Effects of Character Illustration Modalities on the Learning of Chinese Vocabulary

Zhengbin Lu
Spelman College
350 Spelman Lane S.W., Atlanta
Georgia USA 30314

Abstract

Chinese characters are the script for the Chinese written language. They are pictographic, and unlike the English script, they cannot be spelt out in letters. Stroke is the basic component of a Chinese character, just like a letter to an alphabetic word. The construction of a character requires adding one stroke to another, following a certain sequence called stroke order. In both print and digital formats, character construction processes can be illustrated with different stroke display modalities. Character illustrations are widely used for the purpose of helping learners learn stroke orders; they can also serve as visual aids for learner to memorize character vocabulary. Yet, there has been a lack of experimental studies to identify the effects of character illustration on the learning of character vocabulary. This groundbreaking experimental study examined the effects of three character-illustration modalities on Chinese as a foreign language learners' learning of Chinese character words.

Key words: Chinese as a foreign language Chinese characters digital technology character illustration modality

1. Introduction

The Chinese language belongs to the Tibetan language system. Mandarin Chinese is the official language in mainland China, Taiwan, and some other Chinese Diaspora areas, and Chinese characters are commonly used as the written script. Chinese character, also known as *hànzì*(汉字), is often described as logographic. Because each Chinese character represents a morpheme as well as a syllable, it is also described as morph syllabic. Unlike words in alphabetical languages such as English and Spanish, Chinese characters cannot be spelled out with alphabets. Besides, the spoken form and the written form of the characters are not phonetically related (Tzeng& Hung, 1988).

Chinese is considered one of the most challenging languages to learn by non-native learners (Liskin-Gasparro, 1982). The Foreign Service Institute (2015) of the State Department has ranked over 60 foreign languages into five categories with "Category I" as the least difficult and "Category V" the most difficult languages for native English speakers to learn. Mandarin Chinese was ranked as one of the Category V --"exceptionally difficult" languages for native English speakers. According to the recommendation by FSI, Chinese learners need to spend three fold of time in their study to reach the same level of proficiency than they learn Spanish. Learning characters is considered one of the major obstacles for Chinese as foreign language (CFL) learners. This is mainly because of the complexity of the graphic configuration of Chinese characters and that Chinese, as a logographic script, lacks obvious sound-script correspondence (Shen, 2004).

Knowledge of character vocabulary is essential for CFL learners for two reasons: one, characters are Chinese written scripts and all Chinese texts are in characters; two, the characters cannot be replaced by the Romanized phonetic symbols--Chinese *pinyin*--because the spoken Chinese is highly homophonic. One spoken word in Romanization (*pinyin*) form usually corresponds to several characters and each character means differently. Nevertheless, in this digital age, as typing has become a norm, knowledge of character vocabulary no longer requires CFL learners to be able to handwrite characters. At the same time, more and more Chinese textbooks and other instructional materials have turned digital. As Shen (2004) has pointed out, character recognition and production are the foundation of developing reading and writing competences in Chinese.

Digital technology provides great potential for CFL learners to increase efficiency in learning the language. On the one hand, typing characters can significantly reduce the time learners spend on learning writing characters; on other hand, digital technology offers more functions than print in presenting the subject matter. Take character illustration as an example, in print format, characters can only be illustrated in static modality; by contrast, in digital format, characters can be illustrated in at least three modalities: static, gradual displaying one stroke after another; gradual display each stroke and with stroke animation. These functions of digital technology have been widely applied in instructional materials. Some digital or online Chinese instructional materials use the above mentioned character illustrations to help students learn writing Chinese characters, and some use these functions as visual aids for learners to memorize Chinese character vocabulary.

1.1 Statement of the Problem

Even though digital materials have become more and more widely used in the teaching and learning Chinese as a foreign language (CFL), experimental studies on the effects in this area has not been at par with the digital material development. In terms of the effects of character illustration modalities on Chinese character vocabulary learning, there has been no experimental study in existence. So the current study will serve as an ice-breaker to arouse Chinese language practitioners' attention to this respect.

1.2 Research Questions

This study aims to address the following questions: 1. How does the Chinese character illustration modality (static vs. gradual display without stroke animations vs. gradual display with stroke animations) affect learners' achievement in the immediate and delayed Chinese character recognition tests? 2) Is there any difference between students' achievement in the immediate recognition test and their achievement in the delayed recognition test? 3) Which display modality do the learners prefer to use to learn Chinese characters?

2. Literature Review

2.1 Chinese Character Learning

Word Recognition and Recall in Learning Alphabetic Languages First language (L1) reading researchers have long stressed the importance of word recognition in the reading process (Everson, 1998). It is considered as the most basic and most critical process in reading. In this process, a reader identifies a string of letters as a meaningful unit. Strong evidence indicates reading ability and work recognition ability are directly related. Furthermore, there is a strong correlation between word recognition and word recall.

Together with the advancements in technology, visual word recognition has increasingly attracted the interest of cognitive psychologists over the past two decades (Besner & Humphreys, 1991). The classical views of word recognition involve interaction of phonological and visual processing (Patterson & Coltheart, 1987). The phonology of a word can be recovered in two ways. One option is in working with an alphabetic system, the phonological script is "assembled" from translation of orthographic subcomponents of the letter string. A second option is that the word can be "addressed" phonologically as a complete string already stored in memory, without recourse to the assembly process. Often termed "visual" or "direct access", the phonology is determined by processing the complete letter string in a holistic manner (Everson, 1998). Hayes (1988) shares the similar view and he states that words are often recognized directly and holistically by their shapes. The alphabetic-phonetic intervention of the alphabetic languages such as English often provides an intervening process of letter interpretation which can be an aid for the reader.

2.2 Word Recognition and Recall Process in CFL Environment

It should be pointed out that the above mentioned basic word recognition theory has been derived primarily from the L1 environment where individuals are already fluent speakers of the language they are reading or learning to read. In the CFL environment, this basic theory may not apply for two reasons: one, the Chinese orthography does not have regular phonological representation; and two, learners in this environment usually have no or minimal spoken proficiency. The Chinese language, due to its arbitrary character-pronunciation relationship, does not provide the assistance of alphabetic-phonