2] (wall; city), and 河 [he2] (river). Take the complex character 森 (forest) as an example. It is composed of three simple characters of 木 (wood; tree) to form and become a compound ideograph.

Chinese Phonology

Chinese may refer to 15 mutually unintelligible dialects or languages (Tang & Heuven, 2007). Peking Mandarin (Beijing Mandarin), which is also known as Standard Mandarin or Standard Chinese, is one of the languages and has become the official language called *Guoyu* (“national language”) in Taiwan, *Huayu* (“Han language”) in Malaysia and Singapore, and *Putonghua* (“common speech”) in the People’s Republic of China (PRC). The governments in Taiwan and the PRC developed their own auxiliary phonetic scripts to provide more reliable pronunciation matches for Chinese characters. The PRC system to write the sounds of Mandarin is a Romanized alphabetic system called Pinyin, which literally means "spell-sound." The Pinyin system adopted the 26 English letters in addition to *ü*. The Taiwan system is called Zhu-Yin Fu-Hao (Chu-Yin-Fu-Hao; Bopomofo phonetic symbols), which literally translates to the "annotated sound symbols" system. Zhu-Yin Fu-Hao is a set of arbitrary symbols that are used to represent the initials and finals of the language. There are 37 of these phonetic symbols (their Pinyin phonetic alphabet counterparts are listed in parenthesis):

Consonants:

ㄅ(b) ㄆ(p) ㄇ(m) ㄈ(f) ㄉ(d) ㄊ(t) ㄋ(n) ㄌ(l) ㄍ(g)
ㄎ(k) ㄏ(h) ㄐ(j) ㄑ(q) ㄒ(x) ㄓ(zh) ㄔ(ch) ㄕ(sh) ㄖ(r)
ㄗ(z) ㄘ(c) ㄙ(s)

Vowels:

ㄚ(a) ㄛ(o) ㄜ(e) ㄝ(e) ㄞ(ai) ㄟ(ei) ㄠ(ao) ㄡ(ou) ㄢ
(an) ㄣ(en) ㄤ(ang) ㄥ(eng) ㄦ(er) ㄧ(i) ㄨ(u) ㄩ(ü)

Each Chinese syllable, which denotes the sound of a Chinese character, consists of three components: initial, final, and tone. The initial is the beginning consonant (C) of the onset of a syllable; and the final is the vowel(s) (V) that corresponds to the initial; and the tone is the syllable's pitch which carries semantic meaning of a sound.

Based on the place of articulation, the twenty-one consonants that serve as initials can be divided into 7 categories: (1) bilabial: [b], [p], and [m]; (2) alveolar: [d], [t], [n], and [l]; (3) labio-dental: [f]; (4) dental sibilants: [z], [c], and [s]; (5) velar: [g], [k], and [h]; (6) palatals: [j], [q], and [x]; and (7) retroflexes: [zh], [ch], [sh], and [r]. The sixteen vowels served as finals can be divided into 5 categories: (1) 4 basic vowels: [a]; [o]; [e]; and [e] ([e] is for both ㄜ and ㄝ); (2) 3 medial vowels: [i]; [u]; and [ü]; (3) 4 diphthongs: [ai]; [ei]; [au]; and [ou]; (4) 4 nasal vowels: [an]; [en]; [ang]; and [eng]; and (5) retroflexes vowel: [er]. The five tones in Mandarin Chinese are: first (-), second (ˊ), third (ˇ), fourth (ˋ), and neutral (a dot, "˙", or no tonal marker needed). The tonal markers can also be denoted using Arabic numbers from 1 to 4. The combination of the syllable [ba] with five different tones, depicted by numbers for example, can produce five different characters with different meanings: 八 [ba1] (eight); 拔 [ba2] (pull); 把 [ba3](handle); 爸 [ba4] (father); and 吧 [ba] (sentence-ending expression).

Hsueh (1986) proposed a comprehensive formula to analyze the structure of Chinese syllables: (C)(M)V(E), which means: a Chinese syllable has an onset initial Consonant (C), optionally followed by a Medial (M) final, followed by a nucleus Vowel (V) final, and optionally ended with an Ending (E).

Chinese Morphology

Morphology is the study of the structure and content of word forms, especially the morphemes. Crystal (1997) defines morphology as "the branch of grammar which studies the structure or form of words, primarily through the use of the morpheme construct. It is traditionally distinguished from syntax, which deals with the rules governing the combination of words in sentences" (p. 249). A morpheme is the smallest linguistic unit with semantic meaning. The concept of morpheme differs from the concept of word, since morphemes cannot always stand as words on their own. Morphemes in western alphabetical morphology can be categorized into two types based on whether they can stand alone: free morphemes and bound morphemes whereas Chinese morphemes are classified into four types based on two criteria of whether they are free or bound morphemes and whether they are content (lexical) or function (grammatical) morphemes: (1) function word (+ free, + function), (2) root word (+ free, - function), (3) bound root (- free, - function), and (4) affix (- free, + function) (Packard, 2000; Packard & Riley, 1994).

Chen (2005) believes that each character represents one or more free morphemes, and most of the characters can be segmented into smaller parts with semantic meaning. Although a semantic radical of Chinese characters might not be regarded as a morpheme, it is a strong cue to the meaning of the character. Some researchers further argue that the radicals of Chinese characters are not only one aspect of the morphological structure of Chinese words, but also serve as basic morpheme units (Shu & Anderson, 1997) as radicals can disambiguate meanings among a large number of homophones. Therefore, many researchers have indicated that the understanding of the internal structure of the characters is important to the learning of Chinese characters and Chinese writing system (Li *et al.*, 2002; Nagy *et al.*, 2002; Shu & Anderson, 1997). A good design of Chinese character learning program, thus, should place emphasis on radicals that carry semantic meanings to Chinese characters.

Chinese Character Features

Zucker and Mathieu (1993) argue that an early familiarization with Chinese character features is a prerequisite for an efficient memorization of CCL and show, in their model of MEMOCAR approach to CCL, that there are three main Chinese character features: written form, meaning, and pronunciation. *Figure 3* shows the conceptual graph representation of Chinese character features in the MEMOCAR design, where the three main Chinese character features are illustrated (Sowa, 1984). Researchers in CCL generally acknowledge the importance of beginning learners' knowing these three main Chinese character features (e.g., Ann, 1982; Ahn & Medin, 1992) and agree upon the effectiveness of the incorporation of all three main features in a computer-based CCL program (e.g., Chun & Brandl, 1992; Lam, Ki, Law, Chung, Ko, Ho, & Pun, 2001).

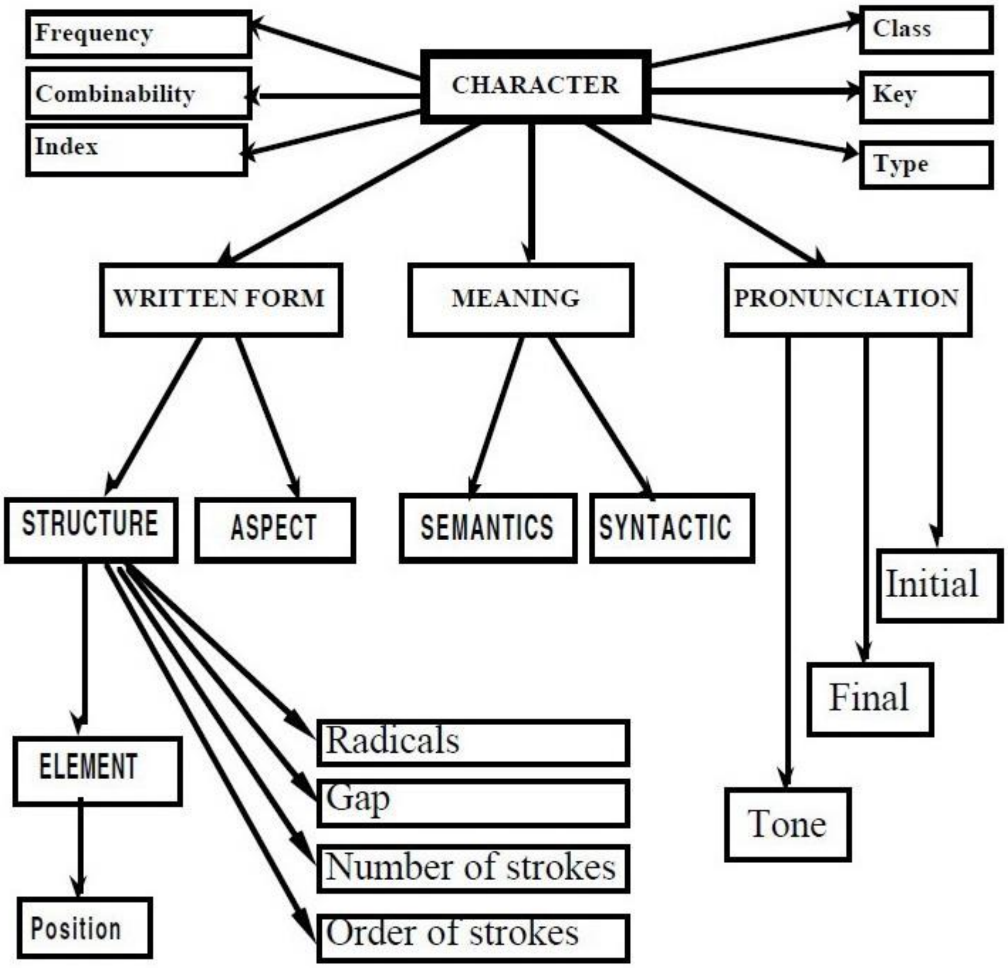

Figure 3- The Conceptual Graph Illustrating the Three Main Chinese Character Features

Visual Complexity of a Chinese Character

Chinese characters, or sinographs, comprise a number of strokes that are packed into a square shape based on stroke assembly rules. Each character contains one to eighty-four strokes and can be written to fit into a square. Therefore, a character can be relatively simple in its visual form if there are only one or a few strokes (*Figures 4* & *5*); or it can be complex if a character comprises many strokes (*Figures 6* & *7*). In fact, characters that have more than 10 strokes are viewed as difficult, and those with more than 20 strokes are considered very complex. The most complex characters are all with many strokes and are very rarely known by even well-educated native Chinese speakers (Lu, Hallman, & Black, 2010). For example, the characters "verbose" [zhe2] (*Figure 8*), the character "a dragon's flying appearance in clouds" [daito] (*Figure 9*), and the character "Shaanxi noodle" [biang2] (*Figure 10*) are considered most complex characters as they are all composed of over 50 strokes.

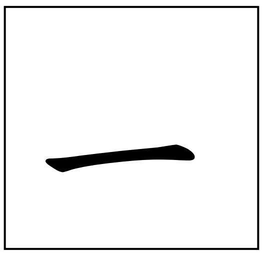

Figure 4- 1 stroke "one"

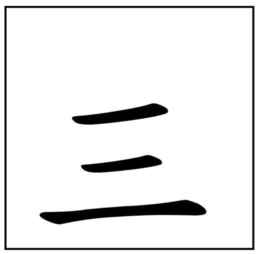

Figure 5- 3 strokes "three"

Figure 6- 16 strokes "black"

Figure 7- 17 strokes "bright"

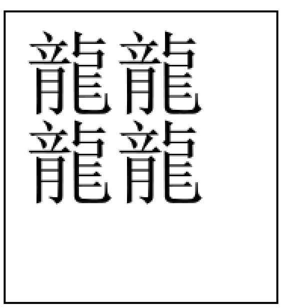

Figure 8- 64 strokes "verbose"

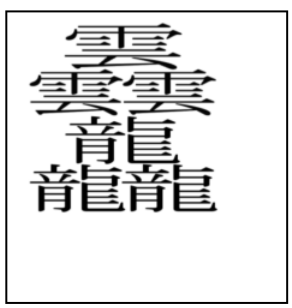

Figure 9- 84 strokes "dragon flying"

Figure 10- 57 strokes "shaanxi noodle"

As the processing of Chinese characters requires fine-grained analyses of the visual-spatial locations of the strokes and other sub-character components such as radicals, the visual complexity of a Chinese character as measured by the number of strokes of the character is an essential factor and should be taken into consideration when the design of an effective Chinese character learning program is concerned (Lu, Hallman, & Black, 2010).

Elements to be Included in the CALL Program for CFL

Lu, Hallman, and Black (2010) have suggested the following elements that are essential for an effective design of a computer-assisted Chinese learning program for beginning learners of Chinese characters. First, to introduce Chinese characters to beginning learners of CFL, it is neither reasonable nor practical to start with characters that are not commonly seen or used. Therefore, among the 100,000+ characters that are in use today, we should first select those that have a high frequency of occurrence. They suggest that a good program for CFL should include Chinese characters that are categorized as common characters with a frequency of occurrence no fewer than 30 per million according to the Modern Chinese Frequency Dictionary (1986).

Second, so far as the types of Chinese characters are concerned, Lu et al. (2010) argue that an effective CCL program should introduce those that are relatively clear in form-meaning mapping mechanism, can be etymologically derived or inferred, or can serve as a component to other more complex or compound characters. Pictographs and indicatives have clear form-meaning mechanisms, can be etymologically derived or inferred from pictures or images of objects, and can serve as radicals of other compound characters. Ideographs can be inferred via their shapes and meaning and can also serve as radicals of other compound characters. In other words, pictographs, indicatives, and ideographs are good choices of characters for beginners and should be introduced to learners first. (See Appendix for a list of all modern Chinese radicals.)

Third, as a Chinese character encompasses three main features (Zucker & Mathieu, 1993; Sowa, 1984), an effective CCL program should include all its features when introducing a character: written form, semantic meaning, and phonology. Learning a Chinese character is just like learning an English word in terms of what should be registered in our memory: the word's form, meaning and pronunciation. For example, when we learn the English word "horse," we should register its spelling of H-O-R-S-E, its meaning of a four-legged mammal that runs, and its pronunciation of [hɔrs] into our long-term memory. Thus, all three features of Chinese characters are important. However, learning a Chinese logograph is different from learning an English alphabet in that the characters take a lot of our visual and spatial areas in the brain (Tan et al., 2001) to analyze the square configuration of a Chinese character's written form. Therefore, when introducing a Chinese character, a good design of CALL for CFL should present and emphasize its written form in a clear and obvious way for better recognition, processing, and meaning-mapping purposes.

Fourth, an effective CCL program should take into consideration the visual complexity of the Chinese characters being introduced, so beginning learners of CCL will not be overwhelmed with extremely complex characters. Since a good measure of the visual complexity of a Chinese character is its number of strokes, Lu et al. (2010) suggest that an effective CCL program choose characters that have eight or fewer strokes to begin with.

Fifth, due to the fact that semantic-phonetic compound characters make up the majority of all modern Chinese characters, an effective design of the CALL program for CFL should systematically and abundantly introduce semantic-phonetic compound characters by connecting pictographs, indicatives, and ideographs to them as these three types of characters can all serve as a part or a component of semantic-phonetic compound characters. Such connections can be in the form of explicit examples, game-like self-advanced transfer tests, or interactive practice drills in the CALL program for CFL.

From what we understand about Chinese characters, what needs to be included in a CALL program for CFL would be: words with higher frequency of occurrence and lower visual complexity, and those that are pictographs, indicatives, or ideographs. Also, good CCL program design should include a character's written form, meaning, and pronunciation, with an emphasis on a clear display of the written form. Last, it should also connect pictographs, indicatives, or ideographs to semantic-phonetic compound characters.

Section 2. Embodied Cognition

Embodied Cognition Theories

Grounded and Embodied Cognition

Grounded cognition appears in many forms and has been widely studied in many fields. In fact, grounded cognition and embodied cognition have many similarities and some researchers have proposed combining the terms (Atkinson, 2010). In his review of grounded cognition, Barsalou (2008) states:

> Conceptions of grounded cognition take many different forms… Some accounts… focus on the roles of the body in cognition, based on widespread findings that bodily states can cause cognitive states and be effects of them… Most accounts of grounded cognition, however, focus on the roles of simulation in cognition… Still other accounts… focus on situated actions, social interaction, and the environment (pp. 618-619).

Grounded cognition, concerned with the role of the body, simulation, environment, and embodiment in cognition, encompasses cognitive linguistics, situated action, simulation and social simulation theories. Research has contributed to the understanding of embodied language, memory, and the representation of knowledge (Barsalou, 2007). Grounded cognition consists of the modal simulations, bodily states, and situated actions and processes that underlie cognition (Barsalou, 2008). Barsalou (2008) further asserts that it should be impossible to have cognition absent of environment and proposes the Perceptual Symbol Systems. Barsalou, Breazeal, and Smith (2007) believe that deep conceptual processing occurs in the simulation system and not merely in the linguistic system. The simulation system in human beings is integrated with the linguistic system, and symbolic capabilities result from interactions between language and simulation. Simulation in cognition is the reenactment of perceptual, motor, and introspective states that are acquired during experience with the world, body, and mind. When an experience occurs, our brain captures states across the modalities, and then integrates them into a multimodal representation, which is then stored in memory (Barsalou, 2007). These multimodal representations that were captured and stored during the initial experience are reactivated when knowledge is needed to represent the category. The reactivated multimodal representations simulate the way the brain initially represented perception, action, and introspection associated with an object (Barsalou, 2007). The simulation mechanisms support cognitive activities.

Similar to Barsalou's (2007; 2008) assertion, Rubin (1995) proposes a Basic Systems Theory, in which he claims that a complex memory contains multimodal components just like the Perceptual Symbol Systems. These components include vision, audition, action, space, affect, and language. When an individual is required to retrieve this complex memory, the retrieval involves simulating its multimodal various components together (Barsalou, 2007).

Embodied cognition is primarily characterized as action and perception in human cognition. Embodiment as an explanation of cognition emphasizes that the body exists as part of the world. In a dynamic process, perception and action occur and the body interacts with the world to allow for the processes of simulation and representation. Glenberg et al. (2004) proposes an embodied cognition hypothesis, the Indexical Hypothesis, which explains how embodiment makes language meaningful. The Indexical Hypothesis suggests that indexing words and phrases to objects or their perceptual symbols is an important component of language learning and comprehension, and meaning making or comprehension requires perceptual symbols that are not amodal or arbitrary symbols. Words or symbols become meaningful language when they simulate the content of sentences.

Clark and Chalmers (1998) propose the term "extended cognition" in an attempt to thoroughly cover the various terms of situated cognition, distributed cognition, grounded cognition, and active externalism. However, they argue that the four propositions that underlie the extended cognition are tightly linked to, if not within, the realm of embodied cognition: (1) cognition is environmental as cognition depends heavily on the external environment; (2) cognition is adaptive because the main purpose of cognition is to facilitate adaptation to an uncertain environment (Barsalou, 2008); (3) the environment is highly structured for cognitive activity; and (4) cognition is shared and distributed.

Gibson (1955; 1966; 1986) described a continuous perception-action cycle, which is dynamic and ongoing. Agents perceive and act with intentionality in the environment at all times. As inspired by Gibson's (1986) perception-and-action theories, Shapiro (2011) claims that embodied cognition focuses on three major aspects: conceptualization, replacement, and constitution. Conceptualization implies that properties of a person's body constrain the ability to acquire and perform. Replacement suggests that the need for representational processes that are believed to be at the core of cognition can be replaced by the person's interaction with the environment. Constitution presupposes that the body and environment have a constitutive role in cognitive processing.

Likewise, Gibbs (2006) argues that perception, concepts, mental imagery, memory, language and reasoning have groundings in embodiment. Gibbs (2006) looks at how people's felt experiences of their bodies in action constitute some fundamental grounding for human cognition and language. He reasons that when our bodies engage the physical and cultural world, our cognition happens. Therefore, to understand human cognition, we should study the dynamical interactions between human beings and the environment. According to Lakoff and Johnson's (1999) suggestion, Gibbs (2006) argues that there are several "levels of personhood that embodiment may refer to: neural events, cognitive unconscious, and phenomenological experience" (p. 10). He further states that, in cognitive science, "embodiment …… refers to understanding the role of an agent's own body in its everyday, situated cognition" (Gibbs, 2006, p. 1). From the empirical evidence he provided, Gibbs (2006) asserts that the mind is embodied. Therefore, the body should not be merely the representation in the somatosensory cortex in the brain; instead, it should be part of our cognitive processing in daily actions. The kinesthetic action of a person has an impact on how he or she thinks, perceives, learns, uses language, and experiences consciousness, feelings, and the world. As Gibbs (2006) puts it, this is "…… because human cognition is fundamentally shaped by embodied experience" (p. 3). He further proposed an "embodiment premise":

> People's subjective, felt experiences of their bodies in action provide part of the fundamental grounding for language and thought. Cognition is what occurs when the body engages the physical, cultural world and must be studied in terms of the dynamical interactions between people and the environment. Human language and thought emerge from recurring patterns of embodied activity that constrain ongoing intelligent behavior. We must not assume cognition to be purely internal, symbolic, computational, and disembodied, but seek out the gross and detailed ways that language and thought are inextricably shaped by embodied action. (p. 9)

To understand the embodied nature of human cognition, Gibbs (2006) urges that researchers specifically look for possible mind-body and language-body connections.

Along the same line, Atkinson (2010) asserts that cognition, perception and motor action are integrated activities. Cognitive representations are embodied and action-oriented. Embodied cognition provides three understandings: simulation, analogical representations, and image schemas. Simulation, as described earlier, is the cognitive "reenactment of perceptual, motor, and introspective states acquired during experience" (Barsalou, 2008). Analogical representations store patterns of how our bodies mesh with the environment. The patterns incorporate environmental information (Glenberg, 1997). Image schemas (Johnson & Rohrer, 2007) are recurrent patterns of bodily experience. They are analog representations based on cumulative sensory experience "that help solve… adaptive problems… in complex physical environments"

(Gibbs, 2006, p. 69).

Glenberg (2010) likens his embodiment framework to all psychological processes that are being influenced by body morphology, sensory systems, motor systems, and emotions. He argues that there are three fundamental elements in embodied cognition. In addition to the element of Barsalou's (2008) Perceptual Symbol Systems in his theory of grounded cognition, one other element emphasizes the contribution of action and cognition to meaning and still another element utilizes the metaphor and language in abstract concept representation. Glenberg (2010) proposes a unifying theory of psychology, in which embodied cognition is central to memory, social psychology, neuroscience, cognitive and social development, language, educational psychology, and other areas, making embodied cognition an integral component of cognition across disciplines (Barsalou, 2010).

Imagination

An Imaginary World involves one's capability to imagine how things could have been different from the way the story plays out (Black, 2007). Imaginary Worlds use visual and spatial imagery to indicate function or action for memory representations.

Based on the premise that "point of view affects narrative comprehension, memory, and production" in the creation of "Storyworlds" (Black, Turner, & Bower, 1979, p. 197) and the notion that narrative point of view can be directly applied to the first-person perspective available within the instruction and development of a particular task, a form of instructional embodiment was created to accommodate the use of imagination in embodiment (i.e., imagined embodiment). In previous studies with three-dimensional virtual worlds (Van Esselstyn & Black, 2001), spatial relationships in functional relations (Hachey, Tsuei, & Black, 2001), and using computer agents to demonstrate students' knowledge (Bai & Black, 2005), learners used various extent of imagination for tasks and student performance was evaluated partially based on spatial task analysis. The concept of an Imaginary World was presented as a way to situated learning in an embodied context, stimulate the learner's imagination, and identify how students demonstrate their understanding of a problem space through spatial relationships.

Lu, Wu, Fadjo, and Black (2010) argue that the use of imagination is effective to comprehend novel concepts and ideas, and has tremendous value in CCL. As has been shown with studies on how students use imagination and demonstrate understanding of a problem space through spatial relationships (Schwartz & Black, 1996; Chan & Black, 2006a, 2006b), the concept of an Imaginary World provides a way for us to situate learning in an embodied context. Black (2007) concludes that, based on the virtual worlds study results where text is spatially located, "the most effective imaginary worlds are the ones where the spatial layout has a meaning and is not just arbitrary" (p. 199).

Glenberg, Gutierrez, Levin, Japuntich, and Kaschak (2004) used a manipulation procedure to ensure the indexing of written words. First and second graders were instructed to read short texts that described characters and actions in three toy scenarios: a farm, a house, and a gas station/garage. Models of the objects were displayed in front of the children. Each child read five sentences and after reading each sentence, the child manipulated the object encountered in the sentence. Glenberg et al. (2004) proposed that to manipulate the right object, the child would have to index the words and phrases to the objects and use the syntax of the sentence to guide the manipulation. After completion of the task and 2 minutes of a distracting conversation task, the children's performance was measured by memory and application tests. In Glenberg et al.'s (2004) first experiment, children were randomly assigned into 3 groups with different kinds of instruction/practice: manipulation, read (no manipulation after children read texts and observed scenarios) and no-practice control. Each group was given a memory test and a transfer test. In their second experiment, the amount of time was controlled by having a reread group read the sentences again so that they spent the same amount of time as the manipulation group. In addition to the memory test, an application test was given which required participants to draw inferences from what they read. This was a reading-comprehension test in addition to the memory test. In their third experiment, the imagined manipulation was introduced. The imagined manipulation group was told to imagine manipulating the objects to practice indexing without explicit manipulation. These children practiced physical manipulation and then were instructed to imagine manipulating a toy scenario. In comparing the reread silently with imagined manipulation, the imagined manipulation resulted in stronger memory and better application than rereading. Children in the imagined manipulation condition could also recall a greater proportion of critical sentences as compared to the reread group and they answered more spatial inference questions correctly.

In both of Black's and Glenberg's research, the use of imagination provided an opportunity and a platform to explore how students demonstrated an ability to index information (Glenberg et al., 2004) for themselves into meaningful representations and to perform tasks in learning environments.

Instructional Embodiment

Though researchers in many different fields (e.g., developmental psychology, biology, history, and philosophy) have explored the idea and concept of embodied cognition, Holton (2010) urges adequate attention to be paid to the application of embodied cognition to the field of education.

Black, Segal, Vitale, and Fadjo (in preparation) argue that since there is no unified framework in which embodied cognition is applied for an instructional setting, researchers and educators should resolve different viewpoints in embodied cognition for learning by providing a comprehensive instructional embodiment framework. In Black et al.'s (in preparation) framework, instructional embodiment can be classified two-fold: as physical embodiment or imagined embodiment. Under physical embodiment, there are three types: direct, surrogate, and augmented. Under imagined embodiment, there are two types: explicit and implicit. In the same vein, Lu, Wu, Fadjo, and Black (2010) reviewed related instructional designs and sought to provide a framework that lists the five types of instructional embodiment: direct embodiment (DE), surrogate embodiment (SE), imagined embodiment (IE), reflective embodiment (RE), and haptic embodiment (HE).

Direct or physical embodiment, often used in robotics research, refers to an agent acting as or embodying a being or robot (Li *et al*., 2009). Physical embodiment requires a coherent physical realization to persist over time (Wainer et al., 2007). Surrogate embodiment refers to physically manipulating an agent, which has been designed to represent a particular object or person (Young, 1983; Fadjo et al., 2009; Gibbs, 2006). Imagined embodiment refers to consciously engaging one's imagination to mentally picture movement or action (Glenberg et al., 2004). Reflective embodiment refers to the use of a webcam in the process of embodiment in which learners are able to see themselves move on the computer screen when they interact (mostly using their hands) with the computer in a game (Hong, 2009). Haptic embodiment emphasizes the sense registry through haptic channel such that learners use their hands to write, touch, or click a mouse. With the provision of several pedagogical examples, Lu et al. (2010) argue that the five types of instructional embodiment are useful in actual teaching and learning for CFL.

Embodied Cognition and Language Learning

Atkinson (2010) summarizes his review of related literature and states that extended cognition conceptualizes mind and brain as inextricably tied to the external environment, and embodied cognition views cognitive activity as grounded in bodily states and action. He argues that these two are related because bodies link minds to the world as we experience, understand, and act on the world through our bodies.

Doughty and Long (2003) indicate that language learning and acquisition are increasingly viewed as a branch of cognitive science because, though researchers recognize that second language acquisition (SLA) takes place in a social context and it can be influenced by that context, more and more researchers now also recognize that language learning, like any other learning, is fundamentally a matter of change in an individual's internal mental state. The ultimate goal, as Doughty and Long (2003) argue, is the understanding of a performance's underlying competence, not the external verbal behavior that depends on that competence.

Atkinson (2010), based on works within sociocognitive cognition, suggests three SLA principles based on embodied cognition: "(1) The Inseparability Principle: Mind, body, and world work together in learning/ SLA; (2) The Learning-is-adaptive Principle: Learning/ SLA facilitates survival and prosperity in complex environments; and (3) The Alignment Principle: A major engine of learning/ SLA is alignment—the means by which we effect interaction" (p. 606).

Atkinson (2010) argues that people cognize and learn not just mentally, but in environmental features. He proposes that "such contexts crucially affect cognition/learning… they cannot be treated as optional extras" (p. 609). Goodwin (2003) also suggests that "the positioning, actions, and orientation of the body in the environment are crucial to how participants understand what is happening and build action together" (p. 20).

Empirical Evidence for Embodied Cognition

There are substantial empirical and experimental studies that provide evidence supporting embodied cognition. For example, Barsalou (2008) asserts that embodied states influence and are influenced by cognition. Iverson and Thelan (1999) find that cognition regions in the brain are active during perception and motor action. Glenberg (1997) finds that memory shows embodiment effects. Carlson and Kenny (2005) show that understanding objects depends on embodied experience with them. Lempert and Kinsbourne (1982) find that bodily orientation affects cognition. Noice and Noice (2001) found that actors could memorize dialogue much better when using scripted actions while reading as compared to simply reading the script (as cited in Glenberg et al., 2004). Embodied learning experiences enhance learning outcome due to increased engagement and motivation (Blumenfeld et al., 2006; Bianchi-Berthouze et al., 2007) and embodiment has a positive effect on memory (Beun et al., 2003).

Research studies that explore the positive effects of embodiment on memory retrieval and comprehension of text as compared to simply reading text typed on paper indicate that embodiment enhances learners' recall and comprehension (Glenberg et al., 2004; Scott et al., 2001). Activity and imagined activity enhance memory and associative learning performance as demonstrated by research on young children by Bender and Levin; Varly, Levin, Severson and Wolff; and Wolff and Levin (Glenberg et al., 2004). In a series of empirical studies, Glenberg et al. (2004) found that imagined and physical embodiment accompanying reading enhances young readers' comprehension and memory retrieval as compared to reading without embodiment.

As to embodied cognition and its relationship to language, there is also evidence from embodied cognition studies as language processing has been studied and viewed as a core function of cognition. Bonda et al. (1994) find that the brain's language-processing areas activate during sensorimotor action. Verbalization of memory is strengthened when assuming original body posture during recall (Dijkstra et al., 2007). Linguistic tasks are facilitated when accompanied by action (Reiser et al., 1994). Descriptions of spatial associations are comprehended faster than those of spatial dissociations (Glenberg et al., 1987). Words with high "body-object interaction" ratings are recognized faster than those without (Saikaluk et al., 2008).

In sum, all the theories and concepts support the notion of encoding information about how perceptual information influences human memory development, organization of propositions into categories, and effectively creates an 'imaginary' world based on these propositions for the purpose of learning Chinese symbols.

Future Trends in CCL and Teaching

Lu, Wu, Fadjo, and Black (2010) have provided evidence to support their argument that future trends of learning and teaching Chinese characters will rely on the use of embodied cognition and computer technology. They believe that since there are a lot of differences between CFL and EFL, teachers should acquire and develop certain pedagogical content knowledge in CFL in order to best teach how to listen, speak, read, and write Chinese. In terms of Chinese character learning and teaching, they assert that when teachers implement the use of embodied cognition and the use of technologies, students will learn better.

Traditionally, in regard to language learning, rote memorization or constant repetition is emphasized if one is to master the target language. Nevertheless, with recent advances in technology and cognitive psychology, many teachers and learners have incorporated various types of technologies and different levels of embodiment cognition in teaching or learning a new language.

Technologies and concepts, including web-based applications, software or hardware use, and computer-assisted learning, are popularly utilized in classrooms nowadays (Lin, et al., 2009). With the use of technologies in CFL or language classrooms, learners tend to learn better, view their learning as more enjoyable, and be more engaged (Lin, Huang, & Chiang, 2009; Lu, Wu, Martin, & Shah, 2009). For example, Lu, Wu, Martin, and Shah (2009) compared a grammar classroom in a computer-assisted language learning (CALL) environment to a grammar classroom in a traditional classroom-based learning environment. They found that adult learners in the CALL environment performed better in posttests, had better future learning capabilities, had more interactions with other students, generated more questions in class, enjoyed the grammar instruction more, perceived the lessons to be more effective, and liked the lesson better than those in the traditional classroom setting.

Though some researchers have pointed out some possible pitfalls of CALL or technology use in language classrooms (e.g., Furstenberg, 1997), the use of technology for language learning and teaching is still encouraged (Chapelle, 1997; Egbert, & Hanson-Smith, 1999; Ha, & Rilling, 2006; Warschauer, Shetzer, & Meloni, 2000). Moreover, as educators are also using computer technology in conjunction with instructional embodiment for embodiment implementation (e.g., Fadjo, Lu, & Black, 2009), the trend of using technologies in classrooms is obvious.

Section 3. CALL and Other Technological Designs for CCL

Many researchers are thinking of new ways to teach and learn this difficult language —Chinese— by applying new technologies and methodologies. For example, to help non native speakers of Chinese learn the language, a growing number of computer-based learning programs and technology-related instructional methodologies have been designed, developed, and implemented over the past 2-3 decades (e.g., Lam et al., 2004; Ki et al., 2003; Lam et al., 2001; Lu, Hallman, & Black, 2010). In this section, I first briefly discuss what CALL entails and then review and examine previous designs of animations that were used for Chinese character learning.

CALL

Unlike the traditional term of technology use in the 1980s, where the application in a language classroom might merely include the use of film, radio, television, language labs with audio and videotapes, computers, and interactive videos (Cunningham, 1998), today's computer-assisted language learning (CALL) puts more emphasis on computer applications in terms of how computers can be used for language learning, and thus CALL today encompasses more interactive features and the integration of various media designed for language learning and teaching purposes. CALL has been compared to the traditional classroom-based learning environment and shows more positive learning effects and results (e.g., Lu et al., 2009). For instance, Liu, Moore, Graham, and Lee (2003) reviewed the literature of refereed print-based journals and

ERIC documents on computer uses in second and foreign language learning from 1990 to 2000, and tried to see, in these 11 years, (1) how computers have been used in second and foreign language learning and teaching and (2) if there is evidence showing how computer-based technology can enhance acquisition of language skills. In summary, they have found that CALL can be an effective tool in instruction and its benefits have been widely explored and accepted. In addition to the increasing interest among educators and learners in the Internet and the use of the World Wide Web in language classrooms, many centered their interest in computer technology on the multimedia capabilities of providing authentic learning materials and situations. Furthermore, research also provides evidence on the effectiveness of computer technology use in second language learning. For example, many studies suggest that the use of visual media supports vocabulary acquisition and reading comprehension, as well as learning in terms of achievement results (Liu et al., 2003).

As discussed in Chapter I, though there is the trend of Chinese learning in U.S. foreign language learning policy (e.g., The White House, 2009; American Council on the Teaching of Foreign Languages, 1999), learners of Chinese still show a motivational decline in their learning after their first semester of Chinese class or when Chinese characters are introduced in class (Branner, 2009; Li, 1996). Therefore, many researchers and teachers of CFL seek for possible uses of computer-based technologies in Chinese language learning in order to help beginners learn characters. I look further at how previous designs of computer-based instructional tools provide visual media support to the acquisition and learning of Chinese character.

Previous Designs of Animations for CCL

As discussed in Section 2, in regard to Chinese language learning, rote memorization or constant repetition has traditionally been emphasized. Therefore, beginning learners of CFL have had to do a lot of repetitive writing and dictation. As Chun and Brandl (1992) emphasize, “We need to develop foreign language software beyond the typical drill-and-practice stage and begin to foster more genuine conveying of messages, negotiation of meaning, and understanding of how form affects communication” (p. 263).

I reviewed several studies that focused on Chinese character learning using computer technologies. Specifically, I examined how animations were used and if they were effective. As a result, some CALL programs that focus on other aspects and skills of Chinese language learning such as *Chinese Character Tutor, Chinese Express, HyperChinese, PinyinMaster, and The Rosetta Stone* (see Zhang, 1998; Chu, 1996, for a complete review) are excluded in this section.

Some popular CALL programs have some animation features (e.g., animated characters, animated displays of character demonstration, animated character writing, and character etymology) but have not yet been empirically tested by researchers, such as *ABC Interactive Chinese*, *HyperChina*, *Professional Interactive Chinese*, *Step into China*, and *Wenlin* (see Zhang, 1998, & Chu, 1996 for a complete review). However, researchers have generally found positive effects of using various types of animations with Chinese character learning. For example, *KanjiCard* (Nakajima, 1988), *HyperCharacters* (Li, 1996), *the multimedia design* (Wang, 2005), *Character Origin* (Lam, Ki, Law, Chung, Ko, Ho, & Pun, 2001), and *Chinese character knowledge base* (Lam et al., 2001) all show positive learning effects and students' improved learning results.

The definition of character animation in this dissertation refers to a sequential and etymological display of a Chinese character's evolution, not the display of the writing order of a character's strokes. As a matter of fact, studies of stroke orders (as some researchers call them, stroke animations) generally do not show better learning results than the traditional control group conditions. For instance, Lu, Crooks, Maushak, Lan, and White (2009) did an experiment to examine factors impacting computer-based Chinese character learning programs. Lu et al.'s (2009) findings do not conform to one of their hypotheses that stroke order animation can significantly help learners in the recognition of Chinese characters. It was hypothesized that Chinese characters illustrated with stroke animation in the experimental group would be better memorized and recalled than those illustrated in the static and in the gradual display without stroke animation subgroups. Their result was the opposite of their hypothesis. So, these stroke order studies are not included in my character animation discussion here. I reviewed some of the previously-conducted animation designs in several studies that helped me develop my designs of embodied animations for Chinese character learning.

KanjiCard

Nakajima (1988) believed that students need enhanced graphic presentations for recognizing character features and enhanced morphology-and-semantic associations in order to better learn logographic scripts, such as Japanese *Kanji*, or Chinese characters used in the Japanese language. She used Macintosh's program Hypercard to develop *KanjiCard*, which is an interactive self-tutorial program for beginning learners of Japanese Kanji. On the main page of *KanjiCard* (see *Figure 11*), there are four major categories that highlight the features of Kanji or Chinese characters: (1) graphic (morphology, graphemes, and written form of character), (2) sound (phonology and phonetics); (3) semantic (meaning or morphemes), and (4) usage (pragmatics, part of speech, and syntax).

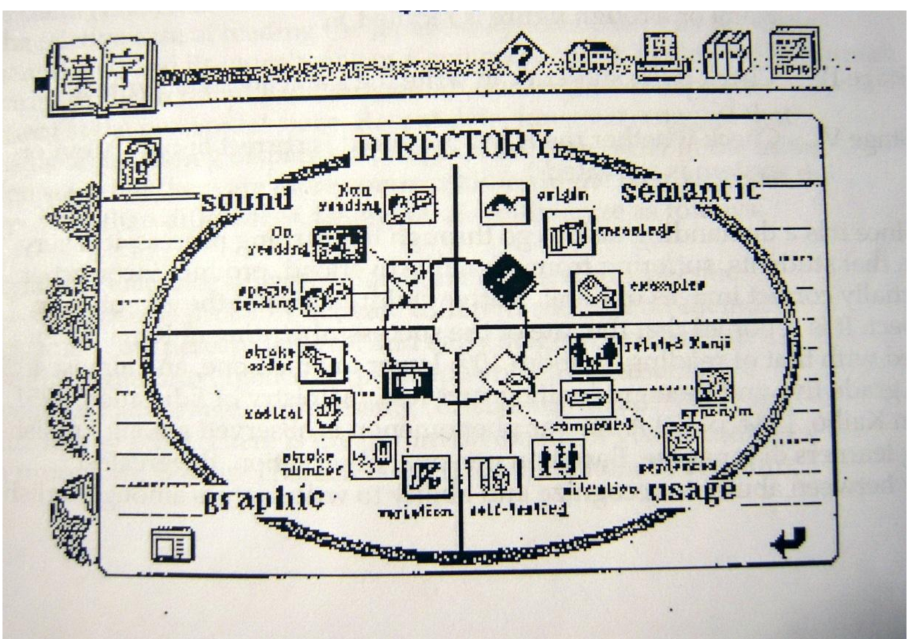

Figure 11. *KanjiCard* Main Page

In the Semantic section, the origin of each Kanji is given an animated representation in addition to a brief textual description of the historical background of the word. The animated representation of Kanji is carefully used to give a close association between the shape and the meaning of Kanji. For example, for the word "house/home," which consists of two parts, the upper part "roof" and the lower part "pigs," *KanjiCard* would start showing a picture of a house, which gradually dissolves to show a mother pig feeding several baby pigs. The house image disappears except for the roof part and the baby pigs evolve to become the bottom part of the word, "pig." The graphic image of the character, "home/ house" is then shown at the end of the animation (see *Figure 12*). *KanjiCard* clearly links the meaning and the written form of the word in the animation.

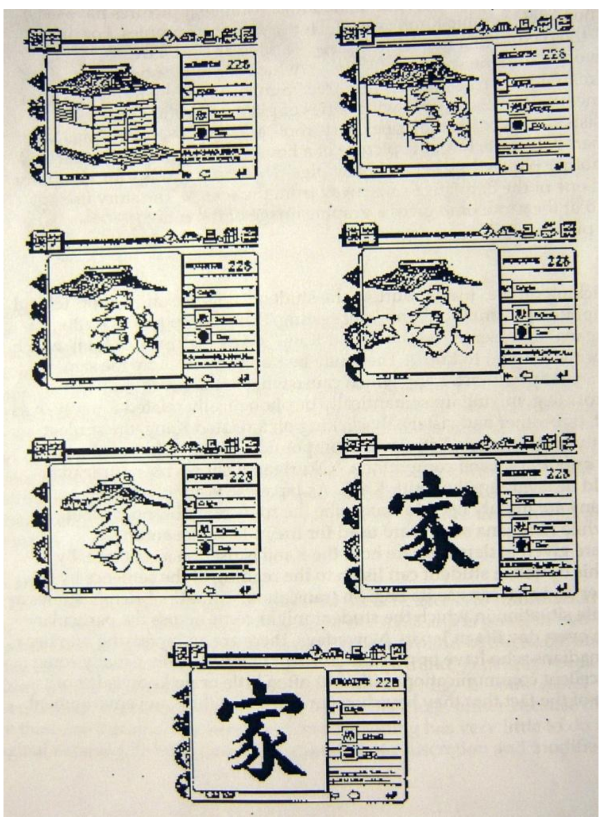

Figure 12. KanjiCard Semantic-Written Form Linkage Animation for Character "Home; House"

HyperCharacters

Li (1996) also used Hypercard and designed a computerized Chinese character learning program called *HyperCharacters*. The program also uses images, graphic symbols, sounds and animated presentations and is intended to help students learn Chinese characters' radicals. In the process of character memorization, Li (1996) asserted that "more systematic, specific, relevant, and visualized information registers better than fragmented, abstract, irrelevant and pure verbal knowledge" (p. 80). The *HyperCharacters* therefore consists of three cards designed for Chinese character learning.

The first of two cards illustrates the meaning of the radical through an easy-to-understand picture resembling the otherwise unfamiliar character such as a mountain picture placed beside the character "mountain" and the character's pronunciation phonetics "shan" (see *Figure 13*), while the other card shows etymological animations of the character's historical evolution (see *Figure 14*). Through the first card, learners would connect the meaning with the character and know the shape of the character from the picture due to the cues for the dots and lines of the characters these pictorial figures provide. Li (1996) argued that learners could thus form and strengthen the sensory short-term memory well. The second card shows, in addition to the mountain picture, the evolution of three classical types of the same Chinese character, from Seal type (i.e., Juan Shu) to Clerical type (i.e., Li Shu) to Standard type (i.e., Kai Shu). Note that *HyperCharacters*' second card shows all forms of the same character on the same screen page. The card is designed to explain the radicals' origins through several graphic representations (and thus the etymological animation) and therefore learners can transfer working memory into long term memory (Li, 1996). The third card is for practice with labeled stroke order (see *Figure 15*). Forty-eight first year Chinese language students in a college participated in the experimental study where they were randomly assigned to two different learning conditions. The results showed that the *HyperCharacters* program significantly helps beginning learners better learn Chinese characters (radicals) compared with the classroom lecture method. Furthermore, the qualitative data indicated that the principles of the formation of the characters, the etymology section, and the visualized description of the characters helped learners learn "in an understanding manner instead of by rote memory" (p. 88).

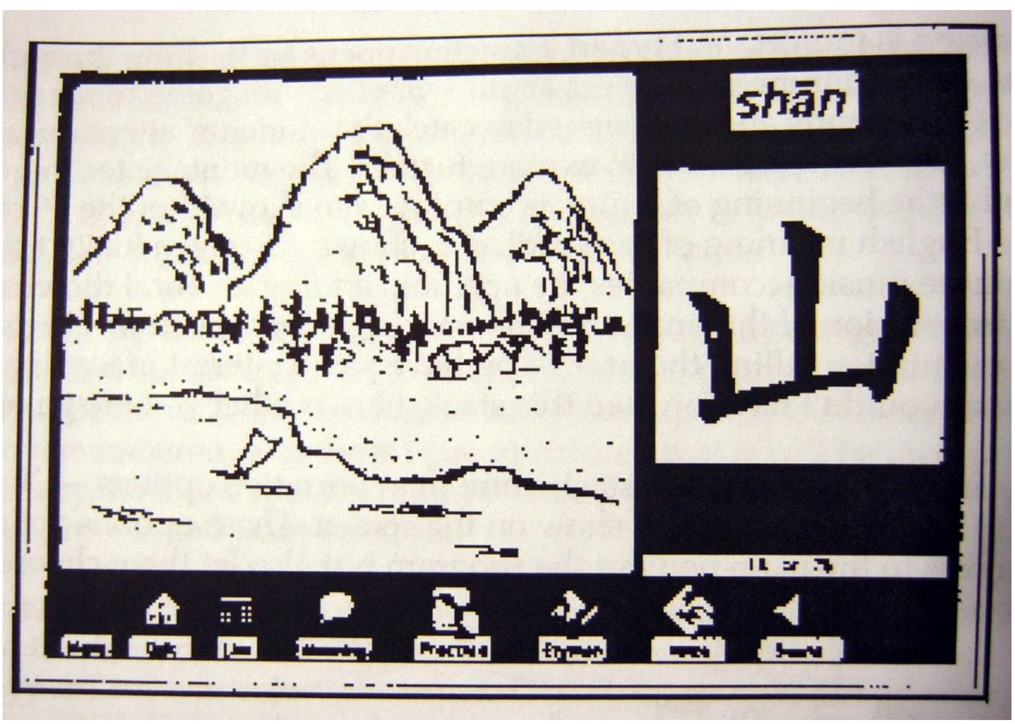

Figure 13. *HyperCharacters* Card 1 with Picture and Phonetic Alphabets

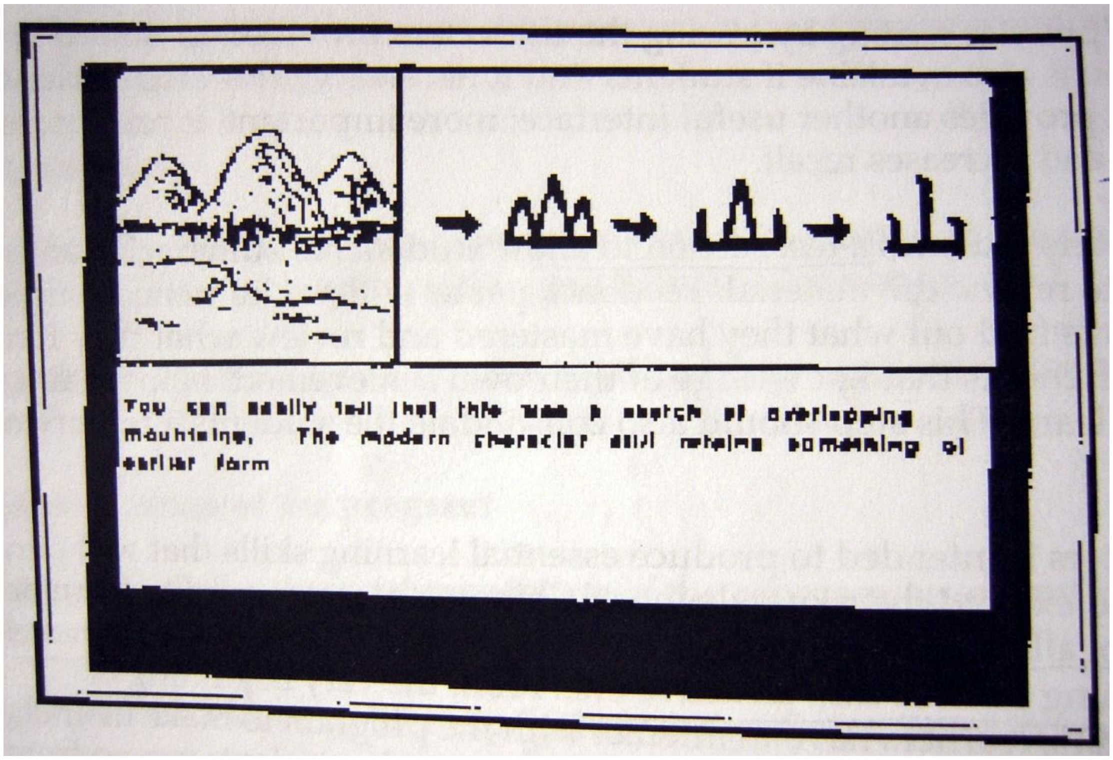

Figure 14. *HyperCharacters* Card 2 with Etymological Forms

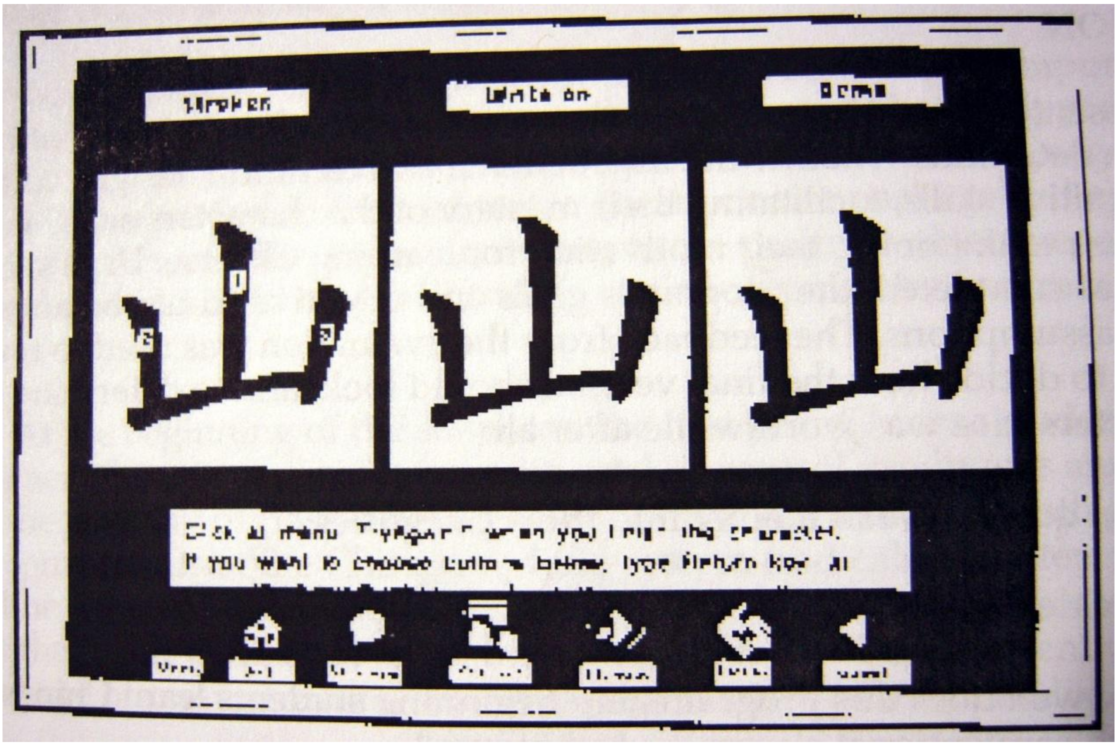

Figure 15. *HyperCharacters* Card 3 with Stroke Orders

The Multimedia Design

Wang (2005) did a study exploring the impact of multimedia design on Chinese learner recognition of characters using a conceptual model depicted in *Figure 16*.

With both quantitative data and qualitative data, she found that in general, the group of learners that learned with printed text accompanied by both audio and animation aids which, elaborate the information through both auditory and visual stimuli, performs the best and generates the best learning effects. Learners who learned with printed text supplemented with animated graphics which provided visual stimuli performed the second best. Learners who learned with printed text supplemented with audio which provided auditory stimuli did not perform as well. And learners who learned with only printed text performed the worst.

Therefore, in terms of a CALL multimedia design for Chinese character learning, both auditory and visualized stimuli should be included. When designing a CALL program for CCL, we thus should include three elements: (1) animation for meaning and morphology, (2) sound for pronunciation, and (3) semantics for meaning.

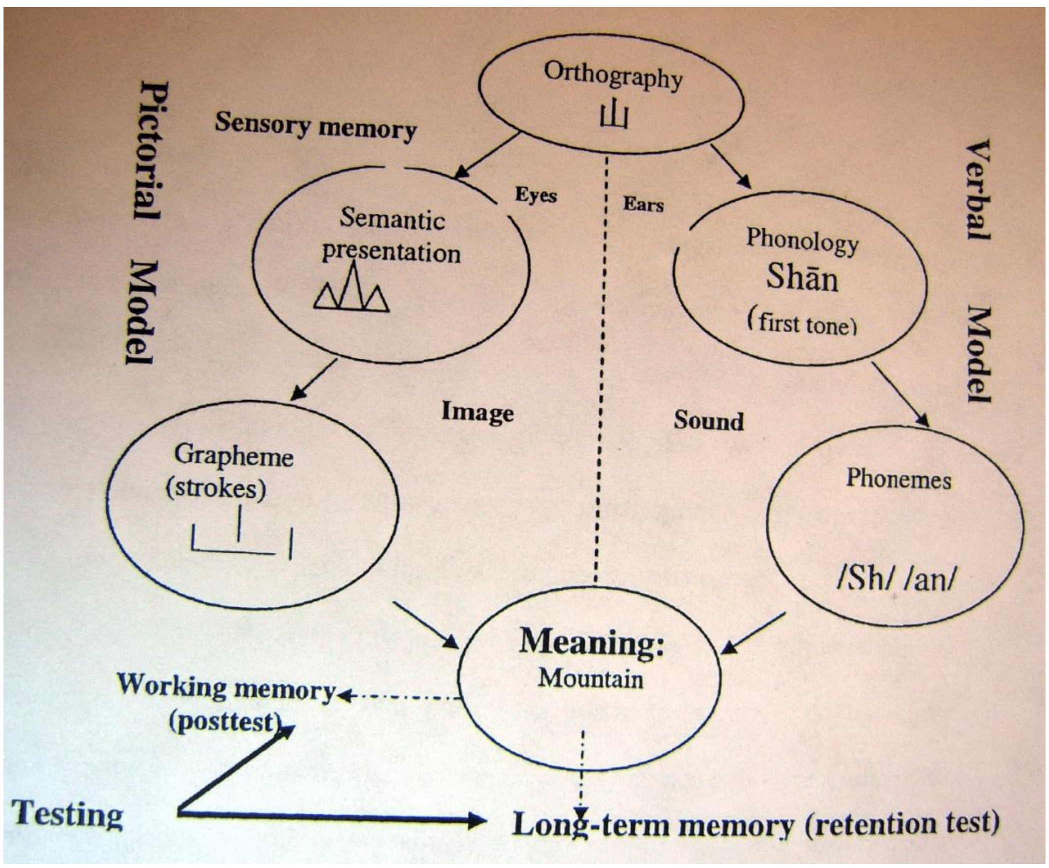

Figure 16. A Conceptual Model of Multimedia Presentation of the Chinese Character "Mountain"

Character Origin

Lam et al. (2001) revisited early Chinese characters, which are mostly hieroglyphic or pictographic. Since many of them have become components and radicals of modern Chinese characters, knowing the ancient forms of characters can help learners to understand and memorize the written form. Lam et al.'s (2001) idea was to allow learners to match characters to their pictorial origins. Using similar animation designs as *KanjiCard* and *HyperCharacters*, *Character Origin* contains etymological animations that depict the transformation and evolution of the characters from pictures to the written form. *Character Origin* consists of a big square on the left hand side of the screen page where pictures and animations are shown. On the right hand side, there is a group of characters in a panel listing six different characters, including the one that matches the picture or animation on the left hand side. One interactive feature, or a possible drawback, of *Character Origin* is that learners have to correctly pick and click on one of the listed characters on the right hand side of the screen that matches the character that is shown in its animation or picture on the left hand side of the screen. If the selection is not correct, the animation will suddenly stop before the completion of character animation. If the selection is correct, the evolution will continue. *Figure 17* shows three screenshots of *Character Origin* where the picture of the *Sun* becomes the character *Sun*.

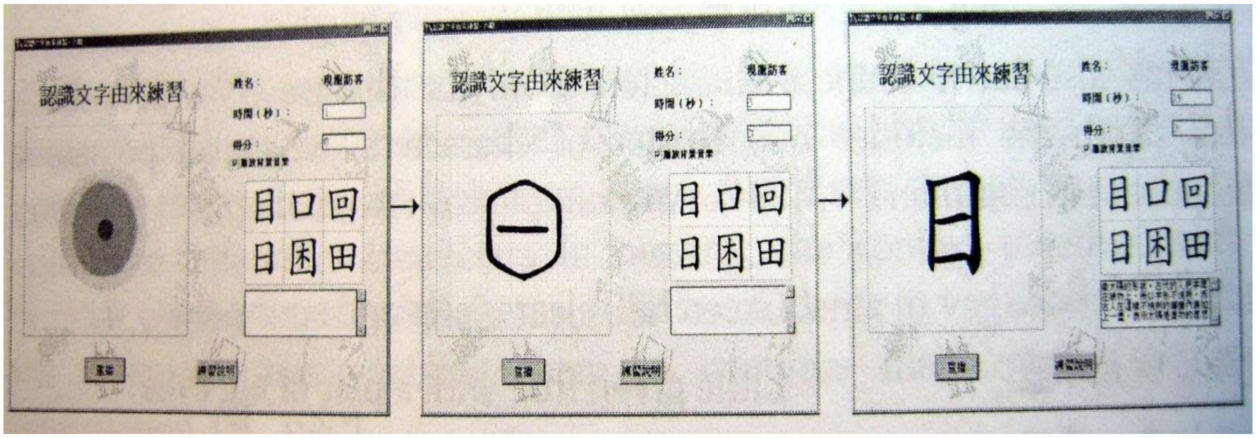

Figure 17. Screenshots of *Character Origin* for the Character “Sun”

Section 4. Neurological Evidence for the Use of Embodied Animations in CCL

With advances in neuroimaging techniques, researchers have used functional magnetic resonance imaging (fMRI) to examine the human brain's cortical activities when processing Chinese characters. They found that some Brodmann's areas are activated that are unique to Chinese character processing. The strong activation of BAs 4, 6, 1, 3, and 7 implies that Chinese character processing is decidedly associated with human body movements, which has led to the proposed embodied animation design for CCL. The purpose of the section is to review related literature that provides neurological evidence for the use of embodied animations in learning Chinese characters as I intend to create a potentially effective design for a computer-based instructional program to increase student engagement and motivation, learn characters better, and offer a more intriguing learning experience for beginning learners of CFL.

Evidence of Neuro-imaging for Chinese Processing

A lot of neurology-related studies have revealed activities inside our brains when we perform certain tasks (e.g., Pu et al., 2001; Chee, Tan, & Thiel, 1999; Kuo et al., 2003). Many have shown that Chinese character processing is unique and is quite different from English word processing (Chee et al., 2000). In the human brain, there are not only areas that are common to general language processing, but also areas that function and respond specifically to certain languages and/ or language features. For example, so far as language is concerned, some areas in the brain are associated with semantic processing whereas others are associated with phonological processing. The studies discussed below show where Chinese characters are processed in the brain and support the use of embodied animations for Chinese character learning. As brain activities and their neuro-imaging results are highly task-specific, I describe in more details of the materials, designs, and tasks used in these studies.

Chinese Character Processing

Tan, Liu, Perfetti, Spinks, Fox, and Gao (2001) used functional magnetic resonance imaging (fMRI) to uncover and examine the neural systems in human brains that are associated with Chinese character processing. They examined six strongly right-handed male native Mandarin Chinese speakers from mainland China aged 29 to 40 years who have lived in the U.S. for no more than 6 years. Forty-four pairs of semantically related Chinese characters and forty-four pairs of Chinese homophones were carefully selected and used in their study. All the Chinese characters were categorized as common characters with a frequency of occurrence of no fewer than 25 per million according to the Modern Chinese Frequency Dictionary (1986). In addition, character visual complexity, measured by the number of strokes in the character, was also matched across the homophonic pairs and the semantic pairs. The participants were asked to judge as quickly and accurately as possible whether the two characters they viewed from an LED projector were semantically related in the semantic decision task and whether the two characters were homophones in the homophonic decision task. In each trial, a pair of characters was presented synchronously for 500 ms, one above and one below a fixation crosshair. After that, a fixation crosshair was exposed for 1000 ms (see *Figure 18* for an example). Participants pressed the key corresponding to the index finger of their dominant hand (right hand) to indicate a positive response that the characters match, or the key corresponding to the index finger of their left hand (nondominant hand) to indicate a negative response. Tan et al. (2001) adopted a block design where semantically related characters (or homophonic characters) were randomly presented within 24 second blocks which were comprised of 11 pairs of semantically related characters (or 11 pairs of homophones) and 5 pairs of unrelated characters that served as fillers. In the control scan, participants maintained fixation on a crosshair. Presentations of the 16 semantic and homophonic pairs of Chinese characters were counterbalanced for each participant and randomized across participants (Tan et al., 2001).

Examples of the stimuli used in their experiment are shown below. *Figure 18* shows an example of two characters for the semantic task. The character above the fixation crosshair is pronounced /yue/, with meanings of "watch," "look," "see," "view," and "read." The character below the fixation crosshair is pronounced /kan/, and it has almost the same meanings of "look," "see," "watch," "read," and "view." *Figure 19* shows an example of two characters for the homophonic task. The character above the fixation crosshair is pronounced /hua/, with meanings of "to draw," "to sketch," "to paint," and "paintings." The character below the fixation crosshair is exactly pronounced the same /hua/, with completely different meanings of "to talk," "to say," and "words." Note that the characters for the homophonic task were also in the same tonal pronunciation.

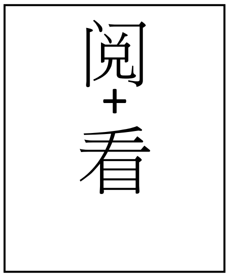

Figure 18

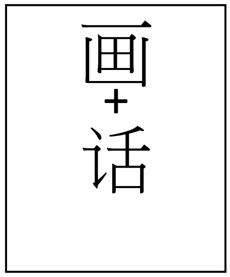

Figure 19

The semantic task results showed that significant areas of activation were in the frontal lobe, the parietal lobe, the occipital lobe, the temporal lobe, the left and right sublobar caudate, and cerebellum. In the frontal lobe, the left middle frontal cortex (Brodmann's Area 9), bilateral inferior and middle prefrontal gyri (BAs 45/47/11), bilateral frontal pole (BA 10), and pre-central (motor) gyri (BAs 6 and 4) were significantly activated. The left middle frontal cortex (BA 9) had the peak activation with 782 voxels of activation volume. The asymmetry index of functional activation AI = 0.62, indicating a strong left lateralization in their regions of interest (ROIs), which were the middle and inferior frontal areas. In the parietal lobe, both left and right superior parietal lobules (BA 7) and inferior or post-central parietal gyri (BA 40) were significantly activated. In the occipital lobe, activations in the right cortex (the cuneus, fusiform, and inferior gyrus) were stronger than those in the left cortex in addition to the left infero-middle gyrus (BA 18), showing an obvious right lateralization of AI = -0.57.

In the temporal lobe, activations were localized to the right superior and middle gyri (BA 38).

The homophonic task results revealed a similar pattern of brain activations to what the semantic task produced. Peak activation was also in the left middle frontal cortex (BA 9). In the frontal lobe, bilateral inferomiddle prefrontal cortex (BAs 44/45 and 47/10) and left medial prefrontal lobe (BA 11) were active. Bilateral pre-central (motor) gyri (BAs 4 and 6) were also active. In the parietal lobe, the bilateral superior parietal lobule (BA 7), left postcentral gyrus (BA 3) and right precuneus (BA 39) were active. In the occipitotemporal regions, significant activations were found in the left and right cuneus (BA 17/18), the extrastriate cortex covering left inferior gyrus (BA 18), the right fusiform gyrus and lingual gyrus (BAs 18 and 19). The left sublobar and right sublobar caudate, as well as cerebellum, were also active. Brain areas that were significantly activated during the homophonic task but not during the semantic task relative to fixation were bilateral middle temporal lobes (BAs 21 and 22).

Therefore, Tan et al (2001) showed that: (A) Processing logographic Chinese requires extensive brain activation; (B) Neural networks that are activated due to Chinese characters' semantic and homophonic tasks largely overlap; and (C) In addition, although many areas that contributed to Chinese language processing overlap with areas that are activated when an alphabetic language is processed, such as the ventral occipitotemporal regions (the fusiform and lingual gyri, BAs 44/45, and BA 47) and the temporo-occipitoparietal junction (BA 39/19), some areas are considered unique to Chinese logographs processing, such as the left lateral middle frontal cortex (BA 9), a region above Broca's area.

In fact, Poldrack et al. (1999) and Price et al. (1997) have found that the activation in this middorsal prefrontal region in word recognition and reading is much weaker for native English speakers. This area, the dorsolateral prefrontal cortex (DL-PFC; BAs 9 and 46), serves as the highest cortical area responsible for motor planning, organization, and regulation. It plays an important role in the integration of sensory and mnemonic information and the regulation of intellectual function and action. It is also believed to be involved in working memory (Tan et al., 2000; Tan et al., 2001). As a matter of fact, for both semantic and homophonic tasks in the study Tan et al. (2001) did, DL-PFC showed peak activations in the processing of characters. Therefore, DL-PFC is assumed by Tan et al. (2001) to be the main execution area that processes Chinese characters.

Chinese Semantics Processing

Using fMRI, Tan, Spinks, Gao, Liu, Perfetti, Xiong, Stofer, Pu, Liu, and Fox (2000) examined how native Chinese speakers process the meaning of three different types of Chinese character(s): semantically vague Chinese single characters, semantically precise Chinese single characters, and two-character Chinese words. Six participants, which were strongly right-handed male native Mandarin Chinese speakers from mainland China, volunteered for the study. For each type of stimuli, there were 60 items. Twenty-five subjects previously assessed single characters’ semantic vagueness or precision to determine these 60 items for study use. According to the Modern Chinese

Frequency Dictionary (1986), both single-character and two-character words were categorized as common words and had the frequency of occurrences of no fewer than 30 per million. In addition to accounting for the possible influence of orthographic properties Weekes et al. (1998) had proposed, Tan et al. (2000) also controlled for the visual complexity and the ratio of simple and compound characters as they were matched across the two sets of single characters. Each single character or two-character word was presented for 250 ms, followed by fixation for 1,250 ms. Blocks of 20 Chinese stimuli (30 sec each) were separated by 20 sec of fixation on a crosshair. The experiment was in a single run, which consisted of three blocks of vague-meaning characters, three blocks of precise-meaning characters, three blocks of two-character words, and nine blocks of crosshair fixation as the control scan (Tan et al., 2000). The participants saw the stimuli through an LED projector system and were asked to silently generate a Chinese word that was semantically related to the Chinese stimulus they had just viewed. During each scan, the participant repeatedly preformed the covert word generation task for this short exposure duration.

Examples of the three types of Chinese character stimuli used in the study, as illustrated by Tan et al. (2000), are shown below. *Figure 20* shows a semantically vague Chinese single-character pronounced /Ji/ that has the meanings of "cross a river," "relieve," "many," "help," "aid," and "benefit." *Figure 21* shows a semantically precise Chinese single-character pronounced /yu/ that has the meaning of "rain." *Figure 22* shows a two-character Chinese word that means "acceleration" with the pronunciation of /Jia Su/.

济

Figure 20

雨

Figure 21

加速

Figure 22

In general, the results showed that the significant areas of activation were very similar in the semantic task results described in the previously mentioned study (i.e., Tan et al., 2001): in the frontal lobe, the parietal lobe, the occipital lobe, the temporal lobe, the left and right sublobar caudate, and cerebellum. Comparisons of each of the three experimental conditions (vague-meaning characters, precise-meaning characters, and two-character words) with fixation also showed peak activations in the left middle frontal gyrus (BA 9), in addition to left temporal fusiform gyrus (BA 37), right postcentral parietal gyrus (BA 3/1), and right occipital lingual gyrus or cuneus (BA 17/18). The patterns of peak activation were consistent for all three comparisons. Also, the left supplementary motor area (BA 6) was also significantly activated for all three comparisons. The vague-meaning character vs. fixation comparison revealed significant activations in right inferior and middle frontal gyri (BAs 46/9 and 47), and both the precise-meaning character vs. fixation comparison and the two-character word vs. fixation comparison revealed significant activations in bilateral inferior frontal gyri (BAs 47 and 9). In addition, the right temporal fusiform gyrus for vague-meaning characters, the right superior and middle temporal gyri for two-character words, left superior parietal lobule (BA 7) and left middle occipital gyrus (BA 18) for all three types of Chinese stimuli, and the bilateral fusiform gyrus (BA 19) for the vague-meaning characters were also activated.

The extent of activations was significantly greater for vague-meaning characters and two-character words than for precise-meaning character in the left frontal cortex. Similar patterns were seen in the left temporal and right parietal cortices, but statistical analyses did not reach significance.

The ROIs were selected as middle and inferior frontal regions (BAs 46, 47, and 9) for asymmetry index (AI) calculation. AIs were 0.88, 0.85, and 0.89 for vague-meaning characters, precise-meaning characters, and two-character words, respectively. It is clear that the left lateralization in the frontal lobe is strongly activated during Chinese character semantic generation. In addition, the left temporal lobe was more strongly activated than the right temporal lobe as AIs were 0.92, 1.00, and 0.82 for vague-meaning characters, precise-meaning characters, and two-character words, respectively. However, the right occipital and parietal cortices were more activated in Chinese word generation than the left ones as the AIs were -0.77, -0.55, and -0.36 for the three stimuli, respectively, in the occipital cortex and -0.39, -0.56, and -0.74 for the three stimuli, respectively, in the parietal lobe.

To reiterate, Tan et al. (2000) found that in the processing of Chinese single-character and two-character words, the left frontal regions (BAs 9, 47) were much more strongly activated than the right frontal regions, which is consistent with the English word processing literature in that the left frontal gyri contribute to the semantic processing of words (Blaxton et al., 1996; Buckner & Petersen, 1996; Buckner et al., 1995; Fiez, 1997). The researchers inferred that the left frontal regions are highly related to the semantic activation of both Chinese single characters and two-character words since the word generation task used in the study required explicitly semantic retrieval of a Chinese item (Tan et al., 2000). In addition, the researchers believed that due to the processing of the visual properties of Chinese characters and words, there were strong activations in the occipital areas such as the lingual gyrus and the fusiform gyrus (BAs 17-19).

Evidence for the Use of Embodied Animations

The extremely strong activation of the left middle frontal gyrus in Chinese processing is associated with the unique square configuration of Chinese logographs (Tan et al., 2001). Chinese characters comprise a number of strokes (1 to 84) that are packed into a square shape based on stroke assembly rules. The processing of Chinese characters requires fine-grained analyses of the visual-spatial locations of the strokes and sub-character components, such as radicals. The DL-PFC, left middorsal lateral prefrontal cortex (BAs 9 and 46), have been suggested mediating spatial and verbal working memory.

Tan et al. (2001) found heavy involvement of the set of right hemisphere cortices. Reading Chinese characters demands intensive visual-spatial analysis. The right frontal pole (BA 10/11), frontal operculum (BA 47/45), dorsolateral frontal gyrus (BA 9/44), and the superior and inferior parietal lobules (BAs 7 and 40/39) mediate semantic and homophonic judgments. These are areas that do not activate with alphabets. As the right BAs 7 and 40/39 are routinely activated in spatial working memory tasks, it is reasonable to assume that the right frontal and parietal regions are involved in perceiving the spatial locations of the strokes and the processes of stroke combinations.

Activations in the occipital cortex were bilateral, but the right hemisphere was dominant over the left (AI = -0.57 in the semantic task and -0.204 in the homophonic task). The strong activation in the right occipital cortex indicated the attribution to the visual properties of Chinese characters since the right occipital cortex is associated with the spatial recognition of visual symbols. Tan et al. (2001) hypothesized that in processing Chinese characters, the left middle frontal cortex is "recruited to coordinate and integrate the intensive visuospatial analysis demanded by logographs' unique square configuration and the semantic (or phonological) analysis" (p. 844).

However, when examining the unique Brodmann's areas that were significantly activated in the Chinese character experiments Tan et al. (2001) and Tan et al. (2000) did, I found that many of these areas are movement-based or action-related. Specifically, areas such as BA 4 (Primary Motor Cortex), BA 6 (Premotor Cortex and Supplementary Motor cortex), BA 3 (Primary Somatosensory Cortex), and BA 7 (Somatosensory Association Cortex) were all strongly activated during both Chinese semantic and Chinese homophonic tasks. Moreover, BA 1 (Primary Somatosensory Cortex) was also strongly activated during the covert Chinese word generation tasks in addition to the other aforementioned motor-related areas. These are not conventional areas that would be strongly activated when an alphabetic language is being processed.

Tan et al. (2000) even stated that, "… the reason why the right parietal regions (BAs 3 and 1) were strongly activated is not clear" (p. 23).

Why would these movement-based or motor-related areas be activated when processing Chinese characters? There are 3 possible explanations (Lu, Hallman, & Black, 2010c). Firstly, the processing and representation of Chinese characters require some of these unique areas to be activated. Some characters may be embodied and processing these characters is thus embodied. Unlike viewing an alphabetic word such as English in which words are formed in linear and orderly configuration, when we see certain Chinese characters, we see, or feel, more than a plain word, but maybe a picture, a scenario, or even a motion picture in a square-shape space that can be packed with up to seven dozen various types of strokes. Second, when encoding and decoding Chinese characters, there is significant assistance to activate these brain areas. In other words, we humans tend to activate more of these areas that are supposed to be helpful in assisting with encoding Chinese characters. Third, the traditional classification of the brain areas is not entirely thorough or completely accurate. That is to say, these Brodmann areas still denote language processing areas, or language-related visual-spatial areas. This third point, however, may be highly unlikely since a great deal of research has revealed the functional specifications of human brain areas, especially Brodmann's areas through many different types of brain and imaging studies.

Therefore, Lu, Hallman, and Black (2010c) argue that, in addition to other animation designs, it is evidently plausible to use Embodied Animations to aid Chinese character learning. Lu, Hallman, and Black (2010b) have therefore designed Embodied

Animations that encompass the features of body movements and word etymology to introduce Chinese characters to beginning learners of CFL.

Section 5. Design of Embodied Animations for CCL

Embodied Animations

Quality software must be grounded in language learning theories, cognitive theories, and multimedia or HCI design principles. I intend to develop my design based on related theories and principles for effective Chinese character learning. My idea of adding an embodied element to animation originates from neuro-scientific evidence and findings, the features of Chinese characters, embodied cognition theories, and other previous animation designs.

As discussed in the previous sections, Chinese characters are unique in their logographic nature; embodied cognition enhances language learning; etymological animations have been used in CCL; and fMRI examinations imply that Chinese character processing is strongly associated with human body movements. I therefore propose the use of embodied animation for Chinese character learning and to use designs that show one's physical enactment of the attributes of a character or character's radical.

To operationalize the construct of embodied animation in the study, the elements of action and perception, imagination, and symbolic representations that are grounded by the environment should be included. An embodied animation for a computer-based CCL program is thus defined as a computer-based CCL program that consists of an animation or a video that demonstrates bodily movements, gestures, or actions, contains symbolic representations, and can be imagined by viewers, for the depiction of both a character's semantic meaning and its morphology of written form.

Designs of Embodied Animations

Examples of the designs of embodied animations are illustrated below. Take the character “fire” as an example. I first show the original meaning of the character in either a picture or an animation format (in this case, an animation of fire; see *Figure 23*). Then I show the etymological animation of this character’s different appearances in evolution, from Bone Inscription (see *Figure 24*), Seal type (Juan Shu; see *Figure 25*), and Clerical type (Li Shu), to Standard type (Kai Shu; see *Figure 26*). Next, the embodied animation as acted out by a real person’s body movements is shown to illustrate both meaning and morphology of a character (to keep the actors anonymous, I am using sketches here to represent a real person; see *Figures 27 & 28*). Finally, the embodied animation stops with clear morphology of the character, highlighted with the character’s written form that mutually matches (using the superimpose feature in Flash; see *Figures 29*).

Figure 23. The original meaning of the character “fire” in an animation format

Figure 24. The etymological animation of the character “fire” in Bone Inscription

Figure 25. The etymological animation of the character “fire” in Seal type

Figure 26. The etymological animation of the character “fire” in Standard type

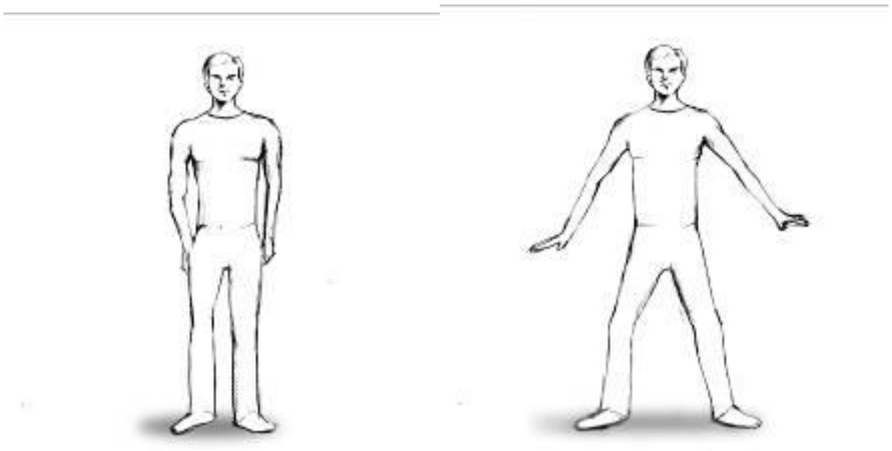

Figure 27. The embodied animations acting out by body movements showing both meaning (semantic meaning) and morphology (written form)

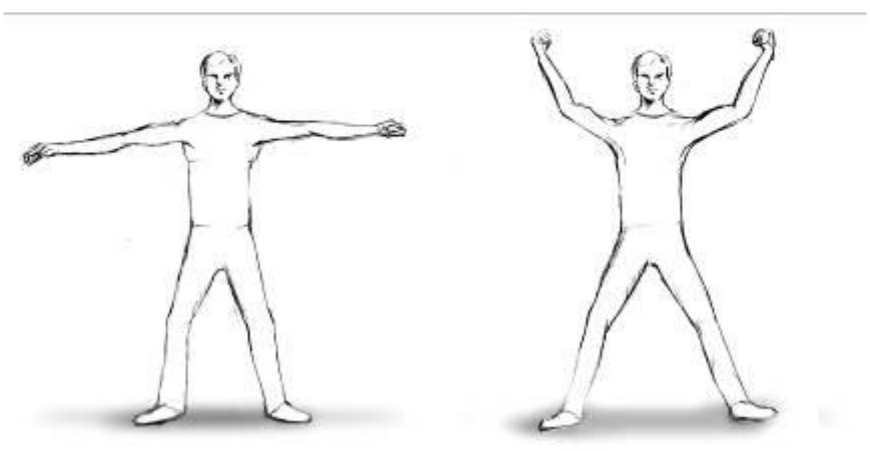

Figure 28. The embodied animations acting out by body movements showing both meaning and morphology- continued

Figure 29. The embodied animation with morphology and meaning of the character, highlighted with a character's written form that mutually matches

Interface of the CCL Program

To incorporate Chinese character's three main elements, written form, phonology, and semantic meaning (Zucker & Mathieu, 1993), with embodied animations, Lu, Hallman, and Black (2010) propose that the interface design for a CCL program that incorporates embodied animation in it should have four main features as shown in *Figure 30*. The design components, from left to right, are: (1) embodied animation video clip with a user-controlled slide bar in the bottom of the clip screen, (2) the enlarged target Chinese character being learned in a black square placed in the middle of the monitor, (3) the semantic meaning (or meanings) of the Chinese character in English, placed beneath the target character, and (4) the pronunciation of the target character both in phonetic alphabets and in audio sound format (pronounced every time the learner hits the "click for pronunciation" button).

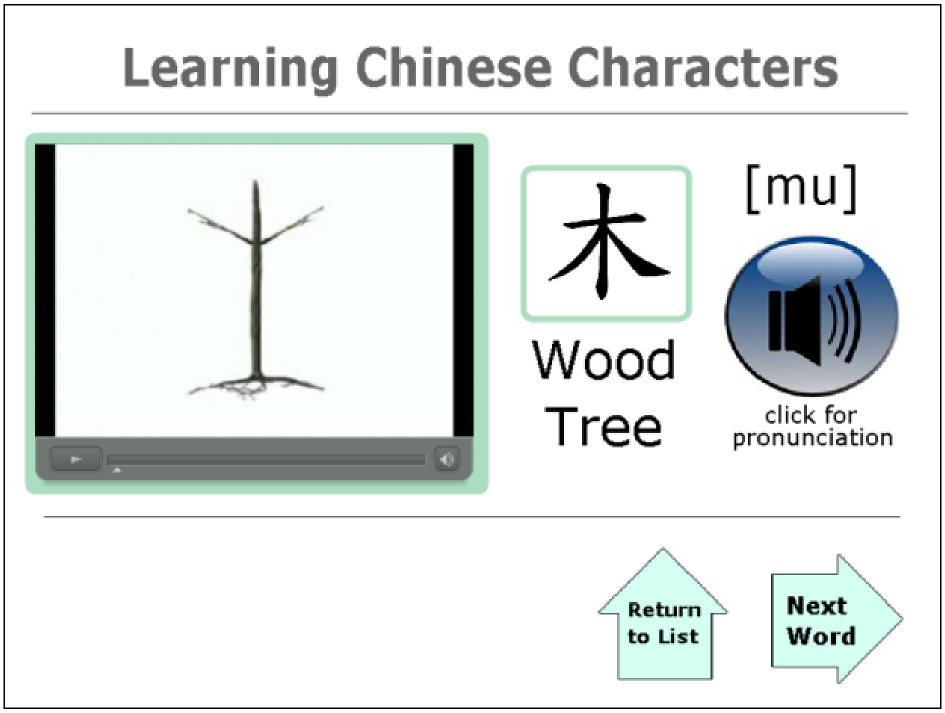

Figure 30. The interface of the CCL program with four main features

In addition to the four main features of an effective CCL program as described by Lu et al. (2010), there are two more buttons on the interface. The "Return to List" button takes the page back to the list of eighteen pictographic, indicative, and ideographic words previously selected for learning. The "Next Word" button takes the page from the current character page to the next character page. *Figure 30* shows a character's (木 wood; tree) individual learning page after a learner clicks on the character in the 18-word table in the previous main page. The learner may choose to go to the next word page or to go back to the previous eighteen-word table page.

In summary, on the individual character learning page (*Figure 30*), there is an introductory video about the character's etymology illustrating its written form and also its semantic meaning on the left, the target character depicting the character's standard written form in a square in the middle, its meaning underneath the square, and its pronunciation on the right. Learners may click the round button for the pronunciation of the character. Learners may also use the slide to go back (rewind) and forth (fast-forward) to watch the videos on the left of the screen. Note that as the program is developed in Flash, any videos, including but not limit to, the embodied animation videos, can be shown in the video frame area on the left of the screen.

Summary of Literature Review

Chinese characters have three main features, semantic meaning, pronunciation, and written form. They are different from English words in that they are non-alphabetic orthographies, and they are deemed to be hard to learn. However, Chinese character processing is found to be related to human body movements, or at least the imagination of them. Literature has also indicated the importance of embodied cognition, imagination, and technology use in human memory and learning. The design of embodied animation is thus developed for CCL.

The literature consistently calls attention to the need for more studies looking at how animations may help CCL for beginning learners of CFL and the relationship between animation programs provided and beginning learners' CCL learning outcome. Many of the findings are based on studies that lacked a control or comparison group and randomization. Thus, to strengthen the efficacy of CCL program for CCL, there is a need for randomly assigned studies to increase internal validity. My studies will add to the literature by building on what is already known and strengthening the knowledge base by:

1. Including a control group and several treatment groups
2. Use of random assignment
3. Increasing sample size
4. Taking into account the impact of human body movements on CCL

CHAPTER III

THE PILOT STUDY

Section 1. Overview

As stated in previous chapters, Chinese is a popular but difficult language for beginning learners of CFL. Due to the complex nature of Chinese characters, learners of CFL exhibit a motivation decline when learning Chinese characters. Therefore, many researchers have designed and developed Chinese character learning programs.

In the pilot study, I proposed a Chinese character learning program using embodied animations and hypothesized that the embodied animation design would yield better learning. To examine whether the design of embodied animation learning (EAL) was effective, I conducted an experiment to compare this design to other two designs, which were traditional learning (TL) and animation-only learning (AL). The purpose of the study was to examine the effectiveness of using embodied animations in learning Chinese characters for beginning adult learners of CFL.

After briefly stating the rationale, purpose, and justification for the study, I describe the research method, report the results, and discuss the limitations and implications of the design of my pilot study in this chapter.

Section 2. Background, Problem, and Rationale

Though Chinese, a macrolanguage coded *zho* under the international language code ISO 639-3 (SIL International), has 15 significantly different individual languages or dialects (Tang & Heuven, 2007), written Chinese uses the same characters across these languages. These characters, or *Hanji*, are non-alphabetic orthographic words that are formed and written in a specific logographic format.

Despite a recent trend of Chinese learning in U.S. colleges (Furman, Goldberg & Lusin, 2007) as well as in U.S. foreign language learning policy (e.g., The White House, 2009), learners of Chinese still exhibit a motivational decline after their first semester of Chinese class or after Chinese characters are introduced (Branner, 2009; Li, 1996), which is often attributed to the difficulty of mastering Chinese characters. This indicates the need for studying and developing a more effective system of Chinese character learning.

Scientific Justification

Traditionally, rote memorization or constant repetition has been emphasized in CFL learning as the chief method to master the target language. CFL learners have to go through a lot of repetitive writing and dictation, which makes Chinese learning "very mechanical, uninteresting, and stressful" (Ki et al., 2003, p. 54). But in recent years, we have found strong technological and neuro-cognitive evidence to support the use of animation technologies, along with embodiment designs to facilitate character learning.

Researchers have found positive effects of using various types of animations on Chinese character learning. For example, *KanjiCard* (Nakajima, 1988), *HyperCharacters* (Li, 1996), *multimedia design* (Wang, 2005), *Character Origin*, and *Chinese character knowledge base* (Lam et al., 2001) have all shown evidence of positive learning effects.

In addition, neuroimaging researchers (Tan et al., 2000; Tan et al.,2001) have used fMRI to examine the brain's cortical activities when one is processing Chinese characters. They found that Brodmann's areas 9, 46, 47, 44, 37, and 17-19 are uniquely activated for Chinese characters. What is interesting and new in the field is that Brodmann's areas 1, 3, 4, 6, and 7 are also strongly activated. The activation of these areas implies that Chinese character processing is strongly associated with human body movements, a finding that has led to this empirical embodiment pilot study.

Building on the effectiveness of instructional embodiment designs for math learning (Fadjo, Lu & Black, 2009; Fadjo et al., 2008; Fadjo et al., 2009), I have proposed the use of embodied animation – and designs that show one's physical enactment of the attributes of a character – for Chinese character learning.

Research Question

In this pilot study, I investigate the following research questions:

RQ1: Does the use of embodied animation in Chinese character learning generate learning outcomes for CFL learners in terms of memorization of Chinese characters superior to those that use no embodied animation?

My hypothesis is that participants in the EAL condition – where they watch the addition of human body movements to the Chinese character learning program videos – will have better learning outcomes than those in either the AL learning condition, where participants watch the etymological animation-only videos, or those in the TL condition where participants watch a static screen rather than any form of video.

RQ2: What roles do learners' attitudes, confidence, and embodiment experiences play in the learning of Chinese characters?

Section 3. Method

Study Design

The present study adopted an experimental between-subject design with three treatment groups to investigate the effectiveness of different Chinese character learning programs for beginning learners of CFL. The learning outcomes across groups were examined through the use of a One-Way Analysis of Variance (ANOVA). Post-hoc Dunnett t-tests were conducted to further examine possible differences in post-instruction test results between any two of the three groups.

Adult participants were randomly assigned to one of the three treatment groups: (a) the Traditional Learning group (TL), in which participants received the Chinese Character Learning Program that contains three features of each of the eighteen Chinese characters but did not include a video in a static interface; (b) Animation Learning group (AL), in which participants received the Chinese Character Learning Program that contains three features of each of the same eighteen Chinese characters plus a video that shows an animation of the character's etymological form changes; and (c) Embodied Animation Learning group (EAL), in which participants received the Chinese Character Learning Program that contains three features of each of the same eighteen Chinese characters plus a video that not only shows an animation of the character's etymological form changes but also human body movements, actions, or gestures that depict both the semantic meaning and written form of the character. *Figure 31*, *Figure 32*, and *Figure 33* show the screenshots of the program interfaces for TL, AL, and EAL.

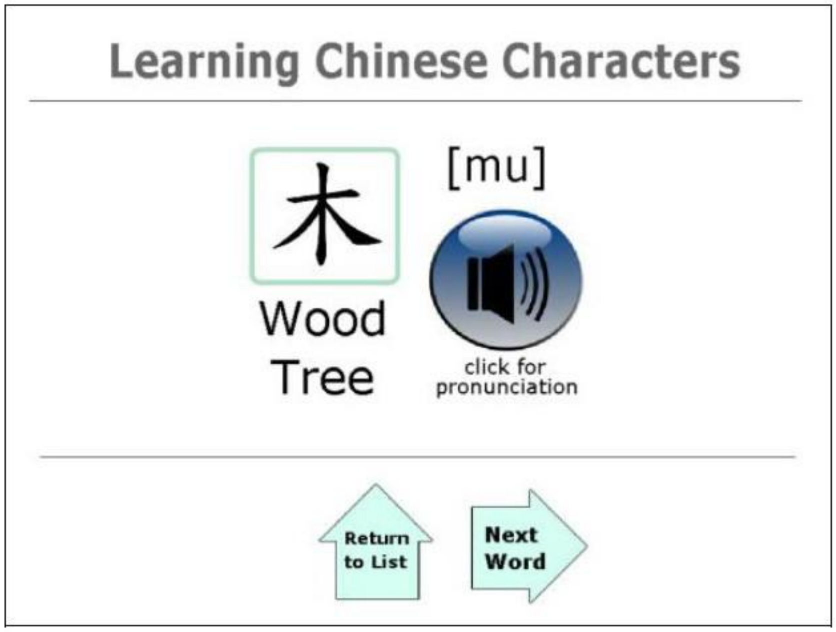

Figure 31. The Chinese character individual learning page of "Tree" for the TL group

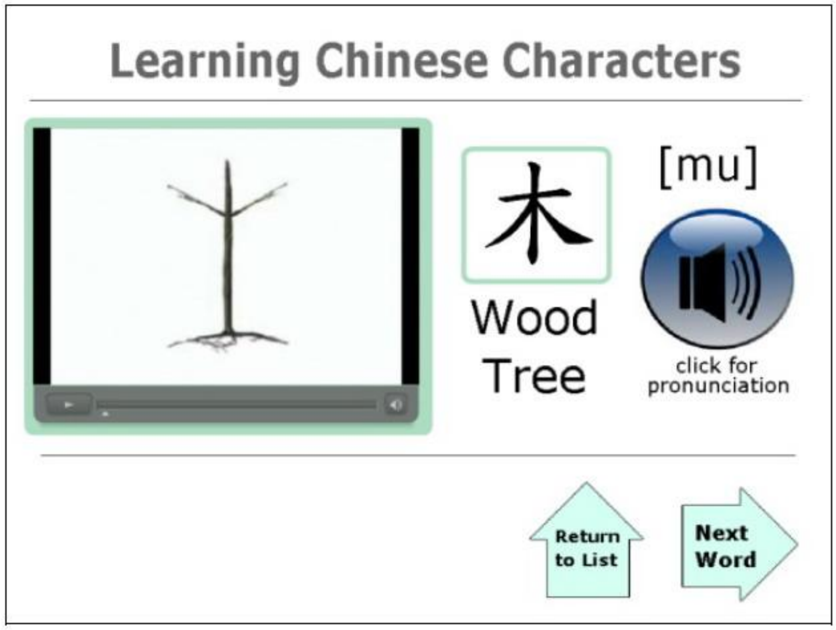

Figure 32. The Chinese character individual learning page of "Tree" for the AL group

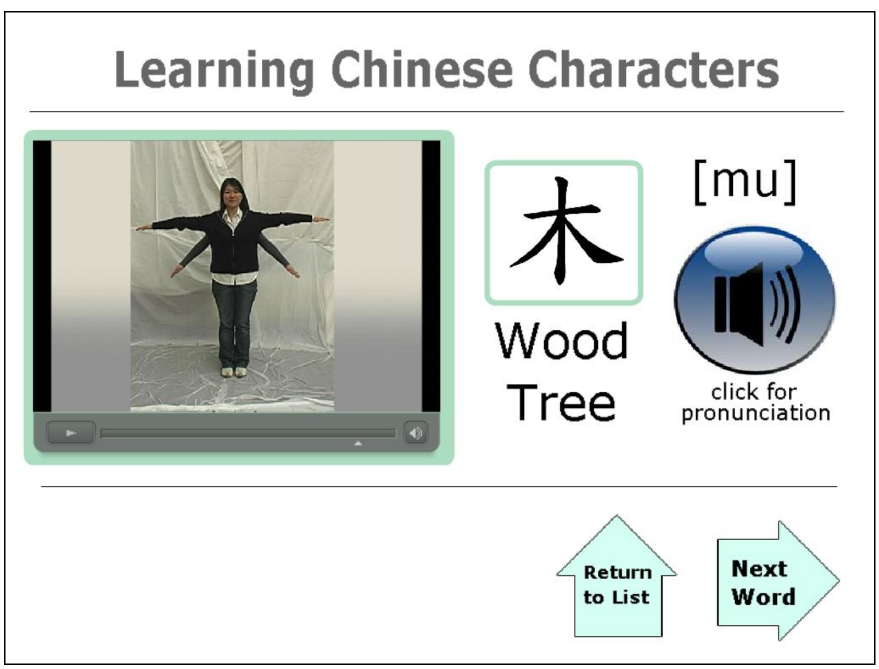

Figure 33. The Chinese character individual learning page of "Tree" for the EAL group

Participants

Thirty-six undergraduate and graduate students from Columbia University, Teachers College, and other colleges voluntarily participated in the study. All participants did not know any Chinese characters at the time of the experiment and were pre-tested to show no prior knowledge of Chinese language before any instruction. In addition, from the pre-instruction questionnaire, none of the participants indicated that they knew any Chinese characters or spoke any Chinese at the time of the experiment. The participants were quite homogeneous such that there were no group differences concerning prior knowledge of Chinese, age ($F(2, 33) = .200$, $p = .82$[1]), level of confidence in Chinese character learning ($F(2, 33) = .061$, $p = .941$), or attitude toward learning new things ($F(2, 33) = .569$, $p = .572$).

Table 3 shows demographic information by groups, including the number of cases, gender, and the means of chronological ages. *Table 3* also shows participants' pre-instruction level of confidence in Chinese character learning (scale from 0-5; 0: not at all confident, and 5: very confident), and pre-instruction attitude toward learning new things (scale from 1-5; 1: “do not like to learn new things at all”, and 5: “like to learn new things very much”). Among all the participants, 19 were female and 17 were male. The mean chronological age across groups was 31.31, with a standard deviation of 8.13. When asked “Do you think that you can learn Chinese characters well?” prior to instruction, the participants yielded an overall confidence level of 3.14, with a standard

[1] *p* value is significant at the .05 level.

deviation of .83. When asked "Do you like to learn new things" prior to instruction, the participants yielded an overall attitude toward learning new things of 4.67, with a standard deviation of .59.

The TL group had 13 participants, the AL group had 10 participants and the EAL group had 13 participants. In terms of their native (first) language, 35 indicated it was English.

Table 3
Demographic Data, Pre-Instruction Confidence Levels, and Pre-Instruction Attitude toward Learning New Things across Groups

	TL Group	**AL Group**	**EAL Group**	**Total/Average**
Number of cases	13	10	13	36
Mean age (SD)	32.15 (9.36)	29.89 (7.29)	31.46 (7.88)	31.31 (8.13)
Female	10	2	7	19
Male	3	8	6	17
Confidence level (Std. Dev.)	3.15 (.80)	3.20 (.79)	3.08 (.95)	3.14 (.83)
Learn new things (Std. Dev.)	4.69 (.48)	4.80 (.63)	4.54 (.66)	4.67 (.59)

Apparatus and Materials

Apparatuses

The apparatuses used were IBM compatible Dell laptops with 15-inch monitors. All laptops came with Adobe Flash CS4 Professional and Scratch software pre-installed. Earphones and speakers were tested to ascertain their proper function before use. Participants learned characters with the Chinese Character Learning Program and with the Scratch game run on Flash and Scratch using these apparatuses. In addition, two pieces of blank paper and two pens were provided during the learning activity time. A picture of the experiment room and a picture of the laptop used in this study are also included in Appendix 1 and Appendix 2.

Materials

The materials used in the study are listed in the Appendix (3-18). They include the Informed Consent/ Participant's Rights form, the Pre-instruction Questionnaire, the General Instruction Sheet, the specific Instruction Sheet for each group, the screenshots of the video instructions for the AL and EAL groups, the screenshots of the Chinese Character Learning programs for each group, the identical immediate and delay tests, the screenshot of the Scratch game, the Scratch game interview sheet, and the Post-instruction Questionnaire that contains a demographic survey.

Instructional Materials

The General Instruction Sheet, the specific Instruction Sheets for each groups, the video instructions for the AL and EAL groups, and the Chinese Character Learning programs for each groups served as instructional materials in the study.

On the General Instruction Sheet, Chinese characters were introduced as logographs that are notably different from alphabets such as those used to construct words in English. Also, characters as a basic writing unit possess a number of strokes that are packed into a square shape. Furthermore, the three features of a Chinese character were introduced: One, a character has its meaning(s). Two, a character has its pronunciation(s). And, three, a character has its unique written form and thus every character is written differently. Eight Chinese characters in eight squares are provided as examples. They are:三 (three) [san], 六 (six) [liou], 七 (seven) [chi], 八 (eight) [ba], 盧(black) [lu], 明 (bright) [ming], 燦 (bright) [tsan], and 爺 (grandfather) [yeh]. Appendix 6 shows the General Instruction Sheet.

On the Instruction Sheet, there were five common points to help all three groups' participants get familiar with the Chinese character learning program and to get ready for the learning phase: 1. Participants were asked to try their best to learn the Chinese characters. 2. Participants were told they would be seeing 18 characters in total, and they would have 2 minutes to learn each character (36 minutes in total). Participants were asked to learn all 18 characters. 3. Participants were informed that testing would take place after the learning phase. 4. A picture sample of the Chinese character individual learning page was displayed and elements on the learning page were explained (i.e., the target character was in a square in the middle, its meaning was underneath, and its pronunciation was on the right). Participants were told they could click the round button for the character's pronunciation. 5. Participants were also informed that all 18 Chinese characters would be shown in a table, and participants could come back to this table page anytime by clicking *Return to List*, or they could go to the next character learning page by clicking *Next Word*. The instruction sheet for EAL group had one more point: "When you watch each of the videos, please imagine doing the movements or gestures yourself." Appendix 7, Appendix 8, and Appendix 9 show these Instruction Sheets for the TL, AL, and EAL groups, respectively.

Participants who were not familiar with computer-based video functions and were assigned to the AL or EAL group were prompted to watch the video instruction video clips before they started the computer program (see Appendix 10 for three screenshots of the video instruction video clips).

When participants started the computer-based Chinese Character Learning Program, they first saw the table of 18 characters where all the to-be-learned targeted characters were listed (see *Figure 34*). These characters include 7 pictographs (木， 火， 山， 心， 人， 魚， 犬), 5 indicatives (上， 下， 中， 大， 小), and 6 ideographs (看， 比， 告， 舟， 長， 去).

木	火	山	心	人	魚
上	下	中	大	小	犬
看	比	告	舟	長	去

Figure 34. Screenshot of the table of 18 characters

Table 4

The Three Features of the 18 Characters

Character Type	**Written Form**	**Semantic Meaning**	**Pronunciation**
Pictographs	木	Tree; Wood	[mu4]
	火	Fire	[huo3]
	山	Mountain	[shan1]
	心	Heart; Mind	[xin1]
	人	Human	[ren2]
	魚	Fish	[yu2]
	犬	Dog	[quan3]
Indicatives	上	Up; Above	[shang4]
	下	Below; Under	[xia4]
	中	Middle; Center	[zhong1]
	大	Big; Huge	[da4]
	小	Small; Little	[xiao3]
Ideographs	看	See; Look; Watch	[kan4]
	比	Compare	[bi3]
	告	Tell; Speak	[gao4]
	舟	Boat; Ship	[zhou1]
	長	Long; Length	[chang2]
	去	Go out; Leave	[qu4]

Table 4 shows each of the 18 characters' character type and the three features of the 18 characters: written form, semantic meaning, and pronunciation. The written forms presented here are in Standard Kai Scripts (標楷體) and the pronunciations are in Pinyin Phonetic Symbols.

When participants clicked on the character they wished to learn, that character's individual learning page would be displayed. Take the top left character as an example. When a TL participant clicked the character 木 (tree) [mu], this character's individual learning page would be displayed as shown in *Figure 31*. For the same character, an AL participant would see the page shown in *Figure 32*. And for the same character, an EAL group participant would see the page shown in *Figure 33*. Similarly, if the character 中 (middle) [zhong] was clicked, that individual character learning page would be displayed. Appendix 11, Appendix 12, and Appendix 13 show the individual character learning pages of the character 中 (middle) [zhong] for the TL, AL and EAL groups, respectively.

Measurement Materials

The Pre-instruction Questionnaire included five questions: two prescreening questions, one opinion question, one confidence question, and one attitude question. The opinion question was, "What do you think about Chinese words/ characters?" Participants could circle all that apply from 10 possible answers: Chinese characters a. are something I have no idea about; b. are a meaningful and interesting writing script; c. are just like some other foreign writing systems; d. are not interesting; e. are meaningless lines and dots; f. are impossible to learn; g. are difficult to learn; h. can be mastered with effort; i. are easy to learn; and j. are useful and powerful. The confidence question was, "Do you think that you can learn Chinese characters well?" The answer was on a 6-point Likert scale from 0 to 5, with 0 as least confident and 5 as most confident. The attitude question was, "Do you like to learn new things?" The answer was on a 5-point Likert scale from 1 to 5, with 1 as not at all and 5 as very much.

Appendix 5 shows the Pre-instruction Questionnaire.

The Post-instruction Questionnaire included the same opinion question and the same confidence question as the pre-instruction questionnaire, a demographic survey, and 12 other opinion and comment questions. All the opinion questions were on a 4-point Likert scale from 2 (very much), 1 (a little), to -1 (not a lot), and -2 (not at all). For example, questions such as “Do you like the Chinese character instruction program?” “Do you think the Chinese character instruction program is effective?” ”Does the video make Chinese characters easier to learn?” “Does the video help you in understanding and remembering the Chinese characters?” “Does the video help arouse your interest in learning Chinese?” “Does the program help maintain your motivation in character learning?” were all rated on this 4-point Likert scale. There were also open-ended questions such as “How would you have improved the program were you an instructional designer?” and “Please share any thoughts on Chinese language learning or extra comments.” Appendix 17 shows the Post-instruction Questionnaire for the AL and EAL groups and Appendix 18 shows the Post-instruction Questionnaire for the TL group.

Testing Materials

The identical test was used for both the immediate test and the delay test. There were 5 parts to the tests. The first part was a retention test in Section 1 and Section 4, where Section 1 tested participants’ meaning-to-form mapping correction rate (as semantic meanings were provided) and Section 4 tested participants’ form-to-meaning mapping correction rate (as written forms were provided). The maximum score on this part was 6 points if all 6 questions were answered correctly. The second part was a retention test in Section 2, which tested if participants could correctly write down the character's written form with the semantic meanings provided. The maximum score on this part was 12 points if all 3 characters were written correctly. The third part was a retention test in Section 3 that tested the participants' form-to-sound mapping correction rate as written forms were provided. The maximum score on this part was 3 points. The fourth part was a near-transfer test in Section 5 and Section 6 in which participants were asked to make inferences about the possible meanings of unknown Chinese characters that contained one of the eighteen components as radicals that were just learned in the learning phase, or to infer possible written forms when semantic meanings were provided. The maximum score on this part was 8 points. The fifth part was a morphology awareness test in Section 7 and Section 8 in which participants were asked to figure out what characters may carry certain meanings or to find characters that do not have similar meanings with other characters. The maximum score on this part was 5 points. The highest possible score for the whole test was 34. Appendix 14 shows the test used in the study as both the immediate test and the delay test. In addition, a character free recall test was performed in which a blank sheet of paper was given to participants to write down all the characters they had learned in the learning phase. The highest possible number of correct characters recalled and written was 18 and, because I coded the correctness of each character from 0 to 4 (with 4 if the character was written correctly and 0 if the character was totally incorrect or unrecognizable), the maximum score on this part was 72 points.

Distraction Materials

I used a pre-programmed Scratch game and the Scratch game interview as distraction materials for 10 minutes between the immediate test and the delay test. Participants were not informed that this activity was meant to be a distraction and were asked to use the 4 arrow keys and the space key to observe and explore both the Scratch program and the three Chinese characters. Appendix 15 shows a screenshot of the Scratch game. Appendix 16 shows the Scratch interview questions.

Procedures

Prescreening

The study was introduced to participants as research about Chinese character learning. Each participant was told that he or she would be completing a Pre-Instruction questionnaire, an immediate test, a language learning game, a delay test, and a Post-Instruction questionnaire in addition to a learning activity where he or she learns 18 Chinese characters using a computer-based Chinese Character Learning program. They were told to try to do their best to learn the characters. From the Pre-instruction Questionnaire, I made sure that all participants did not know anything about the Chinese language and had never learned Chinese through pre-screening. Also, I ascertained that all participants could competently use a computer mouse or touchpad, which was necessary for the study.

Table 5

Experimental Procedures by Groups

Time	TL group	AL group	EAL group
1 min (approx.)	Consent	Consent	Consent
1 min (approx.)	Pre-Instruction Questionnaire	Pre-Instruction Questionnaire	Pre-Instruction Questionnaire
1 min (approx.)	General Instruction	General Instruction	General Instruction
1 min (approx.)	Instruction-TL	Instruction-AL	Instruction-EAL
1 min (approx.)		View Video Instructions.swf	View Video Instructions.swf
Up to 40 min	Character Learning Program-TL.swf	Character Learning Program-AL.swf	Character Learning Program-EAL.swf
10 min	Immediate Test	Immediate Test	Immediate Test
10 min	Scratch game + interview	Scratch game + interview	Scratch game + interview
10 min	Delay Test	Delay Test	Delay Test
5 min (approx.)	Recall Test	Recall Test	Recall Test
5 min (approx.)	Post-Instruction Questionnaire	Post-Instruction Questionnaire	Post-Instruction Questionnaire
Total: 85 min (approx.)			

Process

Table 5 shows the experimental procedures for all three groups. Participants were first randomly assigned to one of the three groups: the TL group, the AL group, or the EAL group. Then they started by reading the Informed Consent and by signing the Participant's Rights form. Afterwards, participants were given the Pre-instruction Questionnaire to fill out. Those who could speak any Chinese or had learned any

Chinese were excluded from the study.

Second, all three groups of participants could take their time and read over the General Instruction Sheet (see Appendix 6), which contained basic information and an introduction to Chinese characters. On the sheet, participants were told that they were going to learn some Chinese characters. After reading the sheet, participants were asked to proceed by reading the next Instruction Page.

Third, the TL and AL group participants were then asked to take their time and carefully read the 5 points on the specific Instruction Sheet for their group (for EAL group participants, 6 points). They were asked to make sure that they fully understood what they had read by placing a check after each points. On the sheet, the participants were asked to try their best to learn all 18 characters.

Fourth, for participants who were not familiar with computer-based video functions and were assigned to the AL group or EAL group, they watched the 1-minute video instructions before they started the computer program (see Appendix 10 for three of the screenshots of the video instructions). The TL group participants did not view this video clip.

Fifth, participants could spend up to 40 minutes learning the 18 Chinese characters using their assigned group-specific Chinese Character Learning Program. Two pieces of blank paper were provided during this learning phase for participants to practice writing or to facilitate memorization if they so wished.

Sixth, participants took the Immediate Test for no more than 10 minutes.

Seventh, they were told to take a short break to play the Scratch game for 3 minutes where they were asked to use the four arrow keys and the space key to observe and explore both the program and the three Chinese characters. A seven-minute interview was conducted with the interview questionnaire.

Eighth, participants then took the identical Delay Test for no more than ten minutes.

Ninth, in the Free Recall Test, participants were asked to write down all the characters they could still remember on a blank sheet.

Tenth, the participants filled out the Post-instruction Questionnaire where they entered their opinions, thoughts, and demographic information.

Finally, participants received $15 remuneration and were told to feel free to ask any questions regarding this study.

Data Analysis

Quantitatively, a one-way analysis of variance was conducted to investigate the effectiveness of different Chinese character learning programs for beginning learners of CFL. Post-hoc Dunnett t tests were conducted to further examine possible differences in the post-instruction test results between any two of the three groups.

Qualitatively, the written forms of characters by participants were rated based on our grading guideline rubrics in the codebook. Pre-instruction Questionnaire and Post-Instruction Questionnaire were compared and analyzed.

Variables and Coding

Table 6 shows all dependent variables' names, descriptions, places in the tests, score ranges, and the highest possible scores from the Immediate Test, the Delay Test, and the Free Recall Test.

Table 6
Variables from the Tests

Variable Name (variable description)	**Problem No. in the Test**	**Score Range**	**Highest possible score**
TestS; DeS **(Semantic Meaning Score)**	No. 1.1	0-1	6
	No. 1.2	0-1	
	No. 1.3	0-1	
	No. 4.1	0-1	
	No. 4.2	0-1	
	No. 4.3	0-1	
TestW; DeW **(Written Form Score)**	No. 2.1	0-4	12
	No. 2.2	0-4	
	No. 2.3	0-4	
TestP; DeP **(Score of Pronunciation)**	No. 3.1	0-1	3
	No. 3.2	0-1	
	No. 3.3	0-1	
Test56; De56 **(Score of Near-Transfer)**	No. 5.1	0-2	8
	No. 5.2	0-2	
	No. 5.3	0-2	
	No. 6.1	0-1	
	No. 6.2	0-1	
Test78; De78 **(Score of Morphology Awareness)**	No. 7.1	0-1	5
	No. 7.2	0-1	
	No. 7.3	0-1	
	No. 8.1	0-1	
	No. 8.2	0-1	
TestTotal; DeTotal		0-34	34
Recall	Blank sheet	0-72	72
RecallPerfect	Blank sheet	0-18	18

There were four dependent variables (DV) in the study: *TestTotal*, *DeTotal*, *Recall*, and *RecallPerfect*. From the Immediate Test, the DV in the study is *TestTotal*, which is the sum of *TestS*, *TestP*, *TestW*, *Test56*, and *Test78*:

TestTotal = TestS + TestW + TestP + Test56 + Test78

Similarly, another DV from the Delay Test, *DeTotal*, is the sum of *DeS*, *Dep*, *DeW*, *De56*, and *De78*:

DeTotal = DeS + DeW + DeP + De56 + De78

From the Free Recall Test, I obtained another DV for measuring the participants' total recall of the characters' written forms called *Recall*. Each character was graded from 0 to 4, and thus if all 18 of the characters were written correctly, the highest possible score for *Recall* was 72. *Table 7* shows the grading guidelines for of any characters' written forms that the participants wrote either in the Recall Test or in *TestW*.

Table 7
Grading Guideline Rubrics for Written Forms

Score assigned	**Description of the character written by participant**
0	No writing; Completely wrong; Entirely unrecognizable
1	Barely recognizable; Some shape; Deducible; Seems like it
2	Recognizable; Several misses; Keeps the shape
3	Easily recognizable; Only 1-2 misses; Near perfect
4	Perfect; Completely correct

I created a final DV called *RecallPerfect* which was the total number of perfect characters written by participants in the Recall Test. The range of *RecallPerfect* was thus from 0 to 18.

For coding of the questions No. 5.1, No. 5.2, and No. 5.3 in variables *Test56* and *De56*, I followed the grading guidelines in *Table 8*.

Table 8

Grading Guideline for Near-Transfer Items

Score assigned	**Description of the semantic meaning from participants**
0	No writing; Completely wrong; Entirely different meaning
1	Guessed at some meaning; Some related meanings
2	Perfect; Completely correct

From Practice Sheets, I calculated the total number of words, meanings, sounds, or graphs that participants generated in their practice on the sheets. The variable *PracW* refers to the number of characters written, the variable *PracS* refers to the number of meanings written, the variable *PracP* refers to the number of pronunciations written, and the variable *PracT* refers to the total number of things written on the sheets. In other words, *PracT* = *PracW* + *PracS* + *PracP*.

Section 4. Results

This study aimed to investigate the effectiveness of different Chinese character learning programs for beginning learners. Specifically, I examined whether Embodied Animation Learning was superior to Traditional Learning or Animation Learning.

Pre-Instruction Questionnaire

All 36 participants indicated that they did not know or speak any Chinese at the time of experiment (with both 0s for No. 1.1 and No. 1.2 in the Pre-instruction Questionnaire). Therefore, there was no group difference in prior knowledge of Chinese. Pre-instruction levels of confidence in Chinese character learning and pre-instruction attitude toward learning new things are listed in *Table 3*. *Table 9* shows the omnibus one-way ANOVA for pre-instruction level of confidence in Chinese character learning and pre-instruction attitude toward learning new things. There were no group differences concerning the levels of confidence in Chinese character learning (F (2,33) = .061, *p* = .941) and attitude toward learning new things (F (2, 33) = .569, *p* = .572).

Table 9
ANOVAs for Level of Confidence and Attitude Toward Learning

		SS	df	MS	F	*p*-value
Confidence	Between	.09	2	.045	.061	.941
	Within	24.215	33	.734		
	Total	24.306	35			
New things	Between	.40	2	.200	.569	.572
	Within	11.60	33	.352		
	Total	12.00	35			

Test Means and Standard Deviations

Table 10 shows mean scores and their standard deviations for Immediate Test (Post), Delay Test, Recall Test, and *RecallPerfect* from the Traditional Learning (TL, n = 13), Animation Learning (AL, n = 10), and Embodied Animation Learning (EAL, n = 13) groups. The variables' possible score ranges are also listed. To examine the effect of embodied animations from that of other common etymological animations in Chinese character learning, effect sizes (ES) r and Cohen's *d* between the AL group and the EAL group were also calculated and reported in *Table 10.*

Table 10
Test Means and Standard Deviations

Variable (possible range)	TL's Mean (SD)	AL's Mean (SD)	EAL's Mean (SD)	ES r (Cohen's d, b/t AL & EAL)
Pre	0	0	0	
Post (0-34)	24.08 (5.299)	27.1 (4.408)	30.54 (2.961)	0.416 (0.934)
Delay (0-34)	24.62 (5.895)	27.4 (4.648)	30.77 (2.743)	0.404 (0.883)
Recall (0-72)	40.08 (9.987)	48.00 (12.824)	57.54 (12.218)	0.356 (0.762)
RecallPerfect (0-18)	7.77 (2.242)	9.40 (3.688)	11.54 (4.719)	0.245 (0.505)
N	13	10	13	

All three groups' participants did not have any prior knowledge of the Chinese language and therefore they yielded an equal 0 for Pre. For Immediate Test (Post), the TL group's M = 24.08 (SD = 5.299), the AL group's M = 27.1 (SD = 4.408), and the EAL group's M = 30.54 (SD = 2.961). The Cohen's *d* = 0.934 (r = 0.416) indicated a large effect size between the AL and EAL groups. For the Delay Test, the TL group's M = 24.62 (SD = 5.895), the AL group's M = 27.4 (SD = 4.648), and the EAL group's M = 30.77 (SD = 2.743). The Cohen's *d* = 0.883 (r = 0.404) indicated a large effect size between the AL and EAL groups. For the Free Recall Test, the TL group's M = 40.08 (SD = 9.987), the AL group's M = 48.00 (SD = 12.824), and the EAL group's M = 57.54 (SD = 12.218). The Cohen's *d* = 0.762 (r = 0.356) indicated a medium to large effect. For *RecallPerfect*, the TL group's M = 7.77 (SD = 2.242), the AL group's M = 9.40 (SD

= 3.688), and the EAL group's M = 11.54 (SD = 4.719). The Cohen's *d* = 0.505 indicated a medium effect. Note that the effect sizes were calculated and reported here after obtaining the evidence of all the related statistical significances, which is listed in the Group Comparisons section below.

Graphs for Test Results

To clearly illustrate the different group means from these tests, I further graphed two bar charts: one clustered with different groups across these tests, and the other clustered with these tests across different groups. *Figure 35* and *Figure 36*, respectively, show group mean comparisons in the pre-test, the immediate test, and the delay test as well as test comparisons in the TL group, AL group, and EAL group.

From *Figure 35*, it seems that the EAL group outperformed both the AL group and the TL group on both the immediate test and the delay test. Also, it seems that the AL group outperformed the TL group on both tests. From *Figure 36*, it seems that there were no differences between the immediate test results and the delay test results for all three groups. I, therefore, chose only to examine the immediate test results further by graphing a box-plot diagram.

Figure 37 shows the box-plot of comparison of the immediate test results (*TestTotal*) across the three groups. Two obvious outliers were detected: No. 26 in the AL group and No. 14 in the EAL group. I included these cases in my final analysis because the inclusion or exclusion of these cases did not dramatically affect the results.

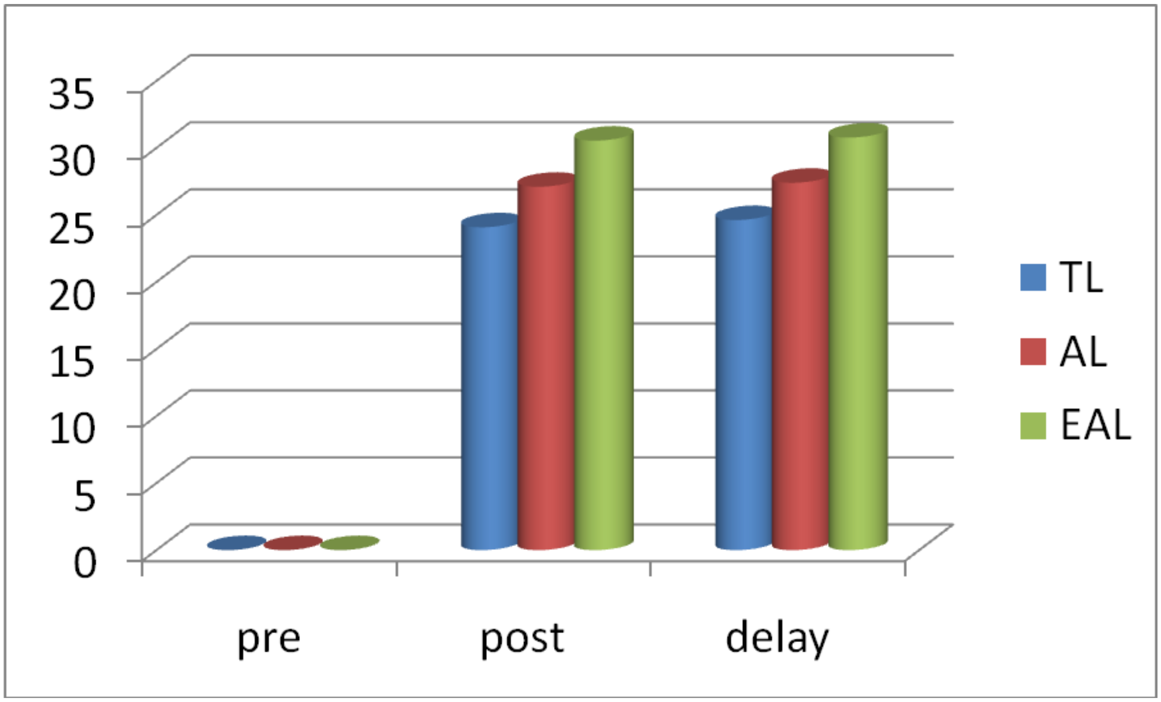

Figure 35. Group comparisons in the pre-test, the immediate test, and the delay test

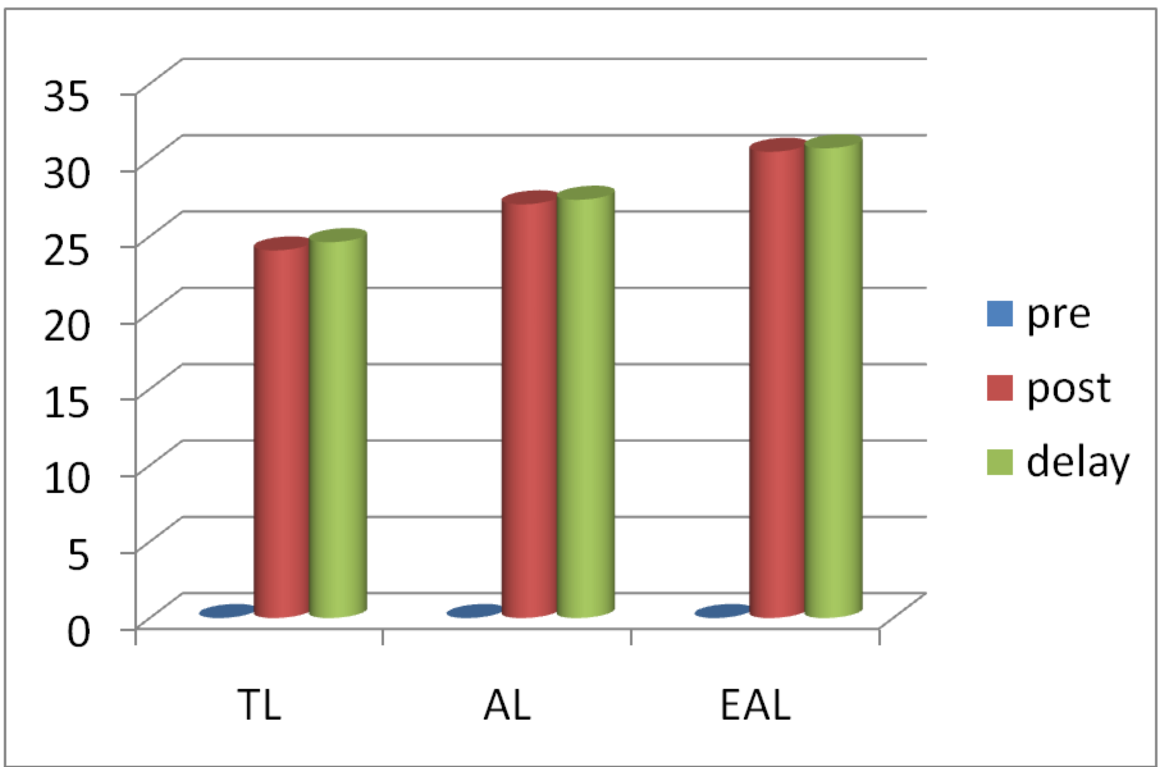

Figure 36. Test comparisons for the TL group, the AL group, and the EAL group

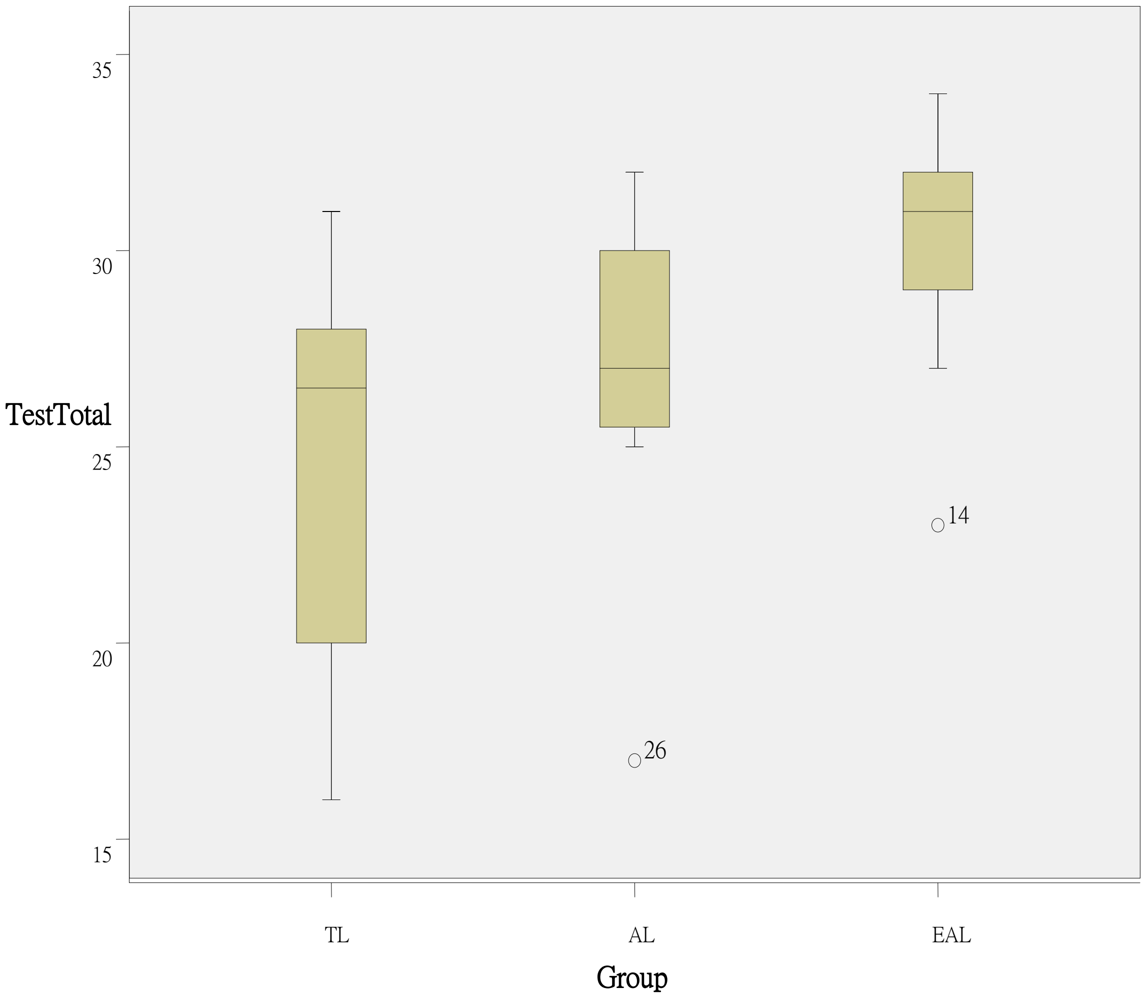

Figure 37. Box plot- comparison of the *TestTotal* (Immediate Test scores) across groups

Figure 38 and *Figure 39* show, respectively, the comparisons of the total number of Chinese characters written by participants (*Recall*) across groups and the comparison of the total number of Chinese characters correctly written by participants (*RecallPerfect*) across groups. They both show a similar pattern that in the Recall Test: the EAL group appeared to outperform both the AL and TL groups while the AL group appeared to outperform the TL group. I chose to further examine the *Recall* by graphing a box-plot diagram (*Figure 40*).

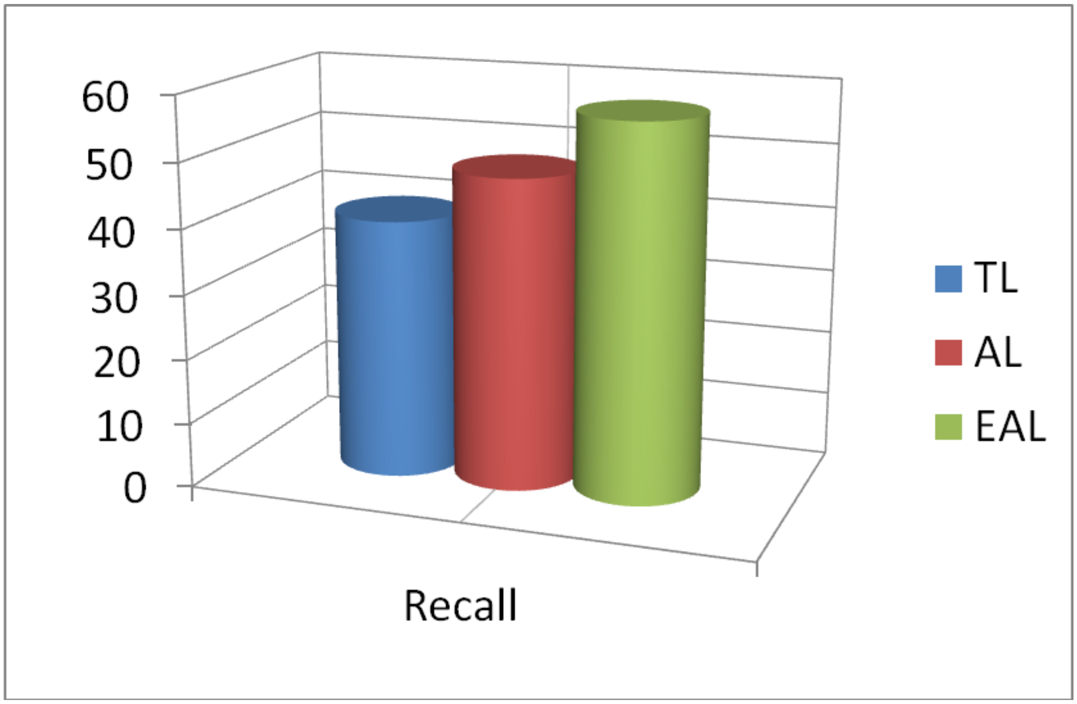

Figure 38. Bar chart-comparison of the *Recall* (the total number of Chinese characters written by participants) across groups

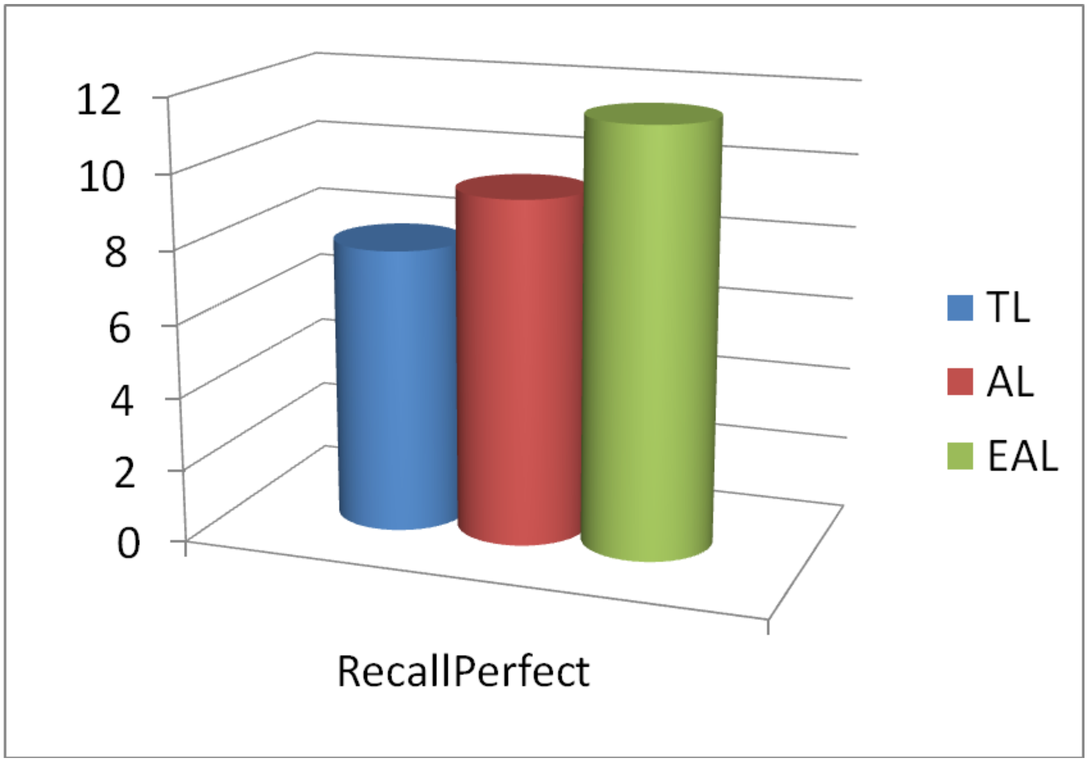

Figure 39. Bar chart-comparison of the *RecallPerfect* (the total number of Chinese characters correctly written by participants) across groups

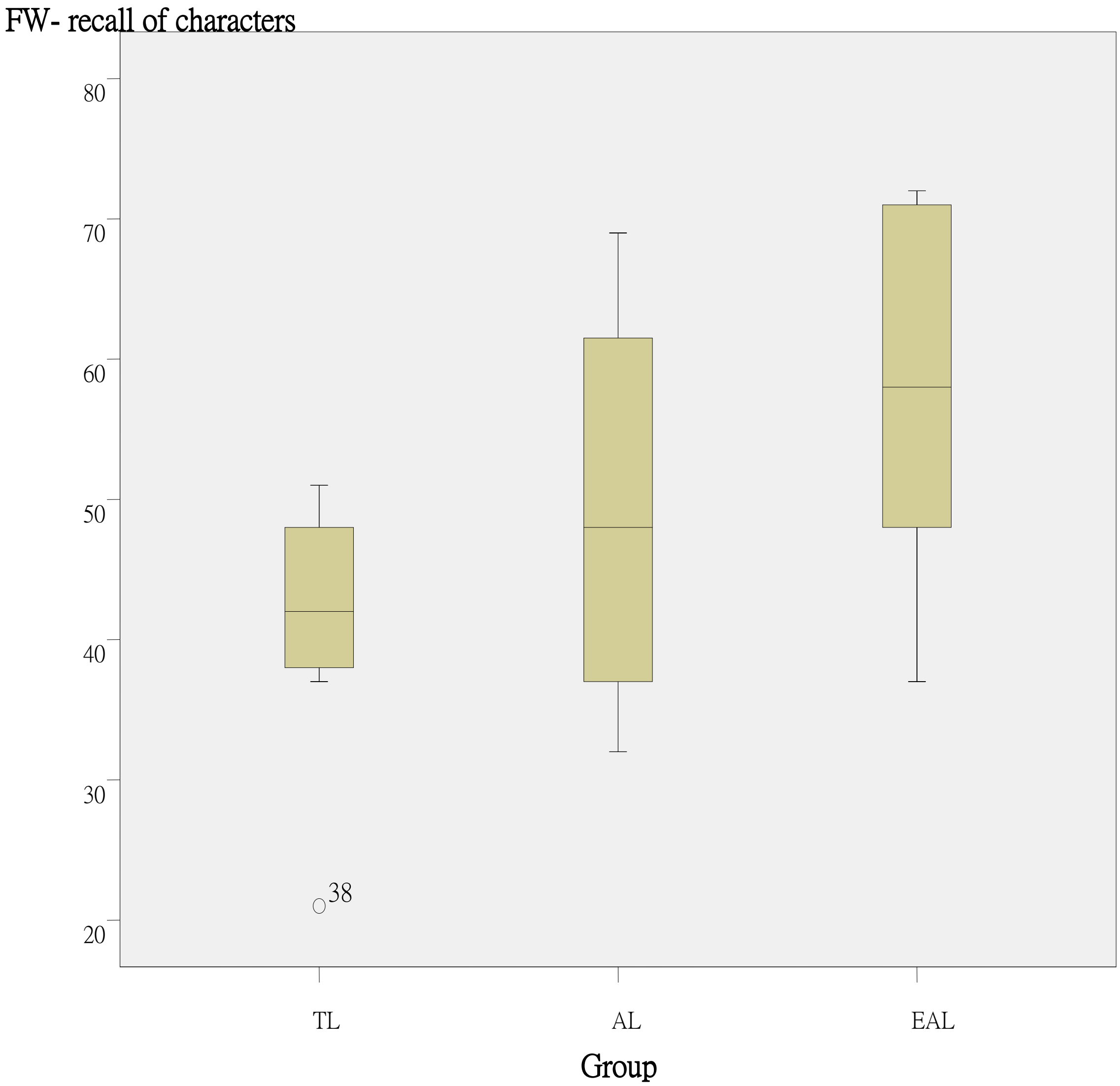

Figure 40. Box plot-comparison of the *Recall* (the total number of Chinese characters written by participants) across groups

Figure 40 shows the box-plot of comparison of the total number of Chinese characters written by participants (*Recall*) across three groups. One obvious outlier was detected: No. 38 in the TL group. I included this case in my final analysis because the inclusion or exclusion of it did not dramatically affect the results.

Group Comparisons

To examine if statistically these group means were indeed different in these tests, I employed a series of one-way ANOVAs. Measures of *TestTotal*, *DeTotal*, *Recall*, and *RecallPerfect* were the DVs, and the treatment groups of TL, AL and EAL were the grouping factor for ANOVA. A significant result indicates a possible difference between any of the two groups among all the groups. *Table 11* shows the omnibus one-way ANOVAs for the Immediate Test (*TestTotal*) and the Delay Test (*DeTotal*). For *TestTotal*, there were significant differences between groups (F (2,33) = 7.265, $p < .01$). For *DeTotal*, there were also significant differences between groups (F (2, 33) = 5.802, $p < .01$).

Table 11
ANOVAs for Immediate Test and Delay Test

		SS	**Df**	**MS**	**F**	***p*-value**
TestTotal	Between	271.696	2	135.848	7.265	.002***
(Immediate)	Within	617.054	33	18.699		
	Total	888.750	35			
DeTotal	Between	246.771	2	123.385	5.802	.007***
(Delay test)	Within	701.785	33	21.266		
	Total	948.556	35			

*** $p < .01$

Table 12 shows the omnibus one-way ANOVAs for the Recall Test (*Recall*) and the total number of perfectly recalled characters (*RecallPerfect*). For *Recall*, there were significant differences between groups (F (2,33) = 7.336, $p < .01$). For *RecallPerfect*, there were also significant differences between groups (F (2, 33) = 3.404, $p < .05$).

Table 12
ANOVAs for Recall of Characters Test and Perfectly Recall of Characters

		SS	**df**	**MS**	**F**	***p*-value**
Recall	Between	1986.596	2	993.298	7.336	.002***
	Within	4468.154	33	135.399		
	Total	6454.750	35			
RecallPerfect	Between	92.812	2	46.406	3.404	.045**
	Within	449.938	33	13.634		
	Total	542.750	35			

*** $p < .01$; ** $p < .05$

In other words, there were significant group differences for all four DVs. To further examine the pair-wise group differences, I performed post-hoc tests. Since the study sought to investigate if EAL was indeed better than AL or TL, I employed one-tailed post-hoc Dunnett t-tests to compare EAL to other groups for all DVs.

Table 13
Post-hoc Dunnett t Test for TestTotal

(I) vs. (J)	**Mean Diff**	**S.E.**	**p-value**	**90% CI-Upper Bound**
TL vs. EAL	-6.462	1.696	.001***	-3.71
AL vs. EAL	-3.438	1.819	.061*	-0.49

*** p < .01; * p < .10

Table 13 shows the post-hoc Dunnett t-test for the Immediate Test (*TestTotal*).

In *TestTotal*, the EAL group marginally outperformed both the AL group by 3.438 points (SE = 1.819) at .10 level of significance (*p* = .061), and significantly outperformed the TL group by 6.462 points (SE = 1.696) at .01 level of significance (*p* < .001).

Table 14

Post-hoc Dunnett t Test for DeTotal

(I) vs. (J)	Mean Diff	S.E.	p-value	90% CI-Upper Bound
TL vs. EAL	-6.154	1.809	.002***	-3.22
AL vs. EAL	-3.369	1.940	.081*	-0.22

*** p < .01; * p < .10

Table 14 shows the post-hoc Dunnett t-test for the Delay Test (*DeTotal*). In *DeTotal*, the EAL group marginally outperformed both the AL group by 3.369 points (SE = 1.940) at .10 level of significance (*p* = .081), and significantly outperformed the TL group by 6.154 points (SE = 1.809) at .01 level of significance (*p* = .002).

Table 15

Post-hoc Dunnett t Test for Recall

(I) vs. (J)	Mean Diff	S.E.	p-value	90% CI-Upper Bound
TL vs. EAL	-17.462	4.564	.001***	-10.06
AL vs. EAL	-9.538	4.894	.054*	-1.60

*** p < .01; * p < .10

Table 15 shows the post-hoc Dunnett t-test for the Recall Test (*Recall*). In *Recall*, the EAL group marginally outperformed both the AL group by 9.538 points (SE = 4.894) at .10 level of significance (*p* = .054), and significantly outperformed the TL group by 17.462 points (SE = 4.564) at .01 level of significance (p < .001).

Table 16

Post-hoc Dunnett t Test for RecallPerfect

(I) vs. (J)	Mean Diff	S.E.	p-value	90% CI-Upper Bound
TL vs. EAL	-3.769	1.448	.013**	-1.42
AL vs. EAL	-2.138	1.553	.151	0.38

** p < .05

Table 16 shows the post-hoc Dunnett t-test for the *RecallPerfect*. In *RecallPerfect*, the EAL group significantly outperformed the TL group by 3.769 (SE = 1.448) at .05 level of significance (p = .013), but the EAL group did not significantly outperform the AL group with a mean difference of -2.138 (SE = 1.553) even at .10 level of significance (p = .151).

Practice Effect

Checks for practice effects were conducted and I found that initially there was no group difference among the three treatment groups (F (2, 29) = .022, p = .978). *Table 17* shows the descriptive statistics of the mean of the total number of practices (*PracT*) participants in different groups generated on the blank practice sheets during the learning phase. *Table 18* shows the omnibus one-way ANOVA table for the total number of practices across groups.

Table 17

Descriptives for Number of Practices by Groups

	TL Mean (SD)	**AL** Mean (SD)	**EAL** Mean (SD)
Practice	65.58 (25.20)	67.43 (46.38)	68.85 (44.68)
Range	27-108	14-139	0-165
N	12	7	13

Table 18

ANOVA for Total Number of Practice across Groups

		SS	**df**	**MS**	**F**	***p*-value**
PracT	Between	66.552	2	33.276	.022	.978
	Within	43852.323	29	1512.149		
	Total	43918.875	31			

However, the overall practice effect stands as a significant predictor of *TestTotal*. *Table 19* shows the ANOVA table of the simple linear regression model with *PracT* as an independent variable (IV) and *TestTotal* as a DV. The model is significant with R^2 = .196, MS = 143.64, F (1, 30) = 7.30, $p < .05$. This simple regression model can explain 19.6% of the variance in *TestTotal*. *PracT* is a significant predictor of *TestTotal* with standardized ß = .442, t = 2.70, $p < .05$.

Table 19

ANOVA Table for the Simple Regression Model with PracT as an IV for TestTotal

		SS	**df**	**MS**	**F**	***p*-value**
PracT	Regression	143.64	1	143.64	7.30	.011**
	Residual	590.327	30	19.68		
	Total	733.969	31			

** p < .05

Post-Instruction Questionnaire

The Post-instruction Questionnaire included the same opinion question and the same confidence question as the pre-instruction questionnaire, a demographic survey, and 12 other opinion and comment questions. All the opinion questions were on a 4-point Likert scale from 2 (very much), 1 (a little), to -1 (not a lot), and -2 (not at all).

Do you like the Chinese character instruction program?

When asked "Do you like the Chinese character instruction program?" after the learning phase, participants yielded a 1.58 score on average (SD = .50), indicating high positive feedback on using the program. Though the mean differences were not statistically significant among groups ($F(2, 33) = 1.46$, $p > .05$), *Table 20* shows that on average all three groups expressed positive feedback.

Table 20
Descriptives for Liking the Chinese Character Instruction Program

	TL Mean (SD)	**AL** Mean (SD)	**EAL** Mean (SD)	**Total** Mean (SD)
Like	1.46 (.519)	1.50 (.527)	1.77 (.439)	1.58 (.500)
N	13	10	13	36

Do you think the Chinese character instruction program is effective?

When asked "Do you think the Chinese character instruction program is effective?" after the learning phase, participants yielded a 1.58 score on average (SD

= .77), indicating high positive feedback on the effectiveness of the program. Though the only difference was between the TL group and the EAL group (mean difference = -.846, SE = .268, $p < .05$) in that the overall mean differences were statistically significant among the three groups ($F(2, 33) = 5.67$, $p < .01$), *Table 21* shows that on average all three groups expressed positive feedback.

Table 21
Descriptives for Effectiveness of the Chinese Character Instruction Program

	TL Mean (SD)	**AL** Mean (SD)	**EAL** Mean (SD)	**Total** Mean (SD)
Effect	1.08 (1.038)	1.80 (.422)	1.92 (.277)	1.58 (.770)
N	13	10	13	36

The responses to other questions in the Post-instruction Questionnaire also yielded similar results. For example, questions such as: "Does the video (or *the program*, for the TL group) make Chinese characters easier to learn?" "Does the video (or *the program*, for the TL group) help you in understanding and remembering the Chinese characters?" "Does the video (or *the program*, for the TL group) help arouse your interest in learning Chinese?" "Does the video (or *the program*, for the TL group) help maintain your motivation in character learning?" all yielded similar results in that there were no mean differences among groups but responses were positive overall. *Table 22* shows that on average all three groups expressed positive opinions toward these variables.

Table 22

Descriptives for Learners' Opinions about the Chinese Character Instruction Program

	TL Mean (SD)	**AL** Mean (SD)	**EAL** Mean (SD)	**Total** Mean (SD)
Easier to learn	1.31 (0.86)	1.60 (0.52)	1.08 (1.26)	1.31 (0.95)
Help memory	0.85 (1.14)	1.70 (.048)	1.08 (1.26)	1.17 (1.08)
Arouse interest	0.92 (1.19)	1.30 (0.95)	0.85 (1.52)	1.00 (1.24)
Keep motive	0.85 (1.14)	1.50 (0.97)	1.08 (1.26)	1.11 (1.14)
N	13	10	13	36

What do you think about Chinese characters?

I asked this same question before and after the learning phase in the Pre-instruction Questionnaire and the Post-instruction Questionnaire. Participants could circle as many of the ten answer choices as applied. I intended to examine whether participants in the pilot study held certain attitudes or had specific thoughts about Chinese characters. In addition, I also explored whether there were possible changes in their responses before and after their learning phase using the Chinese character instruction program. *Table 23* shows the frequencies of the answers to this question from the participants' responses about general ideas and attitudes toward Chinese characters.

Table 23

Frequencies for Participants' Idea and Attitude about Chinese characters

Chinese characters:	**Pre**	**Post**	**Change**
a. are something I have no idea about	18	2	-16
b. are a meaningful and interesting writing script	29	28	-1
c. are just like some other foreign writing systems	6	7	+1
d. are not interesting	0	0	0
e. are meaningless lines and dots	0	0	0
f. are impossible to learn	3	0	-3
g. are difficult to learn	20	16	-4
h. can be mastered with effort	26	29	+3
i. are easy to learn	0	1	+1
j. are useful and powerful	19	17	-2

From answer a in *Table 23*, it seemed that learners felt they had learned some Chinese characters after using the Chinese character instruction program. From answers d and e, none of the participants thought Chinese characters were not interesting or were meaningless lines and dots. From answer f and h, learners tended to think Chinese characters are possible to learn and can be mastered with efforts. From answer g, it seems the number of those who thought Chinese characters were difficult to learn had decreased. The only participant who indicated that Chinese characters were easy to learn was from the EAL group in the Post-instruction Questionnaire. From one-way ANOVAs, there were no statistically significant group differences in their responses to these answers from both the Pre-instruction Questionnaire and the Post-instruction Questionnaire.

Bivariate Correlation Data Analysis

It is worth mentioning that there were no statistically significant correlations between the participants' learning outcomes (*TestTotal*) and the many other variables collected in the Post-instruction Questionnaire such as gender, age, number of languages spoken, post-instruction level of confidence, whether learners liked the program, whether learners thought the program was effective, whether learners thought the program made Chinese character learning easier, whether learners thought the program helped learners better remember characters, whether learners thought the program aroused the learners' interest and whether the learners thought the program maintained their motivation to learn. There were, however, a couple of exceptions: 1. Those who thought the test was easy tended to perform better in *TestTotal* (Pearson's r = -.449, p = .006); and 2. Those in the AL and EAL groups who liked the video feature of the program tended to perform better in *TestTotal* (Pearson's r = .353, p = .038).

In addition, learners who indicated they exercise, watch sports, liked the Chinese character learning program, or liked the videos in the program tended to think the program was effective (r = .638, $p < .001$; r = .427, $p < .0$; r = .501, $p < .01$; and r = .421, $p < .05$, respectively). Learners who exercise also tended to think that the program helped them better remember Chinese characters (r = .349, $p < .05$). Those who liked the program as a whole tended to like the videos in the program (r = .364, p

< .05) and those who liked the program also tended to think the program was effective (r = .501, $p < .01$). For those who liked the videos provided in the program, they also tended to think the program was effective, made learning Chinese characters easier, helped them learn better, and maintained their motivation to learn (r = .421, $p < .05$; r = .339, $p < .05$; r = .410, $p < .05$; and r = .444, $p < .01$, respectively). *Table 24* shows the bivariate correlations of variables investigated in the Post-instruction Questionnaire.

Table 24
Bivariate Correlations of Variables in the Post-Instruction Questionnaire

		Test Total	**exercise**	**watch sports**	**like video games**	**like program**	**like video**	**program effect**	**make easier**	**help remember**	**interest**	**motive**	**test hard?**
Test Total	r	1	.233	.201	.003	.077	.353*	.153	-.273	-.013	-.073	.050	-.449**
	P		.172	.239	.987	.657	.038	.374	.107	.940	.672	.773	.006
	N	36	36	36	36	36	35	36	36	36	36	36	36
Exerci-se	r		1	.378*	.323	.227	.343*	.638**	.225	.349*	.183	.243	-.241
	P			.023	.054	.183	.043	.000	.187	.037	.287	.153	.156
	N		36	36	36	36	35	36	36	36	36	36	36
watch sports	r			1	.103	.314	.248	.427**	.095	.079	.046	.134	.066
	p				.548	.062	.150	.009	.581	.646	.790	.437	.701
	N			36	36	36	35	36	36	36	36	36	36
like video games	r				1	-.122	.194	.214	.249	.148	.000	.143	-.158
	P					.477	.264	.211	.143	.390	1.000	.406	.357
	N				36	36	35	36	36	36	36	36	36
like program	r					1	.364*	.501**	.215	.185	.322	.134	.215
	P						.031	.002	.207	.281	.055	.437	.207
	N					36	35	36	36	36	36	36	36
like video	r						1	.421*	.339*	.410*	.258	.444**	.060
	P							.012	.047	.014	.134	.008	.731
	N						35	35	35	35	35	35	35
program effect	r							1	.335*	.531**	.448**	.412*	-.022
	P								.046	.001	.006	.013	.901
	N							36	36	36	36	36	36
make easier	r								1	.727**	.532**	.521**	.015
	P									.000	.001	.001	.933
	N								36	36	36	36	36
help remember	r									1	.701**	.818**	-.191
	P										.000	.000	.263
	N									36	36	36	36
interest	r										1	.665**	-.040
	P											.000	.817
	N										36	36	36
motive	r											1	-.063
	P												.715
	N											36	36
test hard?	r												1
	P												
	N												36

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Open-Ended Questions

I asked two open-ended questions in the Questionnaire: "How would you have improved the program were you an instructional designer?" and "Please share any thoughts on Chinese language learning or extra comments." The purpose of these questions was mainly to seek learners' opinions on how the program may be improved and to further probe learners' thoughts on better Chinese character learning. Please note that as answering these open-ended questions was not required, not every participant offered their thoughts, suggestions, or criticisms. I will discuss several program improvement suggestions in the next section.

From those participants who commented, most of the comments were very positive in general. Specifically, learners expressed their positive learning experience in Chinese logographs and positive post-instruction learning attitudes.

Positive learning experience in Chinese logographs

For example, many described their learning experience as a "very enjoyable experience," "Encouraging," "I had fun learning this little bit of Chinese," "The instructional program is great ☺," "Very effective. Could be used to teach Chinese," and "I think it is a good start for understanding the written language. I think it will be much more difficult to learn to speak Chinese."

Positive learning attitudes

The learning experience with the program generated a positive learning attitude. For example, learners wrote: “I am interested in learning more,” “Wish I could learn more,” and “It was very interesting, maybe down the road I will start to learn it.”

Section 5. Limitations and Future Directions

Limitations

Due to the limitation of time, I was not able to continue the study over a longer period of time to allow for more participants (for better power and for the investigation of more variables) as well as for better instrument and measurement development (e.g., the inclusion of all the target characters in the measurements and maybe of all the tests in the program). Ideally, more participants ought to be recruited for each group for some other interesting variables' investigation and to carefully collect participants' retention and transfer data after at least one day or maybe 1 week of the treatment. Also, I ought to have designed and developed pre-tested reliable and valid instruments and measures for the testing of the program. Unfortunately, I was not able to do so in this pilot study. However, the statistically significant results undoubtedly encouraged me to believe in the use of embodied animations in Chinese character learning.

Future Directions

For future directions, I'd like first to point out places in the study where improvements could be made and then draw on what could be done in the future.

Immediate Test and Delay Test

Among the 22 questions on the Immediate Test, 3 were meaning-form mapping questions, 3 were written form questions, 3 were form-sound mapping questions, 3 were form-meaning mapping questions, 5 were inference questions, and 5 were morphology awareness questions. To increase the variability of the learners' answers and to better test the learners' real retention and near-transfer abilities, it is essential to increase the number of questions or test items on the test. For example, questions for all target characters could be included. More measures to examine the learners' outcomes – such as a blank sheet for recall of meaning, a blank sheet for recall of written form, and a blank sheet for recall of pronunciation – could also be included. For near-transfer or far-transfer items, maybe more phonetic-morpheme compounds could be used. In addition, I used identical parallel tests such as the Delay Test, but it turned out that the results from the Delay Test were highly similar to the results of the Immediate Test. A similar but different parallel test for the delay test should be developed and implemented.

Distraction Design

I had a 3-minute exploration and observation time period for the Chinese character learning Scratch program and a 7-minute break time for the Scratch program interview questionnaire. Therefore, there was a 10-minute distraction break between my Immediate Test and Delay Test. However, from the participants' feedback, more time for exploration seems to be necessary. Also, an easier-to-understand Scratch program for learning new Chinese characters would be more appropriate. In addition, the characters chosen in this Scratch program should not only be entirely different from the characters used in the Chinese character learning program but should also facilitate other aspects of Chinese character learning, such as phonological awareness or the recognition of morphology radicals of semantic-phonetic compounds. Last, but not least, the distraction design should be longer to achieve true distraction.

For the purpose of distraction, one future distraction design could be totally irrelevant to Chinese characters learning. For instance, I could use simple arithmetic problems such as addition or subtraction for distraction.

Questionnaire

I should adopt a 9-point or 10-point Likert scale for most of the variables in the questionnaire. Currently, my 4-point scale made many of the variables indiscernible. For example, for questions such as “Does the program make Chinese characters easier to learn?” or “Does the program help you in understanding and remembering the Chinese characters?” on the 4-point Likert scale from +2, +1, -1, to -2, many participants chose “A Little” (+1) and thus they yielded mean scores that were all very close to +1. If I used a 9-point Likert scale, I would be able to uncover if indeed there were group differences in these variables from the learners’ thoughts and experience. In addition, some questions are worth adding to the current questionnaire. Specifically, questions such as the strategies learners use and how learners spend their time learning each character during a given time period are of importance if I intend to probe the learning mechanisms of adult learners’ Chinese character learning. Metacognitive judgment questions, therefore, may serve as good open-ended questions. For example, I could ask learners, “How did you learn/ memorize characters?” “Why do you think that you got the characters right/ wrong?” “What strategies did you use in learning Chinese characters?”

“Under what condition did you think you learned best?” or “What features help you learn the best?”

Chinese Character Learning Program

An important question to ask when a video is used for leaning is: How much information is in the video? I examined all of the videos used in the Chinese character learning program and believe that I should cut unrelated forms of characters in form-changing etymology animations, as these forms may distract learning and hinder the recognition of correct characters. Shortened videos would not contain many character forms that are unrelated to what learners eventually learn. For example, many character forms in Clerical Type (Li Shu), Fine Ming typeface, and Song typeface have quite a few variations from, and therefore are not very similar to, their Standard Type or Regular Type (Kai Shu) character forms and should be excluded in the Chinese character learning videos.

For a character’s etymology animation in the videos, I should use more changes of morphs instead of changes of fades because morphs make better connections between the different forms of the same Chinese character. For some characters, learners might have had to guess those connections if fade-ins and fade-outs are used.

Participants in this pilot study expressed in their feedback that the total time of the learning phase was long. I should then make each page visible for a shorter time, such as 90 seconds per character instead of 2 minutes, so that learners do not feel bored during the learning phase.

Future Directions

I may add two more groups in the study design: one group that views the video with no animation but with static sequences, and another group that views the etymological animation with static human images (instead of human movements), a Succinct-Embodied Animation Learning (EAL) group that views shortened videos instead of the current longer version of videos. The first group would serve to compare etymological animation to mere static sequence images. The other group would serve to compare videos that only feature static human images to videos that feature dynamic human body movements. By comparing these five groups, I would get a clearer idea of why and how the EAL groups is or is not better than the other groups.

CHAPTER IV

THE MAIN STUDY

Section 1. Prefatory Statement of the Investigation Questions

To date, my pilot study is original in that it uses an embodied animation paradigm to address novice learners' Chinese character learning. Hence, part of the objective of my dissertation research in this main study is to replicate the pilot study previously conducted to investigate whether embodied animation indeed better facilitates Chinese character learning, and thus provides better learning outcomes, in comparison with other computer-based program designs. In this way, it is meant to provide support for the initial pilot findings. This will be accompanied by using refined measures, a larger sample population, and an improved study design.

Improvements from the Pilot Study

From the pilot study, participants in the embodied animation learning group significantly or marginally outperformed those in the etymological animation learning group and the traditional learning group. That suggests the effectiveness of embodied animation in Chinese character learning. However, as discussed in the previous chapter, there are places for improvements in order to determine whether the factor of human movement and imagination indeed is superior to the factor of static human image, the factor of object-based image, or other factors in the CCL video.

Specifically, I made major changes in three aspects. First, I created an object-image picture plus etymological animation group (OAL), by adding an object-image picture to the AL group videos to make the videos the same length as the other videos shown in the other learning conditions. In addition, I created a static human-image picture plus etymological animation group (HAL), and a no-animation etymology (with only a static picture showing three etymological characters) group (NAL). The time of the videos across the OAL, HAL, and EAL groups is exactly the same and the time for learning is also shortened to be 90 seconds per character across groups. Secondly, I revised the measures to be Free Recall Test (FW), Meaning-Form Mapping Test (MF), Sound-Form Mapping Test (SF), and Form-Meaning-and-Form-Sound Mapping Test (FMS). Thirdly, I looked at participants' character retention results after one week of learning.

Research Questions

The present study aims to investigate the effects of embodied animation on Chinese character learning for beginning learners of CFL. Five types of learning conditions were employed, one of which served as a control group. The research questions addressed in this study are:

1. Do participants in the embodied animation learning condition perform better in

character learning than those in other learning conditions?

2. Between pictographs, indicatives, and ideographs, which type of characters is best learned, and under which learning condition?

Three hypotheses emerge from the research questions:

H1.1: The embodied animation learning group outperforms the other conditional groups in terms of better total recall of characters after one week.

H1.2: The embodied animation learning group yields better long-term retention than other learning conditions in form-meaning mapping and meaning-form mapping tasks.

H2: There are different learning outcomes for different types of characters through different learning conditions.

Section 2. Method

Study Design

The study used Between Subject post-test only true experimental design. The focus of this main study was an investigation of the effects of embodied animation on the retention outcomes of Chinese character learning (CCL) for beginning learners of Chinese as a Foreign Language (CFL). There were five experimental conditions, one of which (the traditional learning condition) served as a control group. In order to examine whether body movement, human-based images, object-based images, etymological animation, or traditional learning yields different learning outcomes in a CALL program for beginning learners of CCL, the study compared five learning conditions, as listed in *Table 25*.

Table 25
Five Learning Groups (Treatment Conditions)

Group Code	Treatment	Description
TL	Traditional Learning	Traditional Learning does not contain a video area on its program screen for any type of animation mentioned below, such as embodied animation, human-image animation, object-image animation, or a still image of etymological characters.
NAL	No-animation Etymology Learning	No-animation Etymology Learning does not show character etymological animations in the video; instead, it shows one still image containing three (3) etymological characters with arrows between them indicating the evolving changes to different characters.
OAL	Object-image Animation Learning	Object-image Animation Learning contains character etymological animation and one still object-based image in the video.
HAL	Human-image Animation Learning	Human-image Animation Learning contains character etymological animation and one still human-based image in the video.
EAL	Embodied Animation Learning	Embodied Animation Learning contains character etymological animation and body movements in the video. Learners are asked to imagine doing the movements when they watch each character's videos.

Five Learning Conditions

Traditional Learning (TL)

Table 25 shows the five learning conditions. Participants in the traditional learning (TL) condition (n = 13) see, on the individual character learning page of the program screen, the target character in a square in the middle, its semantic meaning underneath, its pronunciation phonetics in brackets in the upper right, and the pronunciation button in the lower right. TL does not contain a video area on its program screen for any type of animation. *Figure 41* shows an example of the individual character learning page for the TL condition.

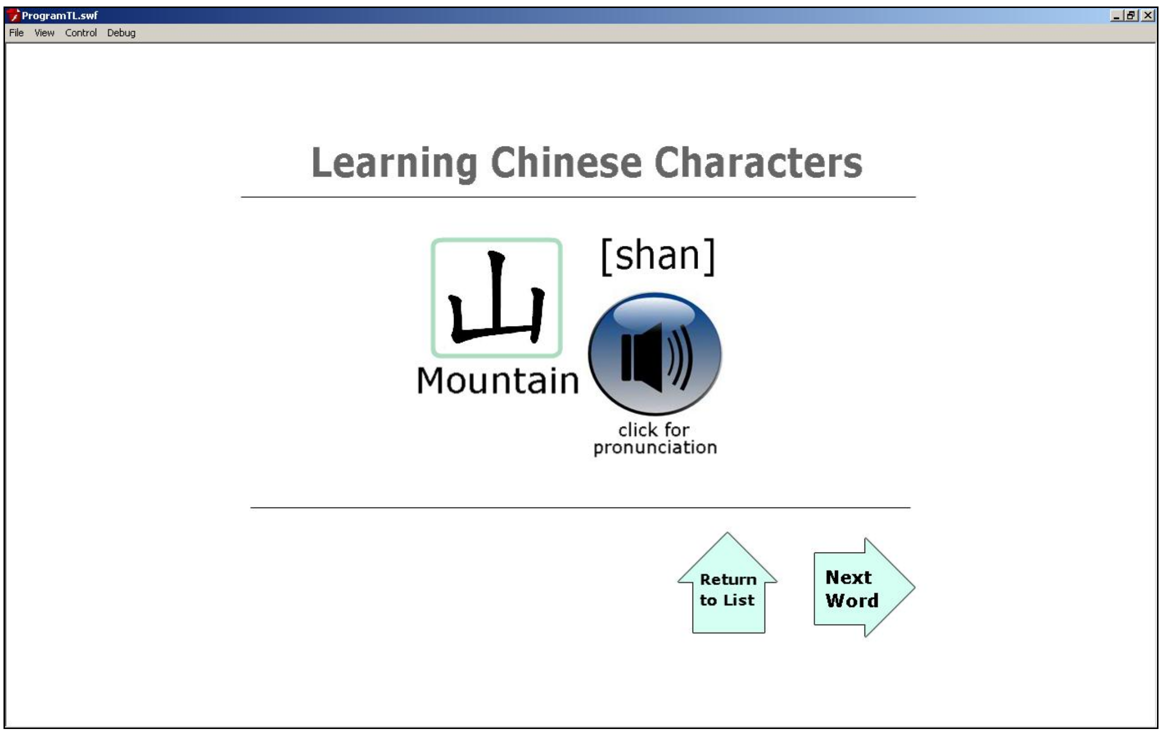

Figure 41. The screenshot of the CCL program—the character "mountain" in the individual character learning page for the traditional learning condition.

No-animation Etymology Learning (NAL)

Participants in the no-animation etymology learning (NAL) condition (n = 13) see everything in the TL condition, as well as a rectangular area on the left side of the target character, which shows a static sequence in a still image containing first a picture of the origin of the character (such as a tree) followed clockwise by three (3) etymological characters with arrows between them indicating the evolving changes to the different characters. NAL does not show character etymological animation in this rectangular area. *Figure 42* shows an example of the individual character learning page for the NAL condition.

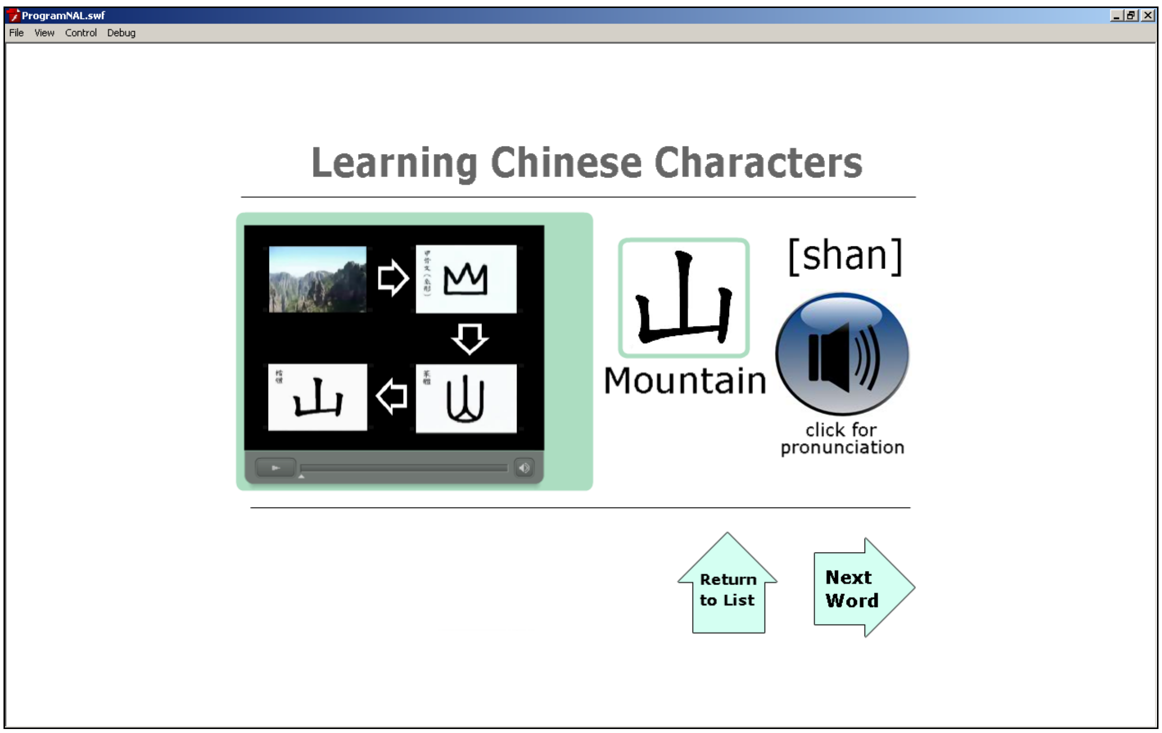

Figure 42. The screenshot of the CCL program—the character “mountain” in the individual character learning page for the no-animation etymology learning condition.

Object-image-animation Learning (OAL)

Participants in the object-image-animation learning (OAL) condition (n = 13) see everything in the TL condition, as well as a rectangular area on the left side of the target character, which shows a video containing the character etymological animation. The animation is followed by a carefully-selected still object-based image that shows some semantic meaning and some written form of the character. *Figure 43* shows an example of the individual character learning page for the OAL condition.

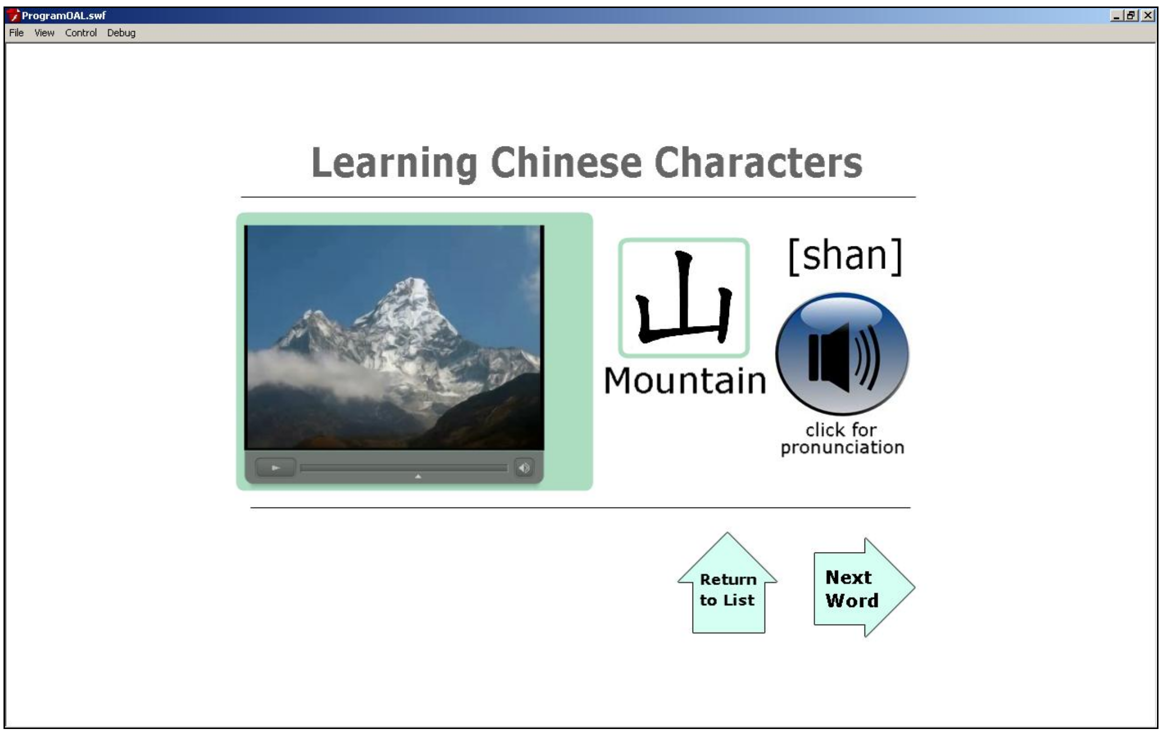

Figure 43. The screenshot of the CCL program—the character "mountain" in the individual character learning page for the object-image-animation learning condition.

Human-image Animation Learning (HAL)

Participants in the human-image animation learning (HAL) condition (n = 15) see similar stimuli as in the OAL condition, except for the video. The video in HAL also contains the same character etymological animation, but the animation is followed by a still human-based image that shows some semantic meaning and the written form of the character. *Figure 44* shows an example of the individual character learning page for the HAL condition.

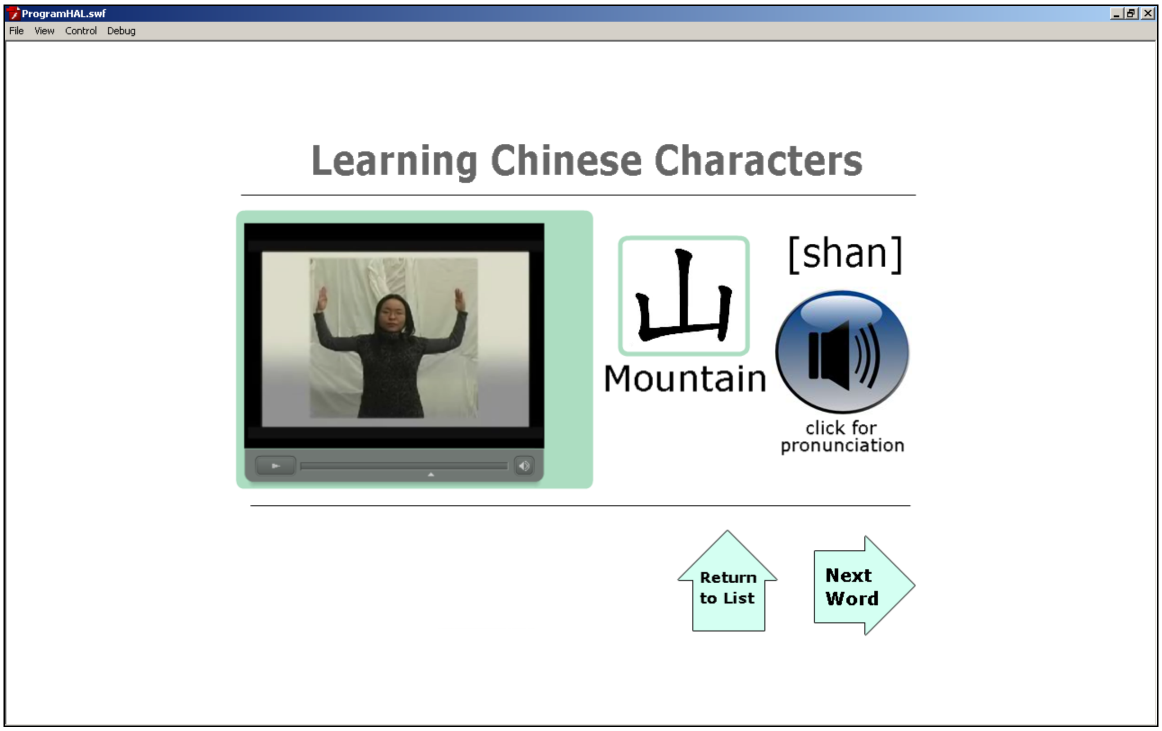

Figure 44. The screenshot of the CCL program—the character "mountain" in the individual character learning page for the human-image animation learning condition and the embodied animation learning condition. N.B. The video in HAL shows a static human image after etymology animation, whereas the video in embodied animation learning shows a person's movements and actions after etymology animation.

Embodied Animation Learning (EAL)

Participants in the embodied animation learning (EAL) condition (n = 15) also see similar stimuli as in the OAL condition, except for the video. The video in EAL contains the same character etymological animation, but the animation is followed by moving actions of human body movements and gestures that show some semantic meaning and the written form of the character. Learners in the EAL condition were asked to imagine doing the movements and gestures while they were watching each character's video. *Figure 44* also shows an example of the individual character learning page for the EAL condition. The total length of the videos in OAL, HAL, and EAL is exactly the same for each target character.

Randomization

Participants were randomly assigned to one of the five learning conditions (EAL, HAL, OAL, NAL, or TL) without knowing what condition they were in. Participants' participation order (i.e. the order of their come-in for the study) was used to determine their groups. Hence, the first participant was in the EAL group, the second was in the HAL group, and the third was in the OAL group.

Participants

Participants were sixty-nine adult learners who did not have any Chinese language background and could not speak or read any Chinese. From the pre-instruction questionnaire, none of the participants indicated that they knew any Chinese characters or spoke any Chinese at the time of the experiment. All participants voluntarily participated in the study, and got course credit and fifteen dollars remuneration upon completion of the study. *Table 26* shows participants' demographic background across groups in terms of the number of participants, age, gender, and number of native speakers of English. The mean age of participants across groups is 28.43 (SD = 6.25). The percentage of male participants across groups in the study is 18.8 percent (13 out of 69). There is a high percentage of English native speakers in the study across groups (89.9%). There is no significant group difference in age (F (4, 64) = .629, *p* = .64), number of native speakers of English (F (4, 64) = 1.065, *p* = .38), and gender (F (4, 64) = 1.66, *p* = .17).

Table 26

Demographic Data of Groups

	TL	**NAL**	**OAL**	**HAL**	**EAL**
N	13	13	13	15	15
Age **(SD)**	29.92 (5.65)	28.62 (7.99)	26.23 (3.49)	29.13 (4.76)	28.20 (8.21)
Gender-Male **(%)**	5 (38.5%)	1 (7.7%)	2 (15.4%)	4 (27.7%)	1 (6.7%)
Native **English (%)**	10 (76.9%)	13 (100%)	12 (92.3%)	13 (86.7%)	14 (93.3%)

Apparatus and Materials

Apparatuses

The apparatuses participants used were IBM compatible Dell laptops with 15-inch monitors. All laptops were installed with Adobe Flash CS3 Professional and Scratch programs. Earphones and speakers were tested to ascertain their proper functions before use. Participants learned characters with the Chinese Character

Learning Program and with the Scratch game run on Flash and Scratch using these apparatuses. In addition, two pieces of blank paper and two pens were provided during the learning activity time. Appendix 1 and Appendix 2 show the experiment room and the laptop used in the study.

Materials

The materials used in the main study are quite similar to the materials used in the pilot study, except for the testing materials. They are listed in the Appendix 3-4, 6-9, 15-16, & 20-24. They include the Informed Consent form (Appendix 3), Participant's Rights form (Appendix 4), the Pre-instruction Questionnaire (Appendix 19), the General Instruction Sheet (Appendix 6), the specific Instruction Sheet for each group (Appendix 7-9), the screenshots of the video instructions for the OAL, HAL, and EAL groups (Appendix 10), the Scratch game screenshot and the Scratch interview sheet (Appendix 15-16), the Free Recall Test (Appendix 20 & 26), the Meaning-Form Mapping Test (Appendix 21), the Sound-Form Mapping Test (Appendix 22), the Form-Meaning-and-Sound Mapping Test (Appendix 23), and the Post-instruction Questionnaire that contains a demographic survey (Appendix 24).

Instructional Materials

Similar to the pilot study, the instructional materials in the main study include the General Instruction Sheet, the specific Instruction Sheets for each group, the video instructions for the OAL, HAL, and EAL groups, and the Chinese Character Learning programs for each group. The learning materials are the same 18 Chinese characters used in the pilot study (see *Figure 34*). Their features are listed in *Table 4*. These Chinese characters are presented in the Chinese Character Learning CALL program. These characters include 7 pictographs (木, 火, 山, 心, 人, 魚, 犬), 5 indicatives (上, 下, 中, 大, 小), and 6 ideographs (看, 比, 告, 舟, 長, 去).

Measurement Materials

Similar to the pilot study, the Pre-instruction Questionnaire served to double check to ascertain that participants did not know any Chinese language at the time of the experiment. The questionnaire lists four pre-screening questions, such as: "Do you know any of these foreign words?" "Do you speak any Mandarin Chinese?" "Do you read or write any Chinese?" and, "Do you recognize any Chinese characters? If yes, please write below at least 5 characters you know." Similar to the pilot study, the Post-instruction Questionnaire served to find out participants' demographic data, probe thoughts about the Chinese character learning experience, and check whether participants in the EAL condition indeed followed the instruction and imagined doing the actions/ movements/ gestures themselves when they watched the videos. Unlike the pilot study, I asked an open-ended question to participants after their One-Week Test, "Why do you remember those characters that you remember? And why do you forget those characters that you forget?" (see Appendix 25)

Testing Materials

For these three time periods (i.e., immediately after the learning phase, 10-minutes after the immediate test, and one-week after the learning phase), the same four tests were implemented. The tests were: the Free Recall Test, the Meaning-Form Mapping Test, the Sound-Form Mapping Test, and the Form-Meaning-and-Sound Mapping Test.

The Free Recall Test is a blank sheet with only the instructions: "Please write down all the Chinese characters that you have just learned. Remember to include all three features of the characters (i.e., written form, meaning, and pronunciation)." (see Appendix 20; and Appendix 26 for One-Week Free Recall Test) The written form participants generated for each character was rated from 0 to 4, using the same Grading Guideline Rubrics for the pilot study listed in *Table 7*. The meaning that was correctly matched to the written form received a score of 1. The sound that was correctly matched to the written form also received a score of 1. Therefore, participants might get 0-6 for each Chinese character they generated, and since there were 18 characters in total, the highest possible score for the whole test is 108.

On the Meaning-Form Mapping Test, the meanings of each character were provided, and participants were asked to write down the written forms of the 18 Chinese characters. (see Appendix 21) The written form participants generated for each character was rated from 0 to 4, using the same Grading Guideline Rubrics for the pilot study listed in *Table 7*. Since there were 18 characters in total, the highest possible score for the Meaning-Form Mapping Test is 72.

On the Sound-Form Mapping Test, the pronunciations of each character were provided, and participants were asked to write down the written forms of the 18 Chinese characters. (see Appendix 22) The written form participants generated for each character was rated from 0 to 4, using the same Grading Guideline Rubrics for the pilot study listed in *Table 7*. Since there were 18 characters in total, the highest possible score for the Sound-Form Mapping Test is 72.

On the Form-Meaning-and-Sound Mapping Test, the forms of each character were provided, and participants were asked to write down both the meanings and the sounds of the 18 Chinese characters. (see Appendix 23) The correct mapping of each meaning or each pronunciation was given a score of 1. Therefore, the highest possible score for the Form-Meaning-and-Sound Mapping Test is 36 (18 from meanings and 18 from pronunciations).

Distraction Materials

I used the same distraction materials described in the pilot study during the 10-minute break.

Procedures

Before the learning activity, all participants went through screening and received a pre-instruction questionnaire in which they indicated that they did not have any knowledge of the Chinese language at the time of the experiment. Right after the learning activity in which participants used the Chinese Character Learning Program for 27 minutes (90 seconds for each character's learning), all participants completed the

Immediate Tests in four different formats: free recall (for 5 minutes), meaning-form mapping (for 2 minutes), sound-form mapping (for 2 minutes), and form-meaning and form-sound mapping (for 2 minutes). All participants completed the Delay Tests in the same four formats after a 10-minute break. During the 10-minute break, all participants observed and explored a Scratch programmed game for 3 minutes, and then had 7 minutes to fill out a short survey about their thoughts on the Scratch game. The One-Week Tests in the same four formats, and with exactly the same total test time of 11 minutes, were employed after one week had elapsed. The procedures by groups are listed in *Table 27*.

Unlike the pilot study, the major difference in the main study is that participants were asked to come back to the same laboratory after one week. They were told to come back to fill out a survey and some other forms, and to get the remunerations. They were also given the One-Week Test which contains all four formats of tests.

Table 27

Experimental Procedures by Groups

Time	**TL; NAL**	**OAL; HAL**	**EAL**
1 min (approx.)	Consent	Consent	Consent
1 min (approx.)	Pre-Instruction Questionnaire	Pre-Instruction Questionnaire	Pre-Instruction Questionnaire
1 min (approx.)	General Instruction	General Instruction	General Instruction
1 min (approx.)	Instruction-TL	Instruction-AL	Instruction-EAL
27 min	Character Learning Program-TL/ Character Learning Program-NAL	Character Learning Program-OAL/ Character Learning Program-HAL	Character Learning Program-EAL
11 min	Immediate Test	Immediate Test	Immediate Test
10 min	Scratch game + interview	Scratch game + interview	Scratch game + interview
11 min	Delay Test	Delay Test	Delay Test
10 min (approx.)	Post-Instruction Questionnaire	Post-Instruction Questionnaire	Post-Instruction Questionnaire
11 min	1 Week Delay Test	1 Week Delay Test	1 Week Delay Test
2 min (approx.)	Open-ended Question	Open-ended Question	Open-ended Question
Total: 86 min (approx.)			

Section 3. Results

Methodology Checks

Internal Consistency Reliability

To assess the consistency of results across items within a test, the internal consistency reliabilities were calculated using the Cronbach's alpha. For the Free Recall Test, the Meaning-Form Mapping Test, the Sound-Form Mapping Test, and the Form-Meaning and-Sound Mapping Test, the Cronbach's alphas were .85, .82, .91, and .88, respectively, which indicate high internal consistency reliability for all the tests employed in the study.

Inter-rater Reliability

In addition to the internal consistency check, an assessment of inter-rater reliability was conducted. Using the same Grading Guideline Rubrics for the pilot study listed in *Table 7*, the written forms of characters were rated by two trained and native Chinese-speaking raters. The written forms of Chinese characters generated by participants in all four formats of the tests were qualitatively reassessed by another independent rater, in addition to myself. The Spearman's rank correlation coefficient was calculated. For the Free Recall Test, the Meaning-Form Mapping Test, the Sound-Form Mapping Test, and the Form-Meaning and –Sound Mapping Test, the inter-rater agreement of .86, .92, .90, and .98, respectively, were obtained, which indicate a very strong inter-rater agreement.

Data Analysis

I first conducted a series of Multivariate Analysis of Variances (MANOVAs) to examine whether, for each type of tests (Free Recall, MF, SF, and FMS), overall there was a significant effect of the experimental conditions, Group, on all of the tests (i.e., Immediate, Delay, and One-Week), considered as a group. A series of one-way ANOVAs were then employed to examine whether there were any group differences in the dependent measures of Free Recall, Meaning-Form Mapping, Sound-Form Mapping, and Form-Meaning and Form-Sound Mapping tasks. To examine whether EAL was more effective than other learning conditions, post-hoc Tukey HSD tests were employed.

MANOVA

Overall, there was a significant effect of Group on all of the free recall tests, considered as a group (Wilk's Λ = .277, F = 8.55, p < .001) from MANOVA. The p-values show that Group had a significant effect on the results of the Immediate Free Recall Test (F (4, 64) = 5.40, p = .001), the results of the Delay Free Recall Test (F (4, 64) = 4.50, p = .003), and the results of the One Week Free Recall Test (F (4, 64) = 31.09, p < .001). In terms of meaning-form mapping, overall, there was a significant effect of Group on all of the meaning-form mapping tests, considered as a group (Wilk's Λ = .275, F = 8.61, p < .001) from MANOVA. The p-values show that Group had a significant effect on the results of the Immediate Meaning-Form Mapping Test (F (4, 64) = 6.86, p = .001), the results of the Delay Meaning-Form Mapping Test (F (4, 64) = 6.05,

p = .003), and the results of the One Week Meaning-Form Mapping Test (F (4, 64) = 36.35, p < .001). In terms of sound-form mapping, overall, there was a significant effect of Group on all of the sound-form mapping tests, considered as a group (Wilk's Λ = .707, F = 1.92, p < .001) from MANOVA. The p-values show that Group did not have a significant effect on the results of the Immediate Sound-Form Mapping Test (F (4, 64) = .880, p = .481), and the results of the Delay Sound-Form Mapping Test (F (4, 64) = 1.87, p = .126). But Group had a significant effect on the results of the One Week Sound-Form Mapping Test (F (4, 64) = 4.07, p = .005). In terms of form-meaning and-sound mapping, overall, there was a significant effect of Group on all of the form-meaning and-sound mapping tests, considered as a group (Wilk's Λ = .469, F = 4.54, p < .001) from MANOVA. The p-values show that Group did not have a significant effect on the results of the Immediate FMS Mapping Test (F (4, 64) = 2.46, p = .054), and the results of the Delay FMS Mapping Test (F (4, 64) = 2.10, p = .091). Yet, Group had a significant effect on the results of the One Week FMS Mapping Test (F (4, 64) = 10.09, p < .001).

Correct Percentages for Free Recall Total Scores

Table 28 and *Figure 45* show the correct retention percentages for the Free Recall task on Immediate, Delay, and One-Week Tests by learning groups. With the highest possible total score of the Free Recall task being 108, the correct percentage is calculated as the correct Free Recall scores divided by the highest possible total score, and then multiplied by 100 %:

$$Correct\ Percentage = \frac{Correct\ Score}{108} \times 100\ \%$$

Table 28

Correct Percentages for Free Recall Total Scores in Immediate, Delay, and One-Week Tests by Learning Group

	Learning Group				
	TL	**NAL**	**OAL**	**HAL**	**EAL**
	(n = 13)	(n = 13)	(n = 13)	(n = 15)	(n = 15)
Tests	% correct	% correct	% correct	% correct	% correct
Immediate	39.8	39.7	44.3	52.3	60.3
Delay	48.3	44.1	41.2	59.4	63.6
One Week	28.9	27.2	25.2	51.1	65.4

Note. n = the number of participants in the indicated group.

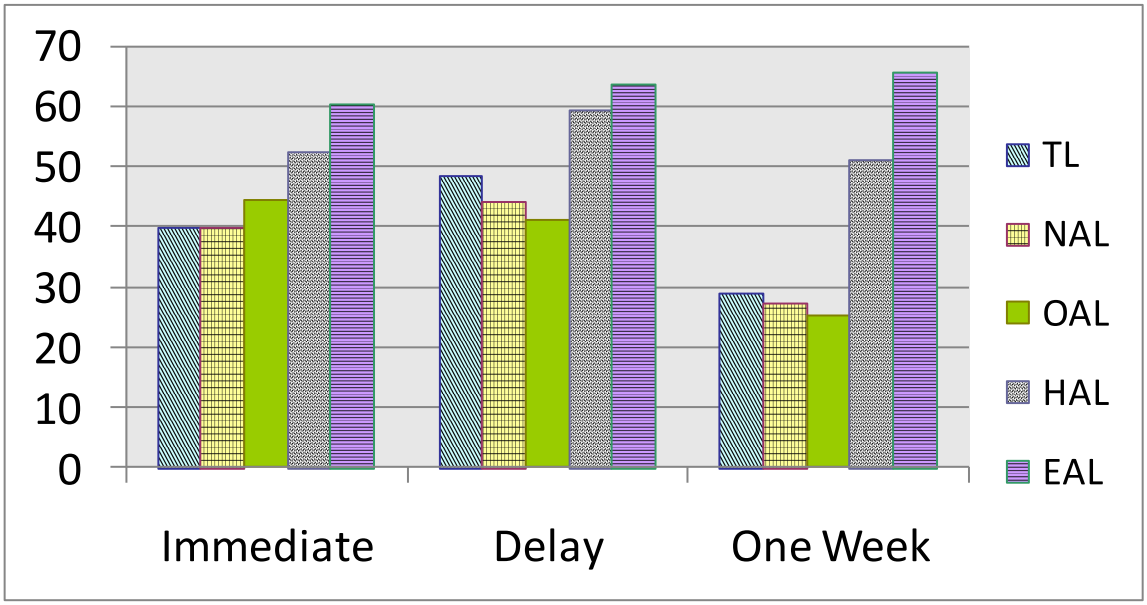

Figure 45. Correct Percentages for Free Recall Total Scores in Immediate, Delay, and One-Week Tests by Learning Group

Across the five experimental conditions and the three testing time points, participants in the EAL and HAL groups had generated more than half of the percent correct, which outperformed those in the OAL, NAL, and TL groups. In general, participants performed the best on the Delay Test, and the worst on the One-Week Test. Yet, participants in the EAL group were an exception, where their scores increased from 63.6% to 65.4%.

Participants in the HAL group performed the second highest with more than half of the correct rates on tests across the three time points (52.3% on the Immediate Test, 59.4% on the Delay Test, and a 51.1% on the One-Week Test). Participants in the OAL, NAL, and TL groups performed with moderate correct rates on the Immediate Test

(44.3%, 39.7%, and 39.8%, respectively) and the Delay Test (41.2%, 44.1%, and 48.3%, respectively), but with dropped correct rates on the One-Week Test (25.2%, 27.2%, and 28.9%, respectively).

The EAL on the One Week Free Recall Test

The first research question was intended to determine whether EAL is an effective method of learning Chinese characters for beginning learners of CFL. To investigate hypothesis H1.1—The embodied animation learning group outperformed the other conditional groups in terms of better total recall of characters in the One-Week retention period—, I examined the performance of the EAL group in comparison with that of the other four groups on the One-Week Free Recall Test by conducting the post-hoc Tukey HSD test. *Table 29* shows the means and standard deviations of all five groups and the mean comparison results for the One-Week Free Recall Test. To complement inferential statistics, I calculated effect sizes to show the estimated magnitude of the relationship between the learning condition (Group) and the recall test results. Cohen's *d* was calculated:

$$Cohen's\ d = \frac{M1 - M2}{\sigma\ pooled} \quad \text{where} \quad \sigma\ pooled = \sqrt{\left[\frac{\sigma 1^2 + \sigma 2^2}{2}\right]}$$

Effect-size correlation $r_{Y\lambda}$ (ES r) was calculated:

$$r_{Y\lambda} = \frac{d}{\sqrt{(d^2 + 4)}}$$

Table 29

Post-Hoc Tukey HSD: Comparison of 5 Groups for One-Week Free Recall Total Scores

M (SD) of Group EAL	**Comparing Group**	**M (SD) of Comparing Group**	**Mean Difference (Std. Error)**	**p-value**	**Cohen's d (ES r)**
70.67 (14.55)	TL	31.23 (12.83)	39.44*** (4.94)	< .001	2.875 (.821)
	NAL	29.38 (11.52)	41.28*** (4.94)	< .001	3.146 (.844)
	OAL	27.23 (15.48)	43.44*** (4.94)	< .001	2.892 (.822)
	HAL	55.20 (10.17)	15.46* (4.76)	.015	1.232 (.525)

*$p < .05$; ***$p < .001$

Table 29 shows the comparisons of the 5 treatment groups for One-Week Free Recall Test after performing the post-hoc Tukey HSD analysis. The EAL group outperformed the other 4 groups. The EAL group performed significantly better than the TL group by a score of 39.44 (S.E. = 4.94) with a large effect size (Cohen's d = 2.875, $p < .001$), the NAL group by a score of 41.28 (S.E. = 4.94) with a large effect size (Cohen's d = 3.146, $p < .001$), the OAL group by a score of 43.44 (S.E. = 4.94) with a large effect size (Cohen's d = 2.892, $p < .001$), and the HAL group by a score of 15.46 (S.E. = 4.76) with a large effect size (Cohen's d = 1.232, p = .015).

The EAL on Meaning-Form (MF) Mapping, Sound-Form (SF) Mapping, and Form-Meaning and Sound (FMS) Mapping Tests after One Week

To investigate hypothesis H1.2— The embodied animation learning group yields better long-term retention than other learning conditions in form-meaning mapping and meaning-form mapping tasks—, I examined the performance of the EAL group in comparison with that of the other four groups in One-Week MF Mapping, SF Mapping, and FMS Mapping Tests by first conducting a series of one-way ANOVAs, and then the post-hoc Tukey HSD tests. *Table 30* and *Figure 46* show the correct percentages of One-Week MF Mapping, SF Mapping, and FMS Mapping Tests by groups. With the highest possible total score of 72 on the Meaning-Form Mapping task (and the Sound-Form Mapping task), the correct percentage is calculated as the correct meaning-form mapping score (or sound-form mapping score) divided by the highest possible total score, and then multiplied by 100 %:

$$Correct\ Percentage = \frac{Correct\ Score}{72} \times 100\ \%$$

With the highest possible total score of 36 on the Form-Meaning and Sound Mapping task, the correct percentage is calculated as the correct form-meaning and sound mapping score divided by the highest possible total score, and then multiplied by 100 %:

$$Correct\ Percentage = \frac{Correct\ Score}{36} \times 100\ \%$$

Table 30

Correct Percentages for Meaning-Form Mapping, Sound-Form Mapping, and Form-Meaning & Sound Mapping Scores in One Week Tests by Learning Group

	Learning Group				
	TL	**NAL**	**OAL**	**HAL**	**EAL**
Test	% correct	% correct	% correct	% correct	% correct
Meaning-Form Mapping	39.4	32.6	30.9	63.6	77.0
Sound-Form Mapping	10.8	5.2	9.5	11.1	28.8
Form-Meaning and –Sound Mapping	41.9	36.1	41.3	51.1	66.3

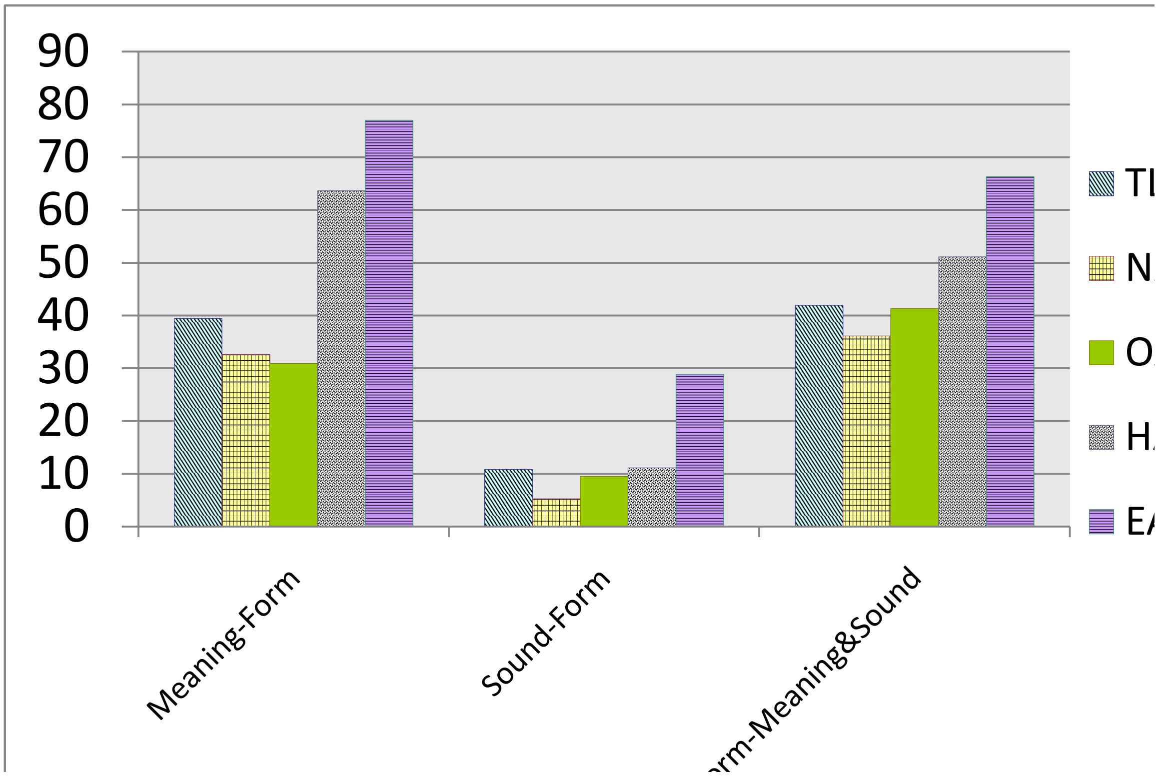

Figure 46. Correct Percentages for Meaning-Form Mapping, Sound-Form Mapping, and Form-Meaning & Sound Mapping Scores on the One-Week Test by Learning Group

It is evident from *Table 30* that the EAL group performed the highest after one week with a correct percentage of 77.0% on the Meaning-Form Mapping Test, 28.8% on the Sound-Form Mapping Test, and 66.3% on the Form-Meaning & Sound Mapping Test. The HAL group performed the second highest after one week with a correct percentage of 63.6% on the Meaning-Form Mapping Test, 11.1% on the Sound-Form Mapping Test, and 51.1% on the Form-Meaning & Sound Mapping Test.

One-way ANOVAs showed that there were significant differences across groups on the Meaning-Form Mapping Test (F (4, 64) = 36.35, $p < .001$), on the Sound-Form

Mapping Test (F (4, 64) = 4.07, $p = .005$), and on the Form-Meaning and Sound Mapping Test (F (4, 64) = 10.09, $p < .001$).

Meaning-Form Mapping on the One-Week Test

To determine whether the EAL group was indeed more proficient than other groups at meaning-form mapping, I compared the EAL group to the other groups by performing a post-hoc Tukey HSD test. Cohen's *d* and effect size r were calculated using the same aforementioned formulas.

Table 31

Post-Hoc Tukey HSD: Comparison of 5 Groups for One-Week Meaning-Form Mapping

M (SD) of Group EAL	**Comparing Group**	**M (SD) of Comparing Group**	**Mean Difference (Std. Error)**	***p*-value**	**Cohen's *d* (ES r)**
55.47 (8.36)	TL	28.38 (10.77)	27.08*** (3.50)	< .001	2.81 (.81)
	NAL	23.46 (10.49)	32.01*** (3.50)	< .001	3.37 (.86)
	OAL	22.23 (10.18)	33.24*** (3.50)	< .001	3.57 (.87)
	HAL	45.80 (6.10)	9.67* (3.37)	.043	1.32 (.55)

*$p < .05$; ***$p < .001$

Table 31 shows the means and standard deviations of all five groups and the mean difference comparison results for the One-Week Meaning-Form Mapping Test. *Table 31* also shows the effect sizes calculated between the EAL group and the other groups and the *p*-values after performing the post-hoc Tukey HSD analysis. The EAL group significantly outperformed the TL, NAL, OAL, and HAL groups. The EAL group performed significantly better than the TL group by a score of 27.08 (*S.E.* = 3.50) with a large effect size (Cohen's *d* = 2.81, *p* < .001), the NAL group by a score of 32.01 (*S.E.* = 3.50) with a large effect size (Cohen's *d* = 3.37, *p* < .001), and the OAL group by a score of 33.24 (*S.E.* = 3.50) with a large effect size (Cohen's *d* = 3.57, *p* < .001). The EAL group has also yielded a significantly higher meaning-form mapping score on the One-Week Test than the HAL group by a score of 9.67 (*S.E.* = 3.37) at the .05 level of significance (*p* = .043). The difference between the EAL group and the HAL group yielded a large effect size (Cohen's *d* = 1.32).

Sound-Form Mapping on the One-Week Test

To determine whether the EAL group was more proficient than the other groups at sound-form mapping, I compared the EAL group to the other groups by performing a post-hoc Tukey HSD test. Cohen's *d* and effect size r were calculated using the same aforementioned formulas.

Table 32

Post-Hoc Tukey HSD: Comparison of 5 Groups for One-Week Sound-Form Mapping

M (SD) of Group EAL	**Comparing Group**	**M (SD) of Comparing Group**	**Mean Difference (Std. Error)**	***p*-value**	**Cohen's *d* (ES r)**
20.73 (21.48)	TL	7.77 (7.38)	12.96 (4.68)	.055	.81 (.37)
	NAL	3.77 (4.09)	16.94** (4.68)	.005	1.09 (.48)
	OAL	6.85 (9.44)	13.89* (3.50)	.033	.84 (.39)
	HAL	8.00 (9.90)	12.73* (4.51)	.048	.76 (.36)

*$p < .05$; **$p < .01$

Table 32 shows the means and standard deviations of all five groups and the mean difference comparison results for the One-Week Sound-Form Mapping Test. *Table 32* also shows the effect sizes calculated between the EAL group and the other groups and the *p*-values after performing the post-hoc Tukey HSD analysis. The EAL group outperformed the NAL, OAL, and HAL groups; it did not statistically outperform the TL group ($p = .055$). The EAL group performed significantly better than the NAL group by a score of 16.94 (*S.E.* = 4.68) with a large effect size (Cohen's *d* = 1.09, *p* = .005). The EAL group also yielded a significantly higher sound-form mapping score on the One-Week Test than the OAL and HAL groups (*p* = .033, and *p* = .048, respectively) and the differences between the EAL group and these two groups yielded medium effect sizes (Cohen's *d'*s = .84, and .76, respectively).

Form-Meaning and Sound Mapping on the One-Week Test

To determine whether the EAL group was indeed more proficient than the other groups at form-meaning and sound mapping, I compared the EAL group to the other groups by performing a post-hoc Tukey HSD test. Cohen's *d* and effect size r were also calculated.

Table 33

Post-Hoc Tukey HSD: Comparison of 5 Groups for One-Week Form-Meaning and Sound Mapping

M (SD) of Group EAL	**Comparing Group**	**M (SD) of Comparing Group**	**Mean Difference (Std. Error)**	**p-value**	**Cohen's d (ES r)**
23.87 (6.01)	TL	15.08 (4.80)	8.79*** (1.93)	< .001	1.62 (.63)
	NAL	13.00 (3.83)	10.87*** (1.93)	< .001	2.16 (.73)
	OAL	14.85 (6.30)	9.02*** (1.93)	< .001	1.47 (.59)
	HAL	18.40 (4.03)	5.47* (1.86)	.036	1.07 (.47)

*$p < .05$; ***$p < .001$

Table 33 shows the means and standard deviations of all five groups and the mean difference comparison results for the One-Week Form-Meaning and Sound Mapping Test. *Table 33* also shows the effect sizes calculated between the EAL group and the other groups and the *p*-values after performing the post-hoc Tukey HSD analysis. The EAL group significantly outperformed the TL, NAL, and OAL groups at the .001 level of significance, and statistically outperformed the HAL group at the .05 level of significance. The EAL group performed significantly better than the TL group by a score of 8.79 (*S.E.* = 1.93) with a large effect size (Cohen's $d = 1.62$, $p < .001$), the NAL group by a score of 10.87 (*S.E.* = 1.93) with a large effect size (Cohen's $d = 2.16$, $p < .001$), and the OAL group by a score of 9.02 (*S.E.* = 1.93) with a large effect size (Cohen's $d = 1.47$, $p < .001$). The EAL group has also yielded a higher meaning-form mapping score on the One-Week Test than the HAL group by a score of 5.47 (*S.E.* = 1.86, $p = .036$). The difference between the EAL group and the HAL group yielded a large effect size (Cohen's $d = 1.07$).

Pictographs, Indicatives, and Ideographs

My second research question sought to explore the non-directional question: between pictographs, indicatives, and ideographs, which type of characters is best learned, and under which learning condition? I first calculated the overall correct percentages of retention for character types on One-Week tests, as shown in *Table 34*; then I presented the correct percentages of retention for character types across the learning conditions and performed a series of one-way ANOVAs and post-hoc Tukey HSD tests to determine whether there was any significant difference between any two conditions.

Table 34

Percent Correct Retention for Character Types After One Week (N = 69)

Character Type	Mean (SD)	Range (min-max)	% Correct
Pictograph	21.36 (8.44)	37 (5-42)	50.86
Indicative	15.22 (8.81)	30 (0-30)	50.73
Ideograph	7.33 (6.98)	29 (0-29)	20.36

Table 34 shows the correct retention percentages for Chinese character types after one week. Overall, pictographs and indicatives were better correctly recalled across groups, with percentages of 50.86 and 50.73, respectively, than ideographs, which only had a 20.36% of correct retention rate.

Pictographs, Indicatives, and Ideographs across Groups

I then examined the correct retention rate of character types by learning groups.

Table 35

Recall of Pictographs, Indicatives, and Ideographs across Groups after One Week

	Learning Group				
Character Type	TL % correct	NAL % correct	OAL % correct	HAL % correct	EAL % correct
Pictograph	43.4	36.5	33.9	61.7	73.6
Indicative	33.3	34.9	32.6	65.6	80.4
Ideograph	8.3	10.1	9.0	26.7	43.3

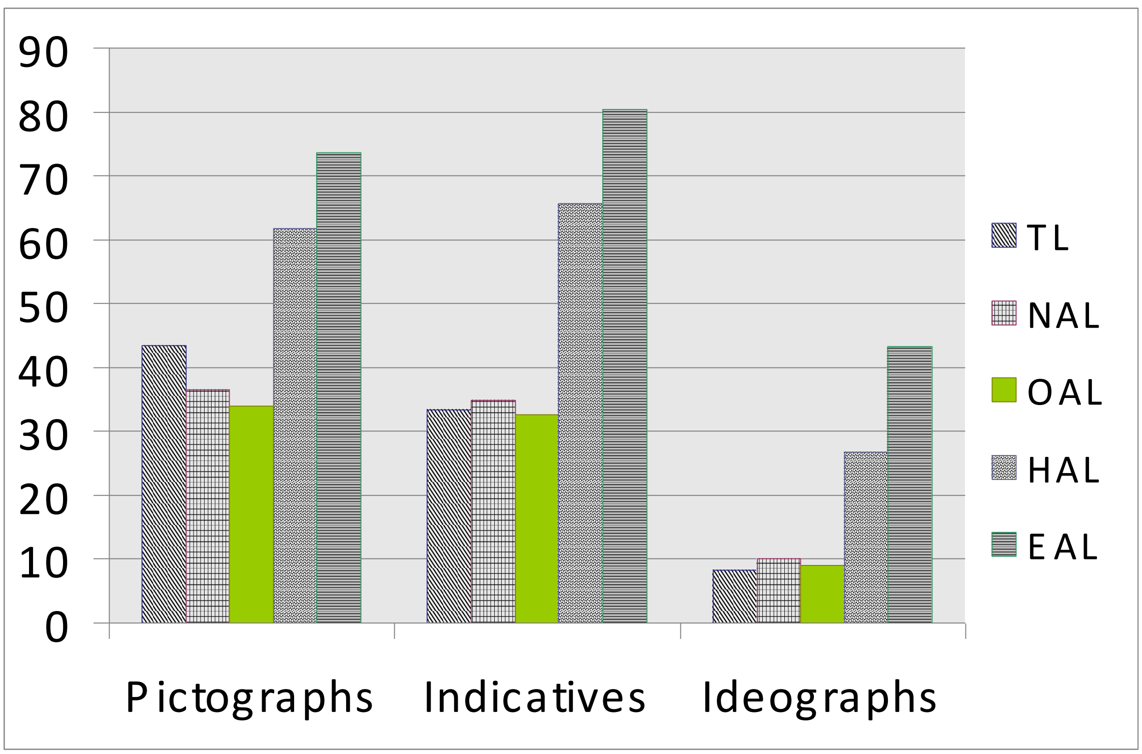

Figure 47. Correct Recall Percentages of Pictographs, Indicatives, and Ideographs across Groups after One Week

Table 35 and *Figure 47* show the total correct recall percentages for pictographs, indicatives, and ideographs across groups after one week of learning. The EAL group recalled 73.6% of pictographs, the HAL group recalled 61.7% of pictographs, and the TL group recalled 43.4% of pictographs. The TL, NAL, and OAL groups recalled about one third of indicatives (33.3%, 34.9%, and 32.6%, respectively), whereas the HAL group recalled 65.6% of indicatives and the EAL group recalled 80.4% of indicatives. Ideographs seem to be the most difficult, with an 8.3% correct recall rate from TL, 10.1% from NAL, 9.0% from OAL, 26.7% from HAL, and 43.3% from EAL.

ANOVA tests revealed significant differences across groups in One-Week Pictograph Recall Total ($F(4, 64) = 24.98$, $p < .001$), One-Week Indicative Recall Total ($F(4, 64) = 14.62$, $p < .001$), and One-Week Ideograph Recall Total ($F(4, 64) = 17.80$, $p < .001$).

Group Comparisons for Pictographs, Indicatives, and Ideographs

Table 36

Post-Hoc Tukey HSD: Comparison of 5 Groups for One-Week Free Recall Scores for Pictograph, Indicative, and Ideograph

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

	M (SD) of Group	**Comparing Group**	**M (SD) of Comparing Group**	**Mean Difference (S.E.)**	**p-value**	**Cohen's d (ES r)**
Pictograph	EAL 30.93 (6.70)	TL	18.23 (5.83)	12.70*** (2.06)	<.001	2.022 (0.71)
		NAL	15.31 (4.42)	15.63*** (2.06)	<.001	2.752 (0.809
		OAL	14.23 (6.48)	16.70*** (2.06)	<.001	2.533 (0.785)
		HAL	25.93 (2.87)	5.00 (1.99)	.099	0.970 (0.436)
Indicative	EAL 24.13 (3.29)	TL	10.00 (7.00)	14.13*** (2.49)	<.001	2.583 (0.790)
		NAL	10.46 (7.29)	13.67*** (2.49)	<.001	2.417 (0.770)
		OAL	9.77 (9.06)	14.36*** (2.49)	<.001	2.107 (0.725)
		HAL	19.67 (5.34)	4.47 (2.40)	.348	1.006 (0.449)
Ideograph	EAL 15.60 (7.99)	TL	3.00 (3.32)	12.60*** (1.88)	<.001	2.059 (0.717)
		NAL	3.62 (3.10)	11.99*** (1.88)	<.001	1.977 (0.703)
		OAL	3.23 (2.77)	12.37*** (1.88)	<.001	2.069 (0.719)
		HAL	9.60 (4.88)	6.00* (1.81)	.013	0.906 (0.413)

Table 36 shows the recall comparisons of 5 learning groups for pictographs, indicatives, and ideographs after one week. For all pictographs, indicatives, and ideographs, the data show a consistent pattern: the EAL and HAL groups performed better than the other three groups (i.e., the OAL, NAL, and TL groups). There was, however, no statistically significant difference between the EAL and HAL groups in pictograph and indicative retention. The only significant difference between the EAL and HAL groups was found in ideograph retention, which had a mean difference of 6.00 (*S.E.* = 1.81, $p = .013$, Cohen's $d = 0.906$). Ideographs seem to be harder to recall than either pictographs or indicatives across all five groups.

What character is best learned?

I examined what character was best or worst recalled by beginning learners of Chinese after one week of learning. In terms of characters' written forms, meanings, and pronunciations, I listed the characters that were most and least recalled based on the results from the One-Week Free Recall Test. *Figure 48, Figure 49*, and *Figure 50* show all 18 characters' retention in their written forms, meanings, and pronunciations.

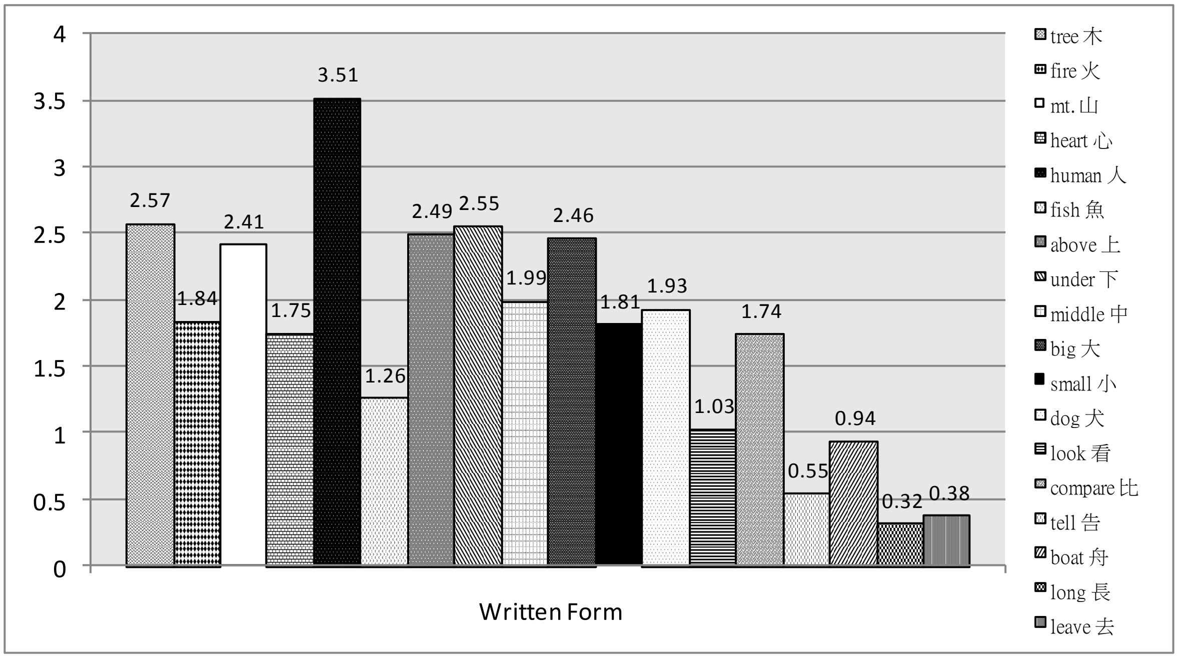

Figure 48. Each character's retention in written form after one week

Figure 48 shows each character's retention in written form after one week. Character's written forms were rated from 0 to 4. Across groups, characters that were most recalled in their written forms were: human (人, M = 3.51, SD = 1.04), tree (木, M = 2.57, SD = 1.51), under (下, M = 2.55, SD = 1.75), above (上, M = 2.49, SD = 1.71), big (大, M = 2.46, SD = 1.75), mountain (山, M = 2.41, SD = 1.87), and middle (中, M = 1.99, SD = 1.89). Characters that were least recalled in their written forms were: long (長, M = 0.32, SD = 0.89), leave (去, M = 0.38, SD = 0.92), tell (告, M = 0.55, SD = 1.06), boat (舟, M = 0.94, SD = 1.36), and look (看, M = 1.03, SD = 1.32).

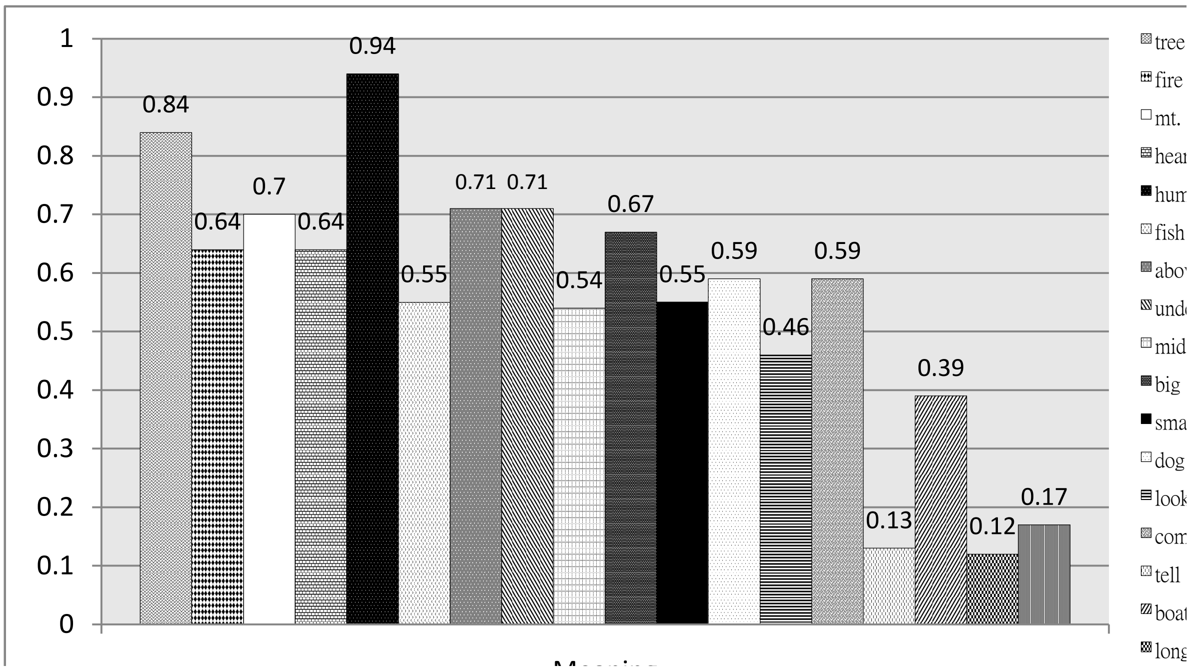

Figure 49. Each character's retention in meaning after one week

Figure 49 shows each character's retention in meaning form after one week. Character's meaning was rated from 0 to 1. Across groups, characters that were most recalled in their meanings were: human (人, M = 0.94, SD = 0.23), tree (木, M = 0.84, SD = 0.36), under (下, M = 0.71, SD = 0.45), above (上, M = 0.71, SD = 0.45), mountain (山, M = 0.70, SD = 0.46), and big (大, M = 0.67, SD = 0.47). Characters that were least recalled in their meanings were: long (長, M = 0.12, SD = 0.32), tell (告, M = 0.13, SD = 0.33), and leave (去, M = 0.17, SD = 0.38).

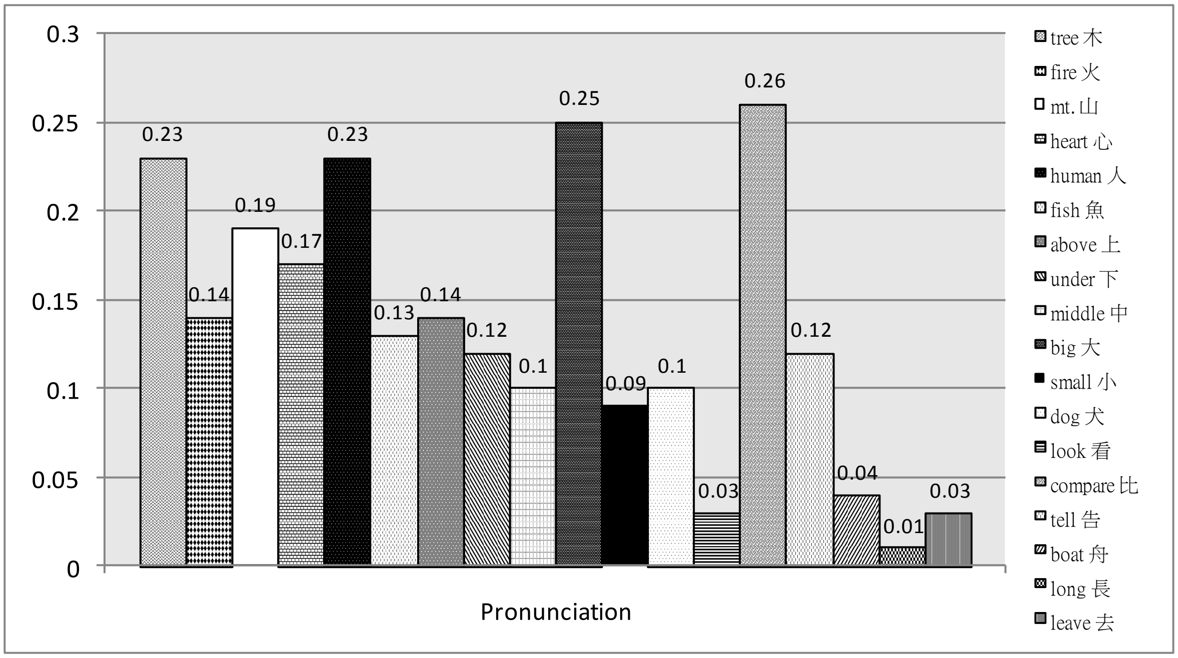

Figure 50. Each character's retention in pronunciation after one week

Figure 50 shows each character's retention in pronunciation after one week. Character's pronunciations were rated from 0 to 1. Across groups, characters that were most recalled in their pronunciations were: compare (比, [bi], M = 0.26, SD = 0.44), big (大, [da], M = 0.25, SD = 0.43), human (人, [ren], M = 0.23, SD = 0.42), and tree (木, [mu], M = 0.23, SD = 0.42). Characters that were least recalled in their pronunciations were: long (長, [chang], M = 0.01, SD = 0.12), leave (去, [qu], M = 0.03, SD = 0.16), look (看, [kan], M = 0.03, SD = 0.16), and boat (舟, [zhou], M = 0.04, SD = 0.20).

Imagination of Movements Check

From the pilot study, some participants in the EAL group reported that they did not imagine doing the movements and gestures while watching the videos. Therefore, on the post-instruction questionnaire in the main study, I checked whether participants imagined doing the movements and gestures while they were watching the videos in the CCL program. There were 20 participants who indicated that they had indeed imagined doing them. Those who imagined doing the movements and gestures were all in the HAL and EAL groups. For both groups, 5 people indicated that they had not imagined doing the movements and gestures, while 10 indicated that they had. No one in the other three groups indicated that they had imagined doing them. *Table 37* and *Figure 51* show the correct recall percentages for those who did or did not imagine doing the movements and gestures in the HAL group and the EAL group on the One-Week Free Recall Test.

Table 37

Correct Recall Percentages for Imagination in the HAL and EAL Groups

	Learning Group		
Imagination	**HAL**	**EAL**	**Total**
No	44.6%	53.9%	49.3%
	(n = 5)	(n = 5)	(n = 10)
Yes	54.4%	71.2%	62.8%
	(n = 10)	(n = 10)	(n = 20)
Total	51.1%	65.4%	58.3%
	(n = 15)	(n = 15)	(n = 30)

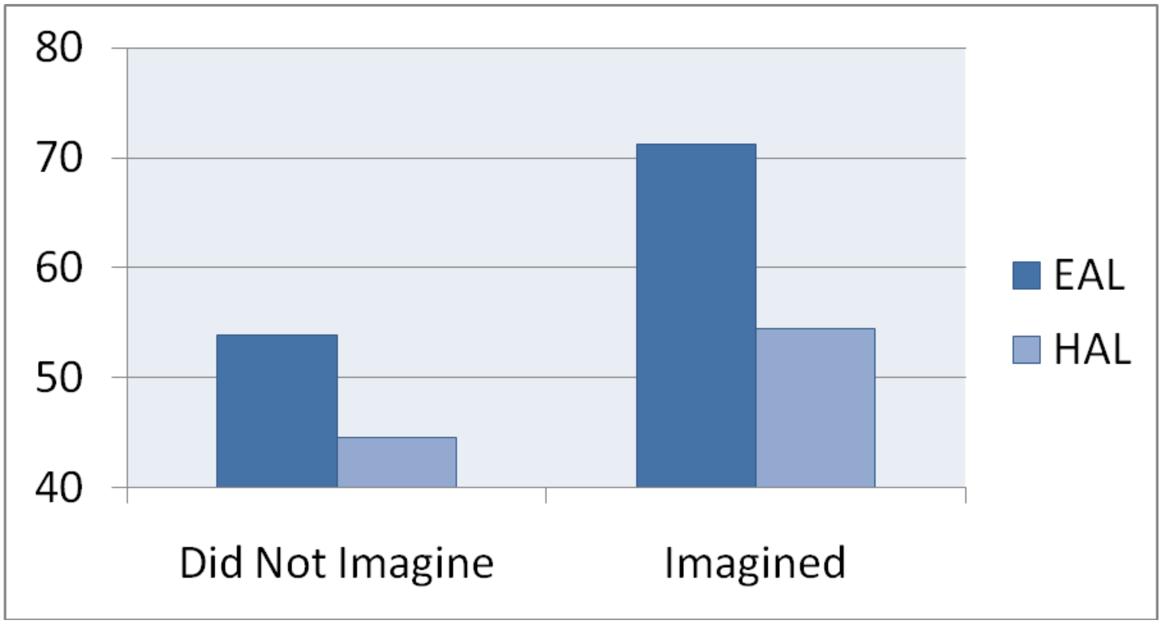

Figure 51. Correct Recall Percentages for Imagined Movements and Gestures in the HAL and EAL groups

A two-way ANOVA was employed to determine whether there were any main or interaction effects between the group and the imagination factor on the One-Week Free Recall Test. After finding that there was no interaction effect between the Group and the Imagination but there were main effects, I ran the analysis again for the model that consists of only main effects. The main effect of the Imagination and the main effect of the Group (being HAL or EAL) were both found to be significant (p = .001 and p < .001, respectively). Therefore, the Group and the Imagination were both significant factors for predicting the One-Week Free Recall Test. *Table 38* presents the results of the analysis.

Table 38

Results of Two-Way ANOVA on the One-Week Free Recall Test Scores of Imagination, Group (being HAL or EAL), and Their Interaction

Source	**Type III SS**	**df**	**MS**	**F**	**p-value**
Corrected Model	3215.20	2	1607.60	14.50	<.001
Intercept	97606.67	1	97606.67	880.61	<.001
Group	1794.13	1	1794.13	16.19	<.001***
Imagine	1421.07	1	1421.07	12.82	.001**
Error	2992.67	27	110.84		
Total	125026.00	30			
Corrected Total	6207.87	29			

Note. Dependent variable: One-Week Free Recall Test.

Group*Device: Interaction between Group being HAL or EAL and Imagination

** $p < .01$; ***$p < .001$

Section 4. General Discussion

Analysis of the Results

Summary

In summary, the study showed that the embodied animation learning group worked well in Chinese character learning for beginning learners of Chinese. The EAL group outperformed the other learning groups with medium to large effects. Specifically, after one week of learning, the EAL group outperformed the other groups in terms of learners' free recall of Chinese characters (*Table 28*, *Figure 45*, & *Table 29*), in character meaning-form mappings (*Table 30*, *Figure 46*, & *Table 31*), and in character form-meaning and-sound mappings (*Table 33*). In addition, the EAL group performed better than the other groups in the retention of all three types of characters (i.e., pictograph, indicative, and ideograph) (*Table 35*, *Figure 47*, & *Table 36*).

It is worth noting that all groups did not do well in the Sound-Form Mapping Test (*Figure 46*). As the percent correct of pronunciation learning result was quite low and random, the current EAL design in my CCL program does not show a specific positive facilitation effect for beginning learners' pronunciation learning.

Overall, pictographs and indicatives were better recalled across groups (*Table 34*). In terms of the written form of a character, three pictographs, *human*, *tree*, and *mountain*, and four indicatives, *under*, *above*, *big*, and *middle* are among those that were best recalled, which happened to be characters with four strokes or fewer. The least recalled characters, in terms of their written forms, were ideographs such as: *long*, *leave*, *tell*, *boat*, and *look* (*Figure 48*). In terms of the meaning, three pictographs, *human*, *tree*, and *mountain*, and three indicatives, *under*, *above*, and *big* are among those that were best recalled, which also happened to be characters with four strokes or fewer. The least recalled characters, in terms of their meanings, were ideographs such as: *long*, *tell*, and *leave* (*Figure 49*). These correspond to the literature of visual complexity of Chinese characters in that characters with more strokes are generally harder to learn and memorize. In terms of the pronunciation, sounds such as *compare* ([bi]), *big* ([da]), *human* ([ren]), and *tree* ([mu]) were best recalled; and sounds such as *long* ([chang]), *leave* ([qu]), *look* ([kan]), and *boat* ([zhou]) were least recalled (*Figure 50*). These results do not reflect a systematic pattern across different types of characters.

Memory Increase in the Delay Test

Results from *Table 28* and *Figure 45* showed that participants might perform better in the Delay Test than in the Immediate Test because of the reviewing effect of the measurement in the study design. When provided with the Form-Meaning and -Sound Mapping Tests, participants were able to see and review the characters that they had just learned in both the Immediate and Delay tests. This also partly explains why the EAL group had a slightly higher recall rate of 65.4% in the One-Week Test than in the Delay test, due to the fact that participants were able to review the three features of all characters in the Delay test.

Embodied Animations

The main study suggests that the approach of using embodied animations to Chinese character learning for beginning learners of CFL is effective with encouraging results. Why does embodied animation work? Previous studies and literature provide possible explanations.

The neurological evidence showed that many of the movement-based or action-related Brodmann's areas were strongly activated when Chinese characters were being processed (Tan et al., 2001; Tan et al., 2000). The strong activation of these areas, BA 4 (Primary Motor Cortex), BA 6 (Premotor Cortex and Supplementaty Motor cortex), BA 3 (Primary Somatosensory Cortex), BA 7 (Somatosensory Association Cortex), and BA 1 (Primary Somatosensory Cortex) indicated the association between Chinese character processing and human body movements. Lu, Hallman, and Black's (2010) have therefore reasoned that (1) the processing and representation of Chinese characters require some of these unique areas to be activated. Some characters may be embodied and processing these characters is thus embodied, and (2) when encoding and decoding Chinese characters, there is significant assistance to activate these brain areas. In other words, the activation of these areas is supposed to be helpful to assist with the encoding of Chinese characters. Therefore, embodied animations work. By triggering motor- and body movement-related cortices, learners may better encode or process Chinese characters.

The CALL program for CCL using embodied animations is effective because it helps learners strengthen the connections between characters' written forms and their meanings through animation simulations for learners' imagination. The work is in line with imagined instructional embodiment that Gibbs (2006), Glenberg (2004; 2008), and Fadjo, Lu, and Black (2009) proposed. In fact, the design of embodied animations echoes our human's capability of imagination and the positive impact of technologies. Black (2007) and Schwartz and Black (1999) revealed the importance of imagination and imagined actions as Black (2010) spoke at the 2010 Teachers College Academic Festival about the magic of experience plus simulation, "having experiences that relate to what you are learning can make a big difference. Technology exists that provides these kinds of experiences." The results from *Table 37, 38* and *Figure 51* showed the importance of imagination in Chinese character learning.

With the computer-based Chinese character learning program, it is easier to imagine and experience the relationship between characters and movements. It further helps learners generate forms when presented with meanings, or derive meanings when characters are displayed. In sum, the program helps learners imagine and experience the relationship between characters and movements and that leads to deeper and better Chinese character learning. All in all, the study shows the effectiveness of embodied animations in Chinese character learning and provides a new approach to CCL by using this technique.

Why does HAL perform the second best?

In terms of one week retention rates in the free recall, meaning-form mapping, and form-meaning and-sound mapping tests, the HAL group constantly performed the second best as it significantly outperformed the OAL, NAL, and TL groups in these tests after one week of learning. Therefore, in addition to the embodied animation learning group's good performance, it is worth asking: Why would human-image animation learning work so well? I would like to point out two aspects. In the Post-Instruction Questionnaire, I checked to see if participants had imagined doing the movements or gestures when they watched the videos during their learning. Two-thirds of the participants in the HAL group (n = 10) indicated that they had imagined doing those movements or gestures while they were learning the characters. From Table 37 and Figure 51, it is clear that those who imagined performed better than those who did not. The fact that many participants in the HAL group had imagined makes the HAL group different from the TL, NAL, and OAL groups, which might make the HAL group perform better than these three groups.

The other aspect lies in the design of human-image animation learning itself. Participants in the group perceived, after the etymology animation, a still human image of a gesture that depicts some semantic meaning and the written form of the target character. It is reasonable to speculate that human body images are more promising than object images in CCL. Note that only the embodied animation learning group participants were asked in the Specific Instruction Sheet to imagine doing the movements and gestures while learning with the program. The HAL group participants did not receive this instruction. Therefore, it is interesting to see that 10 out of 15 participants in the HAL group had imagined. I speculate that the human body image plays an important role in stimulating or arousing our imagination and connecting the character. When we see a still human image that contains gestures, we may imagine some possible meanings of the gestures, or how the person in the image moves to reach that gesture. Thus, learners may be able to imagine the target character's written form and semantic meaning by perceiving a human body image in a CCL program.

Allocation of Characters

In the study, participants recalled pictographs and indicatives better than ideographs. Would the allocation of characters play a role in learners' character learning here? The 18 characters were shown in the identical 3 x 6 table on the main page screen for all groups. Characters displayed from left to right in the first row are tree, fire, mountain, heart, human, fish, which are all pictographs. First five characters displayed from left to right in the middle row are indicatives (above, below, middle, big, and small). Ideographs were displayed in the bottom row. It would be interesting to check if there were more clicks on certain characters displayed on the left and on the top by examining the recorded screens and videos. Although there is this probability that the allocation of characters might make learning results different, it is worth noting that, on the instruction sheet, all participants were told to try their best to learn all 18 characters and each character was given 90 seconds to learn. In addition, the study was conducted under well-controlled experimental conditions such that participants were randomly assigned to their learning groups and the items on testing materials were displayed in different orders for each test for each participant to counterbalance the ordering effect.

Character Attributes and Imagination

From the discussions of embodied animation learning and human-image animation learning, it appears that imagination plays an important role in embodiment in CCL. When we imagine, we process information in a deeper and more elaborate way that is supposed to be helpful with our long term memory (Anderson, 2002). Therefore, it is plausible to surmise that if we prompted learners of CCL with proper imagination instructions or scaffoldings, learners in the OAL or NAL groups could probably boost their learning results.

A related issue that we have to look into is the characters chosen to be displayed for learners. In the study, the characters chosen are concrete or spatial characters because they can be easily animated with movements or gestures. These characters, after acting out by human beings, facilitate learners' imagination and help with CCL. However, would relatively more abstract characters generate a similar effect? Abstract characters or words, such as joy (樂), congratulation (恭), docile (乖), demur (猶), or agnosticism (疑), are certainly harder to depict for their written forms. Nonetheless, three points should be made. First, most of abstract characters are semantic-phonetic compounds or complex ideographs, and they can be further segmented into smaller units such as pictographs or indicatives. Therefore, the movement and imagination part of Chinese character learning can still be applied to those smaller units when learning abstract characters. Secondly, though it may be more difficult to act out abstract characters by human beings than concrete, or spatial, characters in a CCL program video, the imagination of their meaning is possible and feasible. Take the character contemplation as an example. When ancient people were able to get logs or wood for their daily cooking or construction use, they would be joyful. The character has a tree/ wood component as its radical on the bottom, and hence it can be imagined such that people are happy with wood or that people have a good time in their tree house joyfully. Similarly, for the character congratulation, there is a heart/ mind component in the character. When we congratulate people, we use our mind or do so from our hearts. By imagining the congratulation gestures, actions, or ideas using the pictograph component, namely the heart radical, we may better learn the character. Thirdly, as argued by Lu et al. (2010), in the initial stage of CCL, it is more effective and reasonable to introduce to beginning learners fundamental characters such as pictographs, indicatives, and ideographs. Abstract characters, therefore, are to be introduced in a later phase of CCL. For a CCL program designed for beginning learners, the inclusion of abstract characters should be optional and carefully considered. Another issue is, will verbs help facilitate the imagination or learning process than nouns or adjectives? Verbs already contain the meaning of movement and action, and under embodied cognition premise (Gibbs, 2006), they would fit my embodied animation design better than nouns. Yet, further investigations to provide empirical evidence are needed.

Amount of Embodiment

Another way to look at my different experimental groups is from the perspective of the amount of embodiment participants have experienced during their character learning. According to embodied cognition theories (e.g., Glenberg et al., 2004; Gibbs, 2006; Barsalou, 2008; Barsalou, 2010), a fuller and more thorough embodiment would involve one's imagination and body movement. Therefore, the EAL group participants seemed to experience the most amount of embodiment in comparison with other group participants. The NAL group participants, for example, perceived a still image of the unchanging etymological characters along with the three features of the target character. The amount of embodiment learners experienced and its embodied cognition effect are therefore less than the stimulation that includes etymological animation and human body movements. It is worth noting that since the processing of language learning is a change in the mental state, what is happening in our mind internally is more crucial than the merely external stimulation (Rogers et al., 1992). Therefore, what is important for educators or designers in CCL is to strengthen that external stimulation by creating better environments or programs and facilitate the internal processing mechanisms by providing useful prompts and sound instructional designs.

Limitations of the Study

As with every study that utilizes an experimental design, there are potential threats to internal and external validity (Campbell & Stanley, 1963). However, Campbell and Stanley (1963) contend that the design employed in this study (Randomized Posttest-Only Control Group) is actually quite proficient at controlling for them.

Due to the limitation of time, the study could not be carried out over a longer period of time to allow the possible re-examination of participants' long term memory in Chinese characters after two weeks, or three weeks, of learning. It would be interesting to investigate whether embodied animation consistently demonstrates its superiority to other learning conditions, for answering questions such as, "How long (and how much) can learners remember in Chinese characters with the help of embodied animation?" "Do certain types of characters benefit the most from embodied animation over a longer period of time?" and "What instructional designs or learning methods would remedy the characters that are harder to memorize over time?"

CHAPTER V

CONCLUSION

Section 1. Implications for Theories

Why Embodiment?

As discussed in the previous chapter, embodied animation learning works in Chinese character learning. The effectiveness of the new construct, embodied animation in CCL, therefore adds to the literature of embodied cognition. The design of the embodiment (and the program) provides a platform for learners to experience and imagine the Chinese character's meaning and form changes that are related to body movements. Through this imagination of form and meaning, learners make connections between word and actions, which leads to better retention in long term memory. The embodied animation may as well trigger movement cortices which in turn help learners better process many kinds of Chinese characters with stronger encoding ties. Beginning learners of Chinese characters try to link the word's meaning to its written form, which has a logographic nature of pictorial, indicating, or ideographic representation. Therefore, the embodied animation learning fits the encoding process by scaffolding both meaning and written form for learners in the initial stage.

CALL for CCL

Bateson (1972) views interaction with computer systems as an opportunity for new forms of activity and argues that some forms of knowledge are viewed as distributed between users' internal representations and between representations embodied in the artifact itself and employed by users as external representations. In addition, computer-assisted language learning (CALL) for English language has been broadly and deeply implemented, discussed, and researched (Egbert & Hanson-Smith, 1999; Hanson-Smith, 2000; e.g., Ha & Rilling, 2006; Lu, Wu, Martin, & Shah, 2009). However, CALL for Chinese language has not yet been that widely adopted or studied. Furthermore, in terms of embodiment designs for Chinese language learning, the dissertation extends the work of Barsalou's (1999, 2008), Black's (1979, 2007), Gibbs' (2006) and Glenberg's (1999, 2000, 2004, 2008) as they reveal the importance of grounding our human cognition in the proprioceptive experience, imaginary thinking, and meaning generation through imagination and actions. In fact, Fadjo, Lu, Black (2009) and Fadjo, Lu, Shin, Chan, and Black (2008) have been trying to develop embodiment designs for mathematics and video game programming learning and instruction based on embodied cognition theories. What have not been explored are potentially effective embodiment designs for Chinese language learning. Since using computer-assisted animations successfully motivates learners (Hong, 2009), this embodied animation design for Chinese language learning is therefore promising due to both of its embodiment element and animation feature.

Section 2. Implications for Instruction

Instructional Embodiment Designs

Practically, how should teachers implement the different types, or levels, of embodiment in teaching? Lu et al. (2010), Fadjo et al. (2009), and Black et al. (in preparation) have suggested how teachers should implement and apply different designs of embodiment for Chinese character learning. For example, Lu et al. (2010) proposed the five types of instructional embodiment: Direct (or Full) Embodiment (DE), Surrogate Embodiment (SE), Imagined Embodiment (IE), Reflected Embodiment (RE), and Haptic Embodiment (HE).

The design of DE (Fadjo, Lu, & Black, 2009; Fadjo, et al., 2008) entails that learners obtain the proprioceptive experience by meaningfully moving their torsi and thus full-bodily enacting what they are learning, such as embodying Chinese characters that contain 'water' or 'fire' radicals. The DE is effective as evidenced by the iWorld Team related studies.

The design of SE (Glenberg, 2004; Fadjo, Hallman, Harris, & Black, 2009) uses a surrogate's actions to replace torso movements; yet, it is effective in language teaching and learning (Glenberg, 2004; Glenberg, 2008). In practice, teachers may create different radicals' manipulatives as surrogates for learning activities.

The design of HE (Lu, Lin, & Wu, 2008) is effective when learners obtain both 1st and 2nd -hand experiences in the learning activity phase. In addition to learners' clicking the mouse and hearing the target words' pronunciations, active rule-generating actions provide deeper processing in vocabulary recognition and memorization (Lu, et al. ibid.). When teaching CFL using HE, teachers can provide selected Chinese characters on a Smart Board, computers (e.g., programs or second life), or on cards as stimulation, and then ask learners to self-generate and group common morphemes (ex. radicals) or common phonemes.

The design of RE (Hong, 2009) has a unique feature that learners see themselves through a webcam and hence also see themselves move (mostly their hands) on the computer screen when they interact (mostly using their hands) with the computer in a game. Hong (2009) develops the interactive flash player media in hopes that learners would enhance their motivation and learning effects. He has found positive results in that the design indeed intrigues learners more with game components that require identification and active recall skills, with interactive components that show rich-information, and with competitive racing function. Teachers of CFL may design animation-based or interactive games to allow learners use RE for learning different Chinese characters. For example, RE can be used in a word discerning game for word recognition or character differentiation.

The design of IE (Fadjo, Lu, & Black, 2009; Black, 2007) emphasizes learner's imaginary ability and thus can be used when learners are inferring new rules, morphology, or phonetics in Chinese characters. Teachers of CFL should implement IE in the learning activity phase in their instructional designs for deeper learning. For example, during the beginning learning phase of a class, teachers of CFL can ask learners to encode (after seeing certain words) then decode (by thinking and imagining quietly without seeing these words) these Chinese characters.

Though research regarding some of the designs of embodiment is not specifically related to CFL or Chinese character learning, I believe future research will provide more affirmative details in their uses and applications in Chinese language classrooms. With the use of embodiment for language learning and teaching, future Chinese language classes will no longer be marked by tedious repetition and relatively meaningless memorization of words.

Phonological Clue for Character Recognition

In order for beginning learners of CFL to rely on their spoken language resources when identifying Chinese word meanings, Everson (1998) did a word recognition study to investigate the relationship between speech and meaning, in which he also calls it the relationship between naming and knowing. Everson (1998) found that there is a significant relationship between being able to pronounce and being able to identify Chinese words. That is to say, "learning Chinese characters is a 'package deal' that necessarily links meaning with the spoken language" (Everson, 1998, p. 200) because the relationship between knowing a word's meaning and knowing its pronunciation is very strong. Therefore, when teaching Chinese characters, both phonology and morpheme of the words should be introduced and emphasized for best learning results from learners since 'ideographic' processing may not be their primary strategy for learners of CFL. Technology has made presenting both phonology and morpheme of Chinese characters a lot easier for teachers. For example, a teacher can program before class and later present in class a printed character and its pronunciation at the same time in the same slide on the screen. In addition, designs of the embodiments for CFL should incorporate these both factors of characters in presenting, practicing, and even testing Chinese words. For example, when teachers show a Chinese character, its pronunciation should also be made available to learners when implementing instructional embodiment designs.

Note that the participants in Everson's (1998) study are considered beginning to intermediate learners as they have all taken at least one semester of Chinese language course in college. Therefore, it may also be possible to assume that the strong relationship of the sound-meaning mapping mechanism occurs after the initial form-meaning mapping mechanism. For the very beginner of CFL, the embodied animations seem to provide great resources for mapping meaning and written forms in the initial stage of learning characters.

Section 3. Future Directions for the Research

Characters for Beginning Learners of CFL

So far as what characters should be introduced to beginning learners of CFL is concerned, Lu, Hallman, and Black (2010) suggest pictographs, indicatives, and ideographs. As all of them serve as a component of other characters and most of them are radicals, it is therefore plausible for future designers, who wish to create a more thorough database that contains must-learn characters, to include radicals in the CALL program for Chinese character learning. In modern Chinese, there are currently 214 radicals in use, not 540 originally listed in *Shuowen Jiezi*, and their stroke numbers are from 1 to 17 (see Appendix 0 for a complete list of all 214 radicals' written forms, pronunciations (in brackets), and meanings (in parentheses) for future reference).

When ancient Chinese people communicated, they used logographs to convey what they referred to, thought of, or tried to talk about. The form-meaning mapping mechanism should therefore happen and become more universal for Chinese than the sound-meaning mapping mechanism. This probably explains the creation and use of pictographs, indicatives, and ideographs before the creation of other characters. This also inspires me on what features of a character should be placed and presented first as I determine the display of form-meaning-sound from left to right in the individual character learning page design. Furthermore, I believe that for these three types of characters, videos containing pictures, movements, or etymologies can best illustrate meaning and written form and their relationship. Thus the inclusion of videos should benefit CFL learners' Chinese character form-meaning mapping encoding processes and therefore further help them better learn characters.

Embodiment Designs in the Future

Software design or development needs to be based on learning theories, design principles, and pedagogical experience. With empirical and neurological evidence, I designed the embodied animation program for beginning learners of CFL to learn Chinese characters. Li's (1996) research results show that learners prefer user-controlled learning over instructor-driven classroom presentation. Unlike *HyperCharacters* where different types of the character's written form are all shown on one screen at the same time, I present the different types of the character's written form in the same spot. Moreover, my design has a slide for learners to self-control the process of character animations so that any part of the evolution can be seen again.

Since effective use of technology can greatly contribute to student learning, we should also design programs that are acceptable for teacher training. Making teachers become more critically aware of available software and use of new technology is important. The national standards for foreign language teaching urge teachers to place equal emphasis on all four skills of a foreign language (American Council on the Teaching of Foreign Languages, 1997). So all features of Chinese characters should be emphasized and included in the designs. In addition, for future CCL programs and designs, we should also try to see if future designs of embodied animations are self-contained in a tutorial learning environment, if they can make learning more interesting, simple, effective and rewarding, and if they facilitate deeper and better Chinese character learning processes.

Liu et al. (2003), after reviewing 246 CALL related articles from 1990 to 2000, suggested that more research needs to focus on how computer technologies can be used to support L2 learning or FL learning, not merely on the benefits and potentials of them. For example, questions of when teachers should use what tasks or activities in what situations or settings are of importance for future research. Indeed, we need to further explore the implementation conditions of embodied animations for Chinese character learning and teaching. Therefore, when should beginning learners of CFL use the designs of embodied animations to learn characters, what characters should be learned in what order, and under what conditions should these designs best scaffold learning processes are all important questions that are worth further investigation in the future.

Many different instructional materials and designs can be thus created for Chinese character teaching and learning according to our literature reviews and the current study. As shown in the results, by triggering motor- and body movement-related cortices, learners may better encode or process Chinese logographs. Designers can develop effective programs that are based on embodied cognition and use of technologies. We see that embodiment and technology will be the new trend of Chinese character teaching and learning. Teachers' instructional designs will be different from traditional ones when it comes to using embodiment and technology for Chinese language classrooms.

For possible future research, we may study native Chinese children and see if the embodied animation program is effective for them. When native Chinese children first learn characters, they are taught to use pictorial cues to learn radicals, but not to necessarily use body movements or gestures. Therefore, the program may serve not only as a good image resource for children learners but also a source for physical movement stimulation. We may also examine if there is a difference in learning through embodied animations between children and adult learners since beginning adult learners in many ways are like children learners when they do not know anything about the language. In addition, will embodied animations work for other logographic or even non-logographic languages? By answering this question, we will be able to know if the movement/ action elements play a role in language acquisition in general. If they do, our knowledge of language learning and teaching will be understood and treated differently. If they do not, we will be able to conclude that embodied animations are domain-specific such that only Chinese character learning benefits significantly from the design.

It would be also interesting to include a physical embodiment group of which participants are asked to practice writing as much as they can during the learning phase. The five groups that were included in my study, though provided with two pieces of paper and two pens, were not specifically told to practice writing characters when they learned. Furthermore, they were told to learn with the CCL program in front of them. Most participants in the study used the CCL program by clicking the sound button, watching the videos, and reviewing the three main features of the target character. Yet, as writing using our hands (and thus also hand movements) can be deemed a type of embodiment, it would be a good comparison group to other types of conditions employed in this study. In addition, with the advances of technology, we may design the future CCL program that allows learners to practice writing characters on touch-screens to correctly monitor learners' writing. We would be able to further investigate if the amount of embodiment experienced with practice writing would make an impact on CCL and if the haptic channel makes character learning easier or better. Furthermore, by comparing more different designs of embodiment groups, we will be able to find out the amounts of embodiment that are needed for the learning of characters. It would also help future researchers and educators to develop evaluations, classroom activities, and CCL curricula.

As L1 reading researchers reveal that word recognition is a necessary foundation for reading comprehension, the implementation of embodiment and technology in beginner's rudimental stage for better learning a L2 that features nonalphabetic orthographies, such as Chinese character learning, becomes more and more important if we surmise a similar process for CFL reading. In the future, we need more empirical studies to provide evidence to support the idea of Chinese character teaching using embodiment and technologies. Also, we should uncover when and how to use different types of embodiment. For example, are there certain types of Chinese characters that can be best learned and taught using certain embodiment types? In addition, what should be the characters introduced to beginners of CFL? Should teachers only pick words to be introduced to learners that allow them to practice meaning-to-form or sound-to-symbol correspondence? Should teachers include characters only used in vernacular literature or can teachers also include those in classical Chinese in their teaching of CFL? For character learning, is imagination of viewing videos sufficient for children? Or should young learners be instructed or told to embody themselves physically? These are the questions concerning beginners' experience and effects of CFL learning that are worth further investigation.

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AUTHOR NOTE

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APPENDIX

Appendix 0- Character Radicals

List of the 540 Shuowen Jiezi Radicals:

(1 Introduction)

2 一丄示三王玉玨气士丨屮艸募艸蓐茻

3 小八釆半牛犛告口凵吅哭走止癶步此正是辵彳廴㢟行齒牙足疋品龠冊

4 㗊舌干谷只㕯句丩古十卅言誩音䇂丵菐𠬞𠬜共異舁𦥑晨爨革鬲䰜爪丮鬥又𠂇史支𦘒聿畫隶臤臣殳殺几寸皮㼱攴教卜用爻㸚

5 夏目䀠眉盾自白鼻皕習羽隹奞萑𦫳苜羊羴瞿雔雥鳥烏華冓幺𢆶叀玄予放𠬪𣦼歺死冎骨肉筋刀刃㓞丯耒

6 角竹箕丌左工㠭巫甘曰乃丂可兮号亏旨喜壴鼓豈豆豊豐䖒虍虎虤皿𠙴去血丶丹青井皀鬯食亼會倉入缶矢高冂𩫖京亯㫗畗㐭嗇來麥夊舛舜韋弟夂久桀

7 木東林才叒之帀出𣎵生乇𠂹𠌶華𥝌稽巢桼束㯻囗員貝邑䢺

8 日旦倝㫃冥晶月有朙囧夕多毌𢎘𣐺鹵齊朿片鼎克彔禾秝黍香米毇臼凶朩𣏟麻尗耑韭瓜瓠宀宮呂穴㝱疒冖𠔼冃㒳网襾巾市帛白㡀黹

9 人七匕从比北丘㐺𡈼重臥身㐆衣裘老毛毳尸尺尾履舟方儿兄兂皃𠑹先禿見覞欠㱃次旡頁

10 𦣻面丏首𥄉須彡彣文髟后司卮卩印色卯辟勹包茍鬼甶厶嵬山屾屵广厂丸危石長勿冄而豕㣇彑豚豸𤉡易象

11 馬廌鹿麤㲋兔萈犬㹜鼠能熊火炎黑囪焱炙赤大亦夨夭交尣壺壹幸奢亢夲夰大夫立竝囟思心惢

12 水沝瀕く巜川泉灥永𠂢谷仌雨雲魚𩺰燕龍飛非卂

13 乙不至西鹵鹽戶門耳𦣝手𠦬女毋民丿厂乀氏氐戈戉我亅珡乚亡匸匚曲甾瓦弓弜弦系

14 糸素絲率虫䖵蟲風它龜黽卵二土垚堇里田畕黃男力劦

15 金幵勺几且斤斗矛車𠂤𨸏𨺅厽四宁叕亞五六七九禸嘼甲乙丙丁戊己巴庚辛辡壬癸子了孨𠫓丑寅卯辰巳午未申酉酋戌亥

List of all 214 Modern Chinese Radicals:

1. 一 [yi1] (one); 2. 丨[gun3] (line); 3. 丶 [zhu3] (dot); 4. 丿 乀[fu2], 乁[yi2] [pie1] (slash); 5. 乙 乚[yin3], ⺄ [yi4] (second); 6. 亅 [jue2] (hook); 7. 二 [er4] (two); 8. 亠 [tou2] (lid); 9. 人 亻 [ren2] (man); 10. 儿 [ren2] (legs); 11. 入 [ru4] (enter); 12. 八 丷 [ba1] (eight); 13. 冂 [jiong3] (down box); 14. 冖 [mi4] (over); 15. 冫 [bing1] (ice); 16. 几 [ji1] (table); 17. 凵 [qu3] (open box); 18. 刀 刂 [dao1] (knife); 19. 力 [li4] (power); 20. 勹 [bao1] (wrap); 21. 匕 [bi3] (spoon); 22. 匚 [fang1] (right open box); 23. 匸 [xi3] (hiding enclosure); 24. 十 [shi2] (ten); 25. 卜 [bu3] (divination); 26. 卩 [jie2] (seal); 27. 厂 [han4] (cliff); 28. 厶 [si1] (private); 29. 又 [you4] (again); 30. 口 [kou3] (mouth); 31. 囗 [wei2] (enclosure); 32. 土 [tu3] (earth); 33. 士 [shi4] (scholar); 34. 夂 [sui1] (go); 35. 夊 [zhi] (go slowly); 36. 夕 [xi4] (evening); 37. 大 [da4] (big); 38. 女 [nü3] (woman); 39. 子 [zi3] (child); 40. 宀 [mian2] (roof); 41. 寸 [cun4] (inch); 42. 小 [xiao3] (small); 43. 尢 尣 [wang1] (lame); 44. 尸 [shi1] (corpse); 45. 屮 [che4] (sprout); 46. 山 [shan1] (mountain); 47. 川 巛, 巜 [gui4] [chuan1] (river); 48. 工 [gong1] (work); 49. 己 [ji3] (oneself); 50. 巾 [jin1] (turban); 51. 干 [gan1] (dry); 52. 幺 [yao1] (short thread); 53. 广 [yan3] (dotted cliff); 54. 廴 [yin3] (long stride); 55. 廾 [gong3] (two hands); 56. 弋 [yi4] (shoot); 57. 弓 [gong1] (bow); 58. 彐 彑 [ji4] (snout); 59. 彡 [shan1] (bristle); 60. 彳 [chi4] (step); 61. 心 忄 [xin1] (heart); 62. 戈 [ge1] (halberd); 63. 戶 [hu4] (door); 64. 手 扌 [shou3] (hand); 65. 支 [zhi1] (branch); 66. 攴 攵 [pu1] (rap); 67. 文 [wen2] (script); 68. 斗 [dou3] (dipper); 69. 斤 [jin1] (axe); 70. 方 [fang1] (square); 71. 无 [wu2] (not); 72. 日 [ri4] (sun); 73. 曰 [yue1] (say); 74. 月 [yue4] (moon); 75. 木 [mu4] (tree); 76. 欠 [qian4] (lack); 77. 止 [zhi3] (stop); 78. 歹 [dai3] (death); 79. 殳 [shu1] (weapon); 80. 毋 [mu2] (no; do not); 81. 比 [bi3] (compare); 82. 毛 [mao2] (fur); 83. 氏 [shi4] (clan); 84. 气 [qi4] (steam); 85. 水 氵 [shui4] (water); 86. 火 灬 [huo3] (fire); 87. 爪 爫 [zhao3] (claw); 88. 父 [fu4] (father); 89. 爻 [yao2] (double x); 90. 爿 [qiang2] (half tree; trunk); 91. 片 [pian4] (slice); 92. 牙 [ya2] (fang 4); 93. 牛 牜 [niu2] (cow); 94. 犬 犭 [quan3] (dog); 95. 玄 [xuan2] (profound); 96. 玉 王 [yu4] (jade); 97. 瓜 [gua1] (melon); 98. 瓦 [wa3] (tile); 99. 甘 [gan1] (sweet); 100. 生 [sheng1] (life); 101. 用 [yong4] (use); 102. 田 [tian2] (field); 103. 疋 [pi3] (bolt of cloth); 104. 疒 [chuang2] (sickness); 105. 癶 [bo4] (dotted tent); 106. 白 [bai2] (white); 107. 皮 [pi2] (skin); 108. 皿 [min3] (dish); 109. 目 [mu4] (eye); 110. 矛

[mao2] (spear); 111. 矢 [shi3] (arrow); 112. 石 [shi2] (stone); 113. 示 礻 [shi4] (spirit); 114. 禸 [rou3] (track); 115. 禾 [he2] (grain); 116. 穴 [xue4] (cave); 117. 立 [li4] (stand); 118. 竹 [zhu2] (bamboo); 119. 米 [mi3] (rice); 120. 糸 纟 [mi4] (silk); 121. 缶 [fou3] (jar); 122. 网 罒 [wang3] (net); 123. 羊 [yang2] (sheep); 124 羽 [yu3] (feather); 125. 老 [lao3] (old); 126. 而 [er2] (and); 127. 耒 [lei3] (plow); 128. 耳 [er3] (ear); 129. 聿 [yu4] (brush); 130. 肉 [rou4] (meat); 131. 臣 [chen2] (minister); 132. 自 [zi4] (self); 133. 至 [zhi4] (arrive); 134. 臼 [jiu4] (mortar); 135. 舌 [she2] (tongue); 136. 舛 [chuan3] (oppose); 137. 舟 [zhou1] (boat); 138. 艮 [gen4] (stopping); 139. 色 [se4] (color); 140. 艸 艹 [cao3] (grass); 141. 虍 [hu1] (tiger); 142. 虫 [chong2] (insect); 143. 血 [xue3] (blood); 144. 行 [xing2] (walk; enclosure); 145. 衣 衤 [yi1] (clothes); 146. 襾 覀 [ya4] (west); 147. 見 见 [jian4] (see; view); 148. 角 [jue2] (horn); 149. 言 讠 [yan2] (speech); 150. 谷 [gu3] (valley); 151. 豆 [dou4] (bean); 152. 豖 [shi3] (pig); 153. 豸 [zhi4] (badger); 154. 貝 贝 [bei4] (shell); 155. 赤 [chi4] (red); 156. 走 [zou3] (run); 157. 足 [zu2] (foot); 158. 身 [shen1] (body); 159. 車 车 [che1] (cart); 160. 辛 [xin1] (bitter); 161. 辰 [chen2] (morning); 162. 辵 辶 [chuo4] (walk); 163. 邑 阝[yi4] (city); 164. 酉 [you3] (wine); 165. 釆 [bian4] (distinguish); 166. 里 [li3] (village); 167. 金 [jin1] (gold); 168. 長 长 [chang2] (long); 169. 門 门 [men2] (gate); 170. 阜 阝[fu4] (mound); 171. 隶 [dai4] (slave); 172. 隹 [zhui1] (short tailed bird); 173. 雨 [yu3] (rain); 174. 青 [qing1] (blue); 175. 非 [fei1] (wrong); 176. 面 [mian4] (face); 177. 革 [ge2] (leather); 178. 韋 韦 [wei2] (tanned leather); 179. 韭 [jiu3] (leek); 180. 音 [yin1] (sound); 181. 頁 页 [ye4] (leaf); 182. 風 风 [feng1] (wind); 183. 飛 飞 [fei1] (fly); 184. 食 飠 饣 [shi2] (eat); 185. 首 [shou3] (head); 186. 香 [xiang1] (fragrant); 187. 馬 马 [ma3] (horse); 188. 骨 [gu3] (bone); 189. 高 [gao1] (tall); 190. 髟 [biao1] (hair); 191. 鬥 [dou4] (fight); 192. 鬯 [chang4] (sacrificial wine); 193. 鬲 [li4] (cauldron); 194. 鬼 [gui3] (ghost); 195. 魚 鱼 [yu2] (fish); 196. 鳥 鸟 [niao3] (bird); 197. 鹵 [lu3] (salt); 198. 鹿 [lu4] (deer); 199. 麥 麦 [mai4] (wheat); 200. 麻 [ma2] (hemp); 201. 黃 [huang2] (yellow); 202. 黍 [shu3] (millet); 203. 黑 [hei1] (black); 204. 黹 [zhi3] (embroidery); 205. 黽 黾 [min3] (frog); 206. 鼎 [ding3] (tripod); 207. 鼓 [gu3] (drum); 208. 鼠 鼡 [shu3] (rat); 209. 鼻 [bi2] (nose); 210. 齊 齐 [qi3] (even); 211. 齒 齿 [chi3] (tooth); 212. 龍 龙 [long2] (dragon); 213. 龜 龟 [gui1] (turtle); and 214. 龠 [yue4] (flute).

Appendix 1- Picture of the experiment room

Appendix 2- Picture of the laptop used in the study

Appendix 3- Informed Consent

Teachers College, Columbia University

INFORMED CONSENT

DESCRIPTION OF THE RESEARCH: You are invited to participate in a research study on Chinese language learning. The purpose of the research is to see if certain instructional designs are more effective in learning Chinese words (characters) for beginning learners of Chinese as a Foreign Language. You will be placed in one of the learning activity groups by experimenter's random assignment. You will not know which group you are in (except an indicating number, e.g., 1, 2, etc.) until after the completion of your study participation. You will be asked to complete a Pre-Instruction questionnaire, an immediate test, a delay test, and a Post-Instruction questionnaire in addition to a learning activity where you learn the 18 Chinese characters. The research will be conducted by the Principal Investigator, Ming-Tsan Pierre Lu, and Research Assistants Carol Lu, Yanjin Long, and Chi-Ying Wu. The research will be conducted in a classroom at Teachers College (Grace Dodge Hall 556).

RISKS AND BENEFITS: The research has the same amount of risk students will encounter during a usual classroom activity. The study therefore contains minimal risks to the participants. For example, some participants may encounter slight self-imposed performance anxiety. The likelihood should be very low since tasks required in this experiment are generally simple. Risks, if any, are not serious at all and should disappear right after completing of the experiment. The nature of this study is not merely looking at your test performance but your learning, attitude, and thoughts (opinions) about Chinese characters. Potential benefits associated with this study for participants are learning several useful Chinese characters and gaining an insight about how Chinese characters can be learned or taught through certain instructional designs. If at any time you do not feel well and do not wish to continue participating in the study, you may stop and inform us.

PAYMENTS: You will receive $15 as payment for your participation of the study. You will receive the remuneration right after the completion of the study participation.

DATA STORAGE TO PROTECT CONFIDENTIALITY: All the information gathered will be put in a locked file cabinet. Subject confidentiality will be preserved as all private or personal information (age, highest education level, languages spoken…etc) will be confidential and anonymous. Data will be kept confidential and only be used for academic and professional purposes.

TIME INVOLVEMENT: Your participation will take approximately 90 minutes to 100 minutes.

HOW WILL RESULTS BE USED: The results of the study will only be used for academic and educational purposes. Data may be used for the principal investigator's dissertation and academic conferences, and may be presented at meetings or be published in journals or articles.

Appendix 4- Participant's Rights form

Teachers College, Columbia University

PARTICIPANT'S RIGHTS

Principal Investigator: Ming-Tsan Pierre Lu

Research Title: Embodied Animations for Chinese Character Learning

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- I have read and discussed the Research Description with the researcher. I have had the opportunity to ask questions about the purposes and procedures regarding this study.
- My participation in research is voluntary. I may refuse to participate or withdraw from participation at any time without jeopardy to future medical care, employment, student status or other entitlements.
- The researcher may withdraw me from the research at his/her professional discretion.
- If, during the course of the study, significant new information that has been developed becomes available which may relate to my willingness to continue to participate, the investigator will provide this information to me.
- Any information derived from the research project that personally identifies me will not be voluntarily released or disclosed without my separate consent, except as specifically required by law.
- If at any time I have any questions regarding the research or my participation, I can contact the investigator, who will answer my questions. The investigator's email address is ML2254@columbia.edu and phone number is (212) 678-3217.
- If at any time I have comments, or concerns regarding the conduct of the research or questions about my rights as a research subject, I should contact the Teachers College, Columbia University Institutional Review Board /IRB. The phone number for the IRB is (212) 678-4105. Or, I can write to the IRB at Teachers College, Columbia University, 525 W. 120th Street, New York, NY, 10027, Box 151.
- I should receive a copy of the Research Description and this Participant's Rights document.
- If video and/or audio taping is part of this research, I ( ) consent to be audio/video taped. I ( ) do NOT consent to being video/audio taped. The written, video and/or audio taped materials will be viewed only by the principal investigator and members of the research team.
- Written, video and/or audio taped materials ( ) may be viewed in an educational setting outside the research ( ) may NOT be viewed in an educational setting outside the research.
- My signature means that I agree to participate in this study.

Participant's signature: ________________________________ Date:____/____/____

Name: ________________________________

Appendix 5- Pre-instruction Questionnaire

Pre-Instruction Questionnaire

Directions: Please answer the following questions as best as you can.

1.1. Do you know any of these foreign words? No ______ Yes ______ (Circle them)

告	舟	心	犬	下

1.2. Do you speak any Chinese? No ______ Yes ______

1.3. What do you think about Chinese words/ characters? (Circle all that apply)

Chinese characters:

a. are something I have no idea about.
b. are a meaningful and interesting writing script.
c. are just like some other foreign writing systems.
d. are not interesting.
e. are meaningless lines and dots.
f. are impossible to learn.
g. are difficult to learn.
h. can be mastered with effort.
i. are easy to learn.
j. are useful and powerful.

1.4. Do you think that you can learn Chinese characters well? (Circle one)

a. I am very confident that I can master Chinese characters.
b. I think I can learn Chinese characters.
c. I can learn well if I try hard.
d. I am not sure.
e. I don't think I can learn well.
f. There is no way that I can learn Chinese characters well.

1.5. Do you like to learn new things? (Circle one)

Yes, very much | Yes, a little | Well, it depends | No, not really | No, not at all

Thank you! Please hand this questionnaire back to one of our Research Assistants.

Appendix 6- General Instruction Sheet

General Instruction

Please take your time and read over this General Instruction: Introduction to Chinese Characters.

We are going to learn some Chinese words. They are also called characters. Chinese characters are logographs. They are notably different from alphabets such as English words.

Characters as a basic writing unit possess a number of strokes that are packed into a square shape. Therefore, each character contains one or several strokes and can be written to fit into a square.

There are three features of a Chinese character. One, a character has its meaning(s). Two, a character has its pronunciation(s). Three, a character has its unique written form and thus every character is written differently.

Ex., a Chinese character can be: (8 characters below; No need to learn them)

三	六	七	八
Meaning: **“Three”**	**“Six”**	**“Seven”**	**“Eight”**
# of strokes: **3 strokes**	**4 strokes**	**2 strokes**	**2 strokes**
Pronunciation: **[San]**	**[Liou]**	**[Chi]**	**[Ba]**

盧	明	燦	爺
Meaning: **“Black”**	**“Bright”**	**“Bright”**	**“Grandfather”**
# of strokes: **16 strokes**	**8 strokes**	**17 strokes**	**13 strokes**
Pronunciation: **[Lu]**	**[Ming]**	**[Tsan]**	**[Yeh]**

Please proceed by reading the next Instruction Page.

Appendix 7- Instruction Sheet for TL

Instruction Sheet

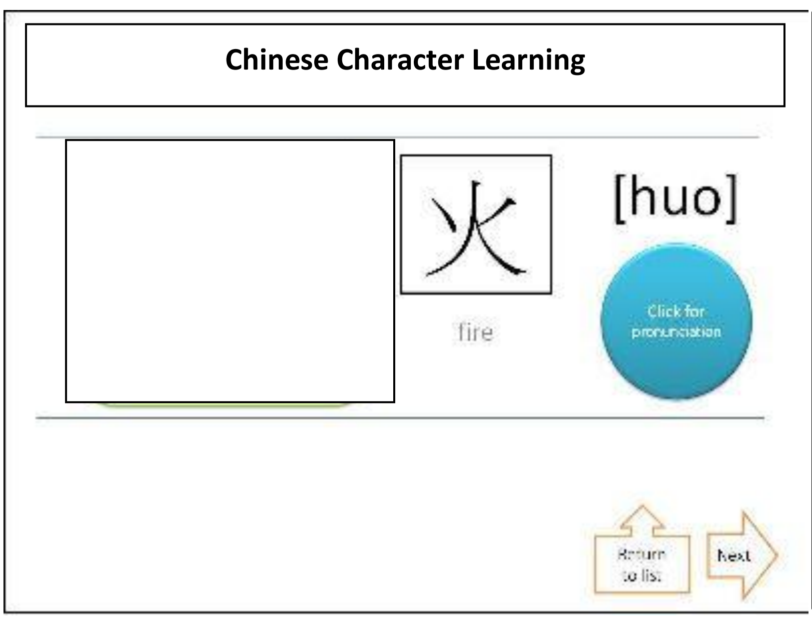
Directions: Please take your time and carefully read the following 5 points and make sure that you understand by placing a check after you have read the points (just click "Check").

1. **Please try your best to learn the following Chinese words/ characters. (Check: _____)**

2. **There will be 18 Chinese words/ characters in total. For each character, you have 2 minutes to learn (36 minutes in total). Please learn all 18 of them. (Check: _____)**

3. **There will be some tests after the learning phase. (Check: _____)**

4. **For each character, the learning page is displayed like this:**



There will be the target character in a square in the middle, its meaning underneath, and its pronunciation on the right. You may click the round button for the

pronunciation. Within the 2 minutes time for each character, you may use paper and pencil provided for your best learning if you'd like. (Check: _____)

5. **The 18 Chinese words/ characters will be shown in a table below after you click START. You may come back to this page anytime by clicking Return to List. Or you may go to the next character learning page by clicking Next. (Check: _____)**

Please proceed by clicking START. The session will be automatically timed (for 40 mins).

Appendix 8- Instruction Sheet for AL

Instruction Sheet

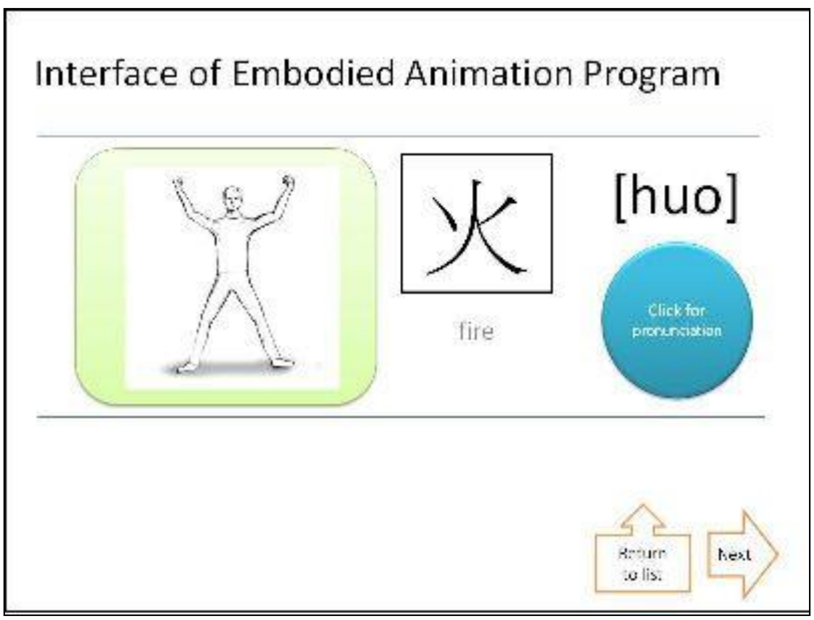
Directions: Please take your time and carefully read the following 5 points and make sure that you understand by placing a check after you have read the points (just click "Check").

1. **Please try your best to learn the following Chinese words/ characters. (Check: _____)**

2. **There will be 18 Chinese words/ characters in total. For each character, you have 2 minutes to learn (36 minutes in total). Please learn all 18 of them. (Check: _____)**

3. **There will be some tests after the learning phase. (Check: _____)**

4. **For each character, the learning page is displayed like this:**



There will be a video on the left, the target character in a square in the middle, its meaning underneath, and its pronunciation on the right. You may click the round

button for the pronunciation. Feel free to use the slide to go back (rewind) and forth (fast-forward) to watch the videos on the left of the screen. Within the 2 minutes time for each character, you may watch more than once if you'd like. (Check: _____)

5. **The 18 Chinese words/ characters will be shown in a table below after you click START. You may come back to this page anytime by clicking Return to List. Or you may go to the next character learning page by clicking Next. (Check: _____)**

Please proceed by clicking START. The session will be automatically timed (for 40 mins).

Appendix 9- Instruction Sheet for EAL

Instruction Sheet

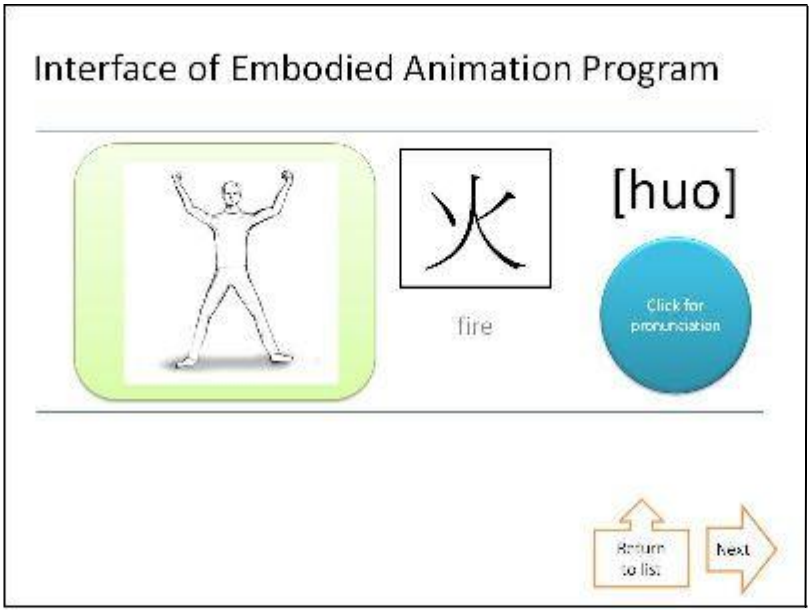
Directions: Please take your time and carefully read the following 6 points and make sure that you understand by placing a check after you have read the points (just click "Check").

1. **Please try your best to learn the following Chinese words/ characters. (Check: _____)**

2. **There will be 18 Chinese words/ characters in total. For each character, you have 2 minutes to learn (36 minutes in total). Please learn all 18 of them. (Check: _____)**

3. **There will be some tests after the learning phase. (Check: _____)**

4. **For each character, the learning page is displayed like this:**



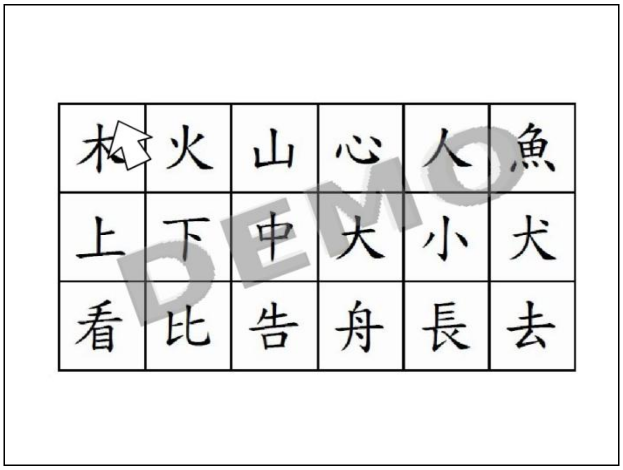
There will be a video on the left, the target character in a square in the middle, its meaning underneath, and its pronunciation on the right. You may click the round button for the pronunciation. Feel free to use the slide to go back (rewind) and

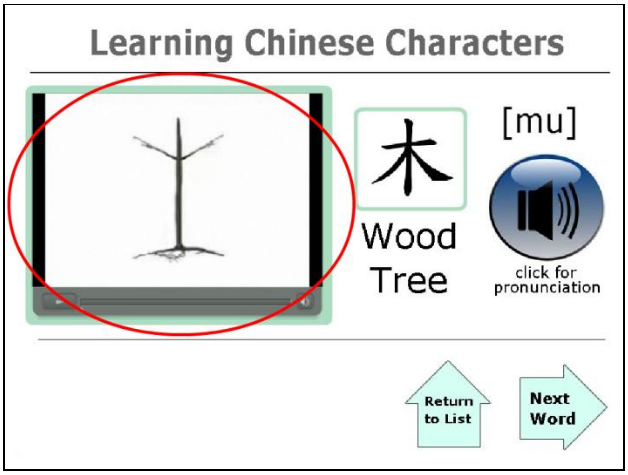
forth (fast-forward) to watch the videos on the left of the screen. Within the 2 minutes time for each character, you may watch more than once if you'd like. (Check: _____)

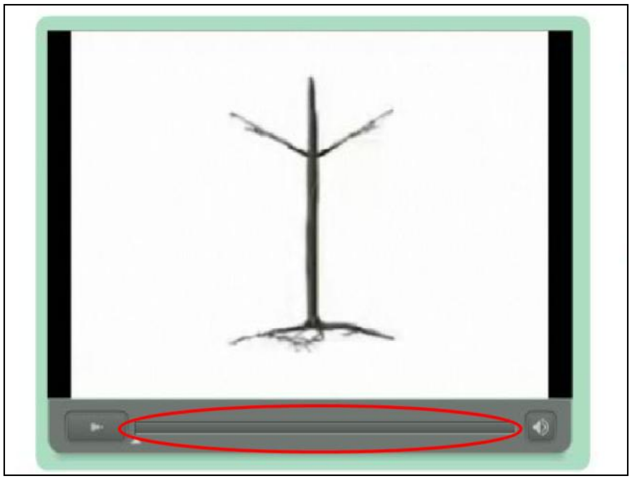
5. **When you watch the videos, please imagine doing the movements or gestures yourself. (Check: _____)**
6. **The 18 Chinese words/ characters will be shown in a table below after you click START. You may come back to this page anytime by clicking Return to List. Or you may go to the next character learning page by clicking Next. (Check: _____)**

Please proceed by clicking START. The session will be automatically timed (for 40 mins).

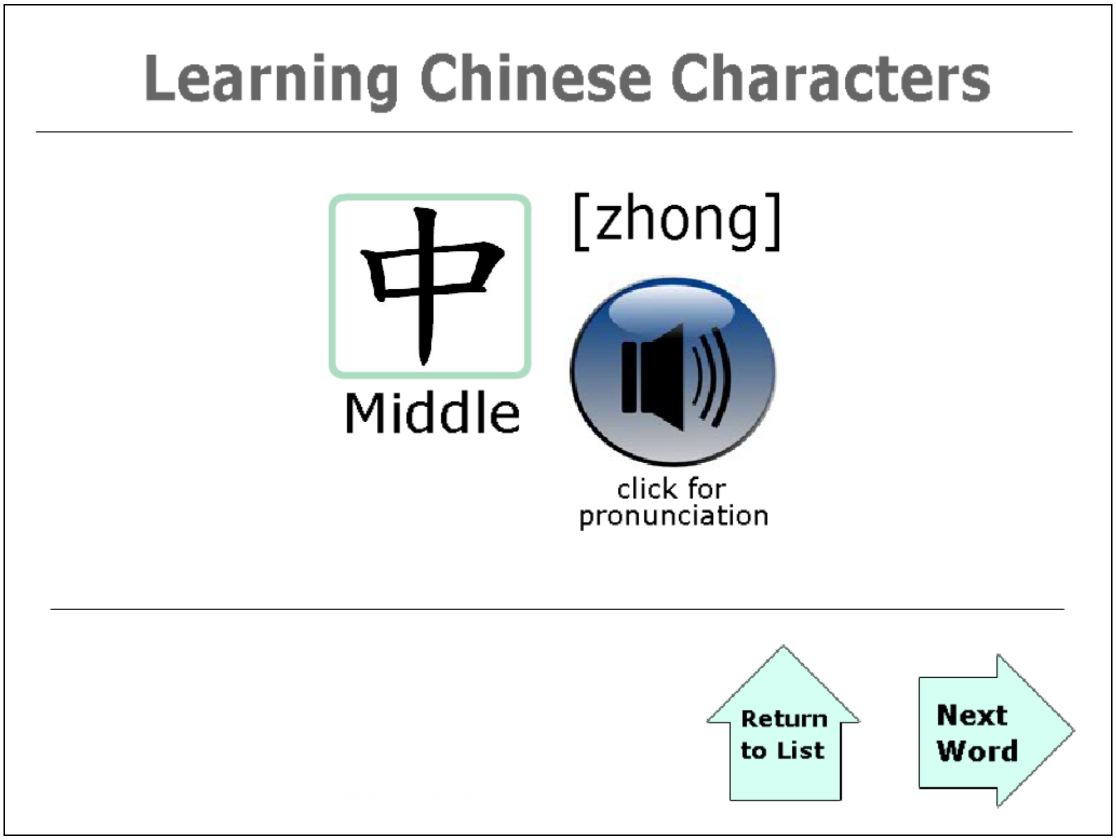
Appendix 10- Screenshots of the Video Instructions for the AL and EAL groups



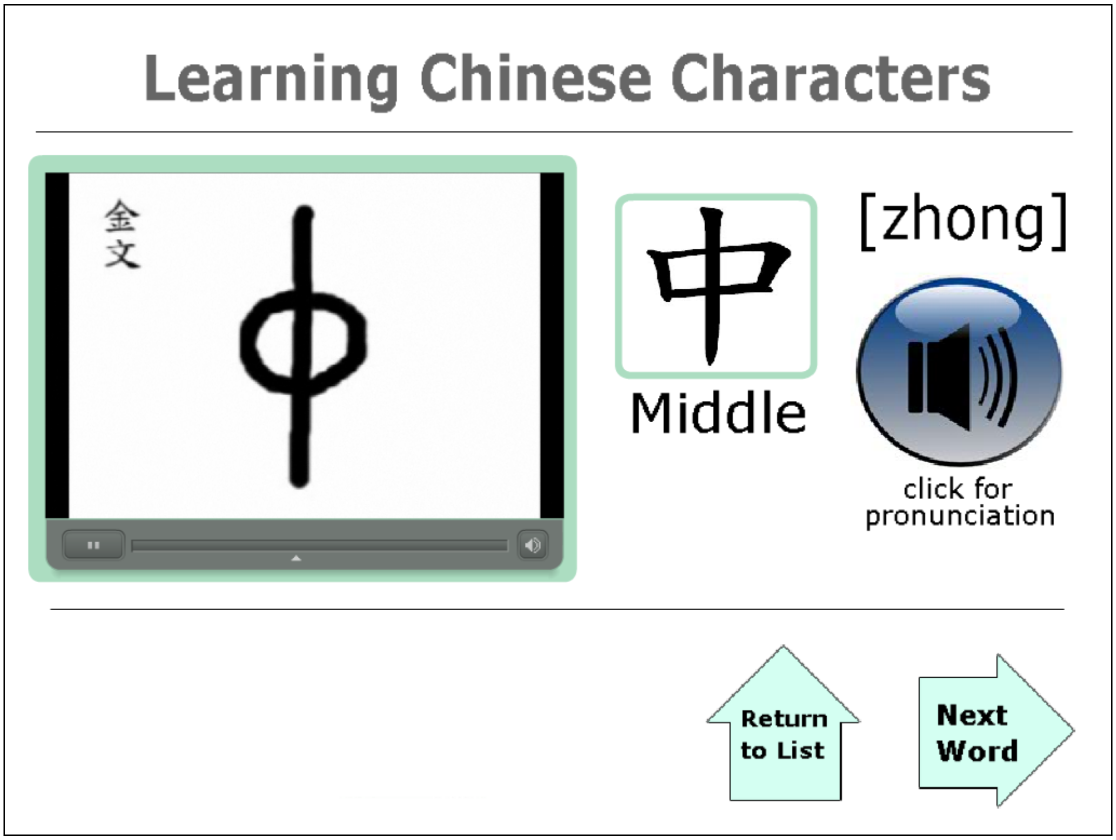




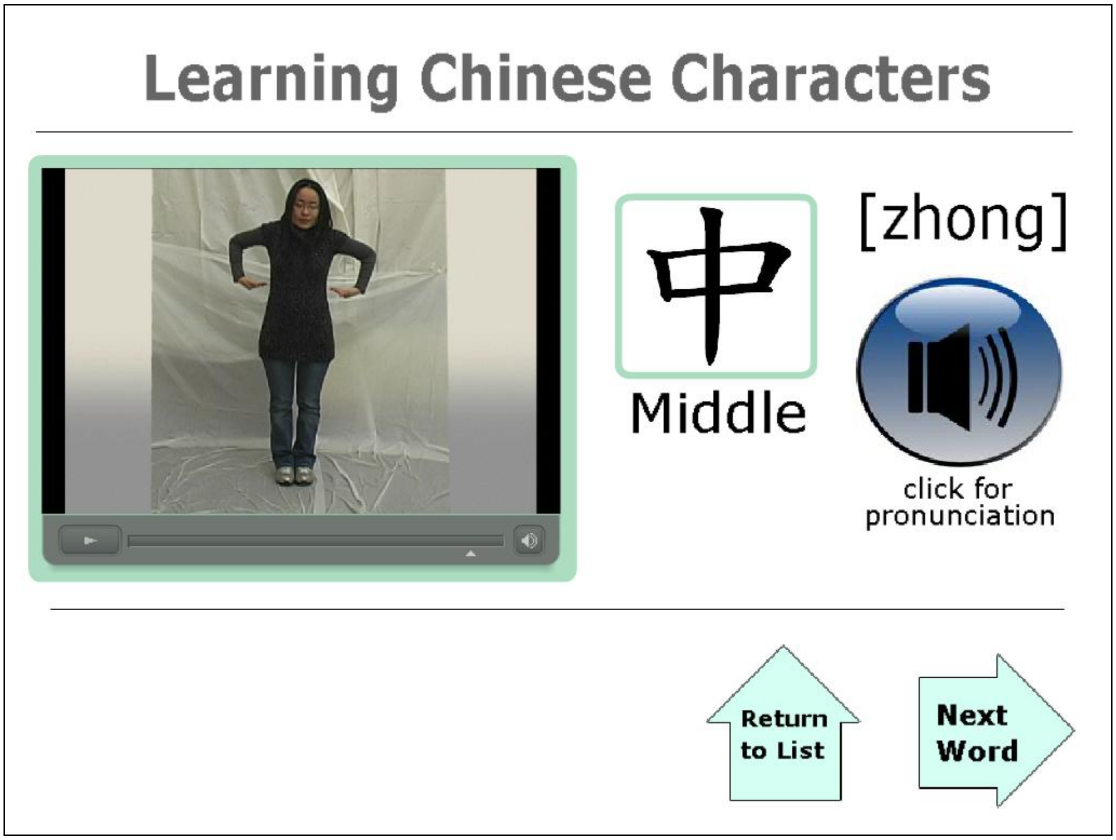
Appendix 11- Screenshots of the Chinese Character Learning Program for TL



Appendix 12- Screenshots of the Chinese Character Learning Program for AL



Appendix 13- Screenshots of the Chinese Character Learning Program for EAL



Appendix 14- The Immediate and Delay Tests

Test

Directions: Please answer the following questions as best as you can.

1.1. Which of the following Chinese character means “heart?” (Circle one)

告	舟	心	犬	下

1.2. Which of the following Chinese character means “small?” (Circle one)

魚	去	火	小	中

1.3. Which of the following Chinese character means “to compare?” (Circle one)

比	去	山	小	魚

2.1. Please write down the Chinese character “above; up.”

2.2. Please write down the Chinese character “to see; to watch; to look.”

2.3. Please write down the Chinese character “human; mankind; man.”

3.1. What is the pronunciation of the Chinese character “ 山 ?” (Circle one)

Ken	Shan	Gao	Chiu	Mu

3.2. What is the pronunciation of the Chinese character “大?” (Circle one)

Chen	Ren	Shang	Da	Huo

3.3. What is the pronunciation of the Chinese character “長?” (Circle one)

Chang	Wong	Bi	Ming	Xiao

4.1. What does this Chinese character “ 火 ” mean?

4.2. What does this Chinese character “ 中 ” mean?

4.3. What does this Chinese character “看 ” mean?

Directions: Based on the Chinese characters you have learned, please answer the following questions as best as you can. (Make best guesses!)

5.1. What may be the meaning of this character 炸 ?

5.2. What may be the meaning of this character 船?

5.3. What may be the meaning of this character 鮭?

6.1. Based on your understanding of the character “wood,” which of the following Chinese character probably means “forest?” (Circle one)

炎	串	鮪	張	林

6.2. Based on your understanding of the character “fire,” which of the following Chinese character probably means “hot/ burn?” (Circle one)

炎	串	森	尖	如

7.1. What is the Chinese character that probably means “fry/ cook”? (Circle one)

紗	砂	沙	炒	吵

7.2. What is the Chinese character that is probably a type of tree? (Circle one)

忠	張	炮	舢	杉

7.3. What is the Chinese character that is probably a type of mountain? (Circle one)

峰	沅	建	明	快

8.1. Please circle one word that does not have similar meanings with other words?

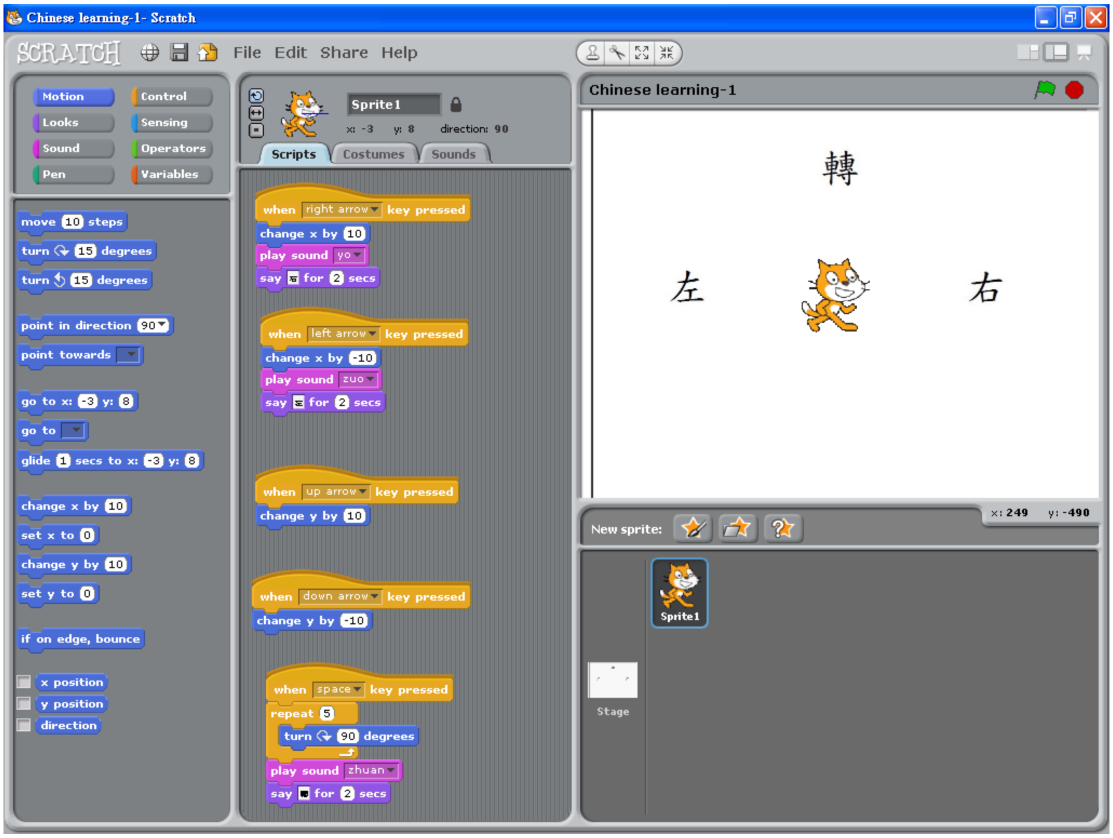
河	江	溪	吃	湖

8.2. Please circle one word that does not have similar meanings with other words?

他	你	炮	倫	佚

Thank you! Please return the test to one of our Research Assistants.

Appendix 15- Screenshot of the Scratch Game



Appendix 16- Scratch Game Interview Sheet

Scratch Break- Q

1. In the game, there are 3 Chinese characters.
   Could you write down the word “Right” below?

   Could you write down the word “Left” below?

2. Could you pronounce the word “Right” to the experimenter?

3. Could you pronounce the word “Left” to the experimenter?

4. In the game, there are 3 Chinese characters. What do you think this character may mean? 轉

5. Could you pronounce the word “轉” to the experimenter?

6. Do you think you have learned these 3 Chinese characters?

7. Do you think that you understand the programming language used here (under Script column)? (E.g., “When up-arrow key is pressed, then change y 10.”)

8. What do you think about the programming language? (E.g., difficult, easy, manageable…)

9. Do you think that you are capable of doing the programming using this software?

10. If you were a programmer/ game designer, what changes would you make to introduce these 3 Chinese characters? Why?

Appendix 17- Post-instruction Questionnaire for AL and AEL

<u>Post-Instruction Questionnaire-E</u>

Directions: Please answer the following questions as best as you can.

1.6. Do you know any of these foreign words? No _____ Yes _____ (Circle them)

木	火	山	心	人	魚
上	下	中	大	小	犬
看	比	告	舟	長	去

1.7. Do you think you have learned some Chinese? No ______ Yes ______

1.8. What do you think about Chinese characters now? (Circle all that apply)

Chinese characters:

k. are something I have no idea about.

l. are a meaningful and interesting writing script.

m. are just like some other foreign writing systems.

n. are not interesting.

o. are meaningless lines and dots.

p. are impossible to learn.

q. are difficult to learn.

r. can be mastered with effort.

s. are easy to learn.

t. are useful and powerful.

1.9. Do you think that you can learn Chinese characters well now? (Circle one)

g. I am very confident that I can master Chinese characters.
h. I think I can learn Chinese characters.
i. I can learn well if I try hard.
j. I am not sure.
k. I don't think I can learn well.
l. There is no way that I can learn Chinese characters well.

2.1. Do you play sports or exercise? No ______ Yes ______

If Yes, what kind? ________________________________

2.2. Do you watch sports? No ______ Yes ______

If Yes, what kind? ________________________________

2.3. Do you play video games? No ______ Yes ______

If Yes, what kind? ________________________________

3.1. Do you like the Chinese character instruction program?

Like Very Much | Like Little | Dislike Little | Dislike Very Much

3.2. Which part(s) of the program/ instructional design do you like?

(Circle all that apply)

Video (on the left) | Character Written Form (in the middle) | Meaning (underneath)

Pronunciation Button (on the right) | Return to List & Next Buttons (in the bottom)

Other: ____________

3.3. Do you think the Chinese character instruction program is effective?

Very Much | A Little | Not A Lot | Not At All

3.4. Does the video make Chinese characters easier to learn?

Very Much | A Little | Not A Lot | Not At All

3.5. Does the video help you in understanding and remembering the Chinese characters?

Very Much | A Little | Not A Lot | Not At All

3.6. Does the video help arouse your interest in learning Chinese?

Very Much | A Little | Not A Lot | Not At All

3.7. Does the video help maintain your motivation in character learning?

Very Much | A Little | Not A Lot | Not At All

4.1. What do you think about the tests?

Very Hard | A Little Hard | A Little Easy | Very Easy

4.2. How would you have improved the program were you an instructional designer?

5.1. What is your first [native] language(s)?

5.2. How many languages do you speak? What are they?

5.3. Gender: F | M **5.4. Age: ________** **5.5. Country of Origin: ___________**

5.6. Highest Education: ____________ **5.7. Major (s): ______________________**

5.8. What language(s) do your parents (or your primary caregiver) speak?

6.1. Please share any thoughts on Chinese language learning or extra comments.

Thank you! Please hand this questionnaire back to one of our Research Assistants.

Appendix 18- Post-instruction Questionnaire for TL

Post-Instruction Questionnaire-C

Directions: Please answer the following questions as best as you can.

1.10. Do you know any of these foreign words? No _____ Yes _____ (Circle them)

木	火	山	心	人	魚
上	下	中	大	小	犬
看	比	告	舟	長	去

1.11. Do you think you have learned some Chinese? No ______ Yes ______

1.12. What do you think about Chinese characters now? (Circle all that apply)

Chinese characters:

u. are something I have no idea about.

v. are a meaningful and interesting writing script.

w. are just like some other foreign writing systems.

x. are not interesting.

y. are meaningless lines and dots.

z. are impossible to learn.

aa. are difficult to learn.

bb. can be mastered with effort.

cc. are easy to learn.

dd. are useful and powerful.

1.13. Do you think that you can learn Chinese characters well now? (Circle one)

m. I am very confident that I can master Chinese characters.
n. I think I can learn Chinese characters.
o. I can learn well if I try hard.
p. I am not sure.
q. I don't think I can learn well.
r. There is no way that I can learn Chinese characters well.

2.1. Do you play sports or exercise? No ______ Yes ______

If Yes, what kind? ________________________________

2.2. Do you watch sports? No ______ Yes ______

If Yes, what kind? ________________________________

2.3. Do you play video games? No ______ Yes ______

If Yes, what kind? ________________________________

3.1. Do you like the Chinese character instruction program?

Like Very Much | Like Little | Dislike Little | Dislike Very Much

3.2. Which part(s) of the program/ instructional design do you like?

(Circle all that apply)

Paper & Pencil | Character Written Form (in the middle) | Meaning (underneath)

Pronunciation Button (on the right) | Return to List & Next Buttons (in the bottom)

Other: ____________

3.3. Do you think the Chinese character instruction program is effective?

Very Much | A Little | Not A Lot | Not At All

3.4. Does the program make Chinese characters easier to learn?

Very Much | A Little | Not A Lot | Not At All

3.5. Does the program help you in understanding and remembering the Chinese characters?

Very Much | A Little | Not A Lot | Not At All

3.6. Does the program help arouse your interest in learning Chinese?

Very Much | A Little | Not A Lot | Not At All

3.7. Does the program help maintain your motivation in character learning?

Very Much | A Little | Not A Lot | Not At All

4.1. What do you think about the tests?

Very Hard | A Little Hard | A Little Easy | Very Easy

4.2. How would you have improved the program were you an instructional designer?

5.1. What is your first [native] language(s)?

5.2. How many languages do you speak? What are they?

5.3. Gender: F | M 5.4. Age: ________ 5.5. Country of Origin: ________

5.6. Highest Education: __________ 5.7. Major (s): ______________________

5.8. What language(s) do your parents (or your primary caregiver) speak?

6.1. Please share any thoughts on Chinese language learning or extra comments.

Thank you! Please hand this questionnaire back to one of our Research Assistants.

Appendix 19- Pre-Instruction Questionnaire for the Main Study

Chinese Character Learning Experimentation

Number:

Pre-Instruction Questionnaire

Directions: Please answer the following questions as best as you can.

1.1. Do you know any of these foreign words? No ______ Yes ______ (Circle them)

告	舟	心	犬	下

1.2. Do you speak any Mandarin Chinese? No ______ Yes ______

1.3. Do you read or write any Chinese? No ______ Yes ______

1.4. Do you recognize any Chinese characters? No ______ Yes ______
(If yes, please write below at least 5 characters you know:
(____

1.5. Do you think that you can learn Chinese characters well? (Circle one)

a. I am very confident that I can master Chinese characters.
b. I think I can learn Chinese characters well.
c. I guess I can learn well if I try.
d. I am not sure.
e. I don't think I can learn well.
f. There is no way that I can learn Chinese characters well.

1.6. How much do you agree or disagree with these statements?

From 1 to 10, please rate your level of agreement. (1 = lowest; 10 = highest)

“I am confident that I can learn Chinese characters well.” _________
“I am a good learner. I can learn things fast.” _________
“I think Chinese language is difficult.” _________

1.7. Do you like to learn new things? (Circle one)
Yes, very much | Yes, somewhat | Well, it depends | No, not really | No, not at all

---

Thank you! Please hand this questionnaire back to one of our Research Assistants.

Appendix 20- Free Recall Test in the Main Study

Please write down all the Chinese characters that you have just learned. Remember to include all three features of the characters (i.e., written form, meaning, and pronunciation)

Written Form	Meaning	Pronunciation
-----------------	----------------	---------------

Appendix 21- A sample of the Meaning-Form Mapping Test

Please write down the written forms of the Chinese characters.

Meaning	Character
See; Look; Watch	
Compare	
Tell; Speak	
Boat; Ship	
Long; Length	
Go out; Leave	
Up; Above	
Below; Under	
Middle	

Meaning	Character
Big; Huge	
Small; Little	
Tree; Wood	
Fire	
Mountain	
Heart; Mind	
Human	
Fish	
Dog	

Thank you! Please return this sheet to one of our research assistants.

[Id-In-Pi-1]

Appendix 22- A sample of the Sound-Form mapping Test

Please write down the written forms of the Chinese characters.

Pronunciation	Character
[da4]	
[xiao3]	
[zhong1]	
[xia4]	
[shang4]	
[huo3]	
[quan3]	

[yu2]	
[ren2]	

Pronunciation	Character
[shan1]	
[xin1]	
[mu4]	
[qu4]	
[chang2]	
[zhou1]	
[gao4]	

[bi3]	
[kan4]	

Thank you! Please return this sheet to one of our research assistants.

[In-Pi-Id-4]

Appendix 23- A sample of the Form-Meaning-and-Sound Mapping Test

Please write down the characters' meaning and pronunciation.

Character	Meaning	Pronunciation
去		
長		
舟		
告		
比		
看		
小		
大		
中		

Character	Meaning	Pronunciation
下		
上		
木		
火		
山		
心		
人		
犬		
魚		

Thank you! Please return this sheet to one of our research assistants.

[Id-In-Pi-1]

Appendix 24- Post-Instruction Questionnaire (for the OAL, HAL, and EAL groups) in the Main Study

Number:

Post-Instruction Questionnaire-E

Directions: Please answer the following questions as best as you can.

1.14. Do you know any of these foreign words? No _____ Yes _____ (Circle them)

木	火	山	心	人	魚
上	下	中	大	小	犬
看	比	告	舟	長	去

1.15. Do you think you have learned some Chinese? No ______ Yes ______

1.16. Do you think that you can learn Chinese characters well now? (Circle one)

s. I am very confident that I can master Chinese characters.
t. I think I can learn Chinese characters well.
u. I guess I can learn well if I try.
v. I am not sure.
w. I don't think I can learn well.
x. There is no way that I can learn Chinese characters well.

1.17. How much do you agree or disagree with these statements now?
From 1 to 10, please rate your level of agreement. (1 = lowest; 10 = highest)

"I am confident that I can learn Chinese characters well." _________

"I am a good learner. I can learn things fast." _________

"I think Chinese language is difficult." _________

1.18. Did you imagine doing the actions/ movements/ gestures yourself as you watched the videos? (Circle one)

Yes, a lot | Yes, a little | No, not really | No, not at all

2.1. Do you like the Chinese character learning program?

Like Very Much | Like Little | Dislike Little | Dislike Very Much

2.2. Which part(s) of the program do you like? (Circle all that apply)

Video (on the left) | Character Written Form (in the middle) | Meaning (underneath)

Pronunciation Button (on the right) | Return to List & Next Buttons (in the bottom)

Other: ____________

2.3. How much do you agree or disagree with the following statements?
From 1 to 10, please rate your level of agreement. (1 = lowest; 10 = highest)

“I like the Chinese character learning program.” __________

“I enjoyed learning Chinese characters.” __________

“The Chinese character learning program is effective.” __________

“The videos make Chinese characters easier to learn.” __________

“The videos help me understand and remember Chinese characters.” __________

“The videos help arouse my interest in learning Chinese.” __________

“The videos help maintain my motivation in Chinese character learning.”_________

“I would love to learn more Chinese using the program.” __________

“If the program were for sale, I would buy it.” __________

3.1. How much time do you think you need to learn 1 Chinese character?

3.2. How much time do you think you need to learn all 18 of the characters?

3.3. From 1 to 10, how difficult is this character to you? How much effort is needed? Why? (1 = lowest; 10 = highest)

	Level of difficulty	**Efforts needed**	**Why?**
木			

火			
山			
心			
人			
魚			
上			
下			
中			
大			
小			
犬			
看			
比			
告			
舟			
長			

去			

3.4. Which feature of a character do you think you need to spend most time on?

Character Written Form ______ | Meaning ______ | Pronunciation ______

3.5. How much effort do you think you need to put in to each of the features? From 1 to 10, please rate your level of efforts. (1 = lowest; 10 = highest)

Character Written Form ________

Meaning ________

Pronunciation ________

4.1. From 1 to 10, what do you think about the tests? (1 = easy; 10 = hard) ______

4.2. If you were given 10 more minutes to learn these characters, what would you have done differently?

4.3. How would you have improved the program were you an instructional designer?

5.1. What is your first [native] language(s)?

5.2. How many languages do you speak? What are they?

5.3. Gender: F | M 5.4. Age: ________ 5.5. Country of Origin: ____________

5.6. Highest Education: _____________ 5.7. Major (s): ________________________

5.8. What language(s) do your parents (or your primary caregiver) speak?

6.1. Which part(s) of the character learning program did you spend most time?

(Rank from 1 to 5; 1 = least time; 5 = most time)

Video ______ | Character Written Form ______ | Meaning ______

Pronunciation ______ | Return to List & Next Buttons ______

6.2. How did you learn the characters in the given time period?

7.1. What do you think about the Chinese character learning program and your Chinese character learning experience just then?

7.2. Please share any thoughts on Chinese language learning or extra comments.

Thank you! Please hand this questionnaire back to one of our Research Assistants.

Appendix 25- Open-Ended Question

Why do you remember those characters that you remember?   And why do you forget those characters that you forget?

Appendix 26- After One Week Free Recall Test for the Main Study

Please write down all the Chinese characters that you have learned last week.
Remember to include all three features of the characters (i.e., written form, meaning, and pronunciation)

Written Form	Meaning	Pronunciation
-----------------	----------------	---------------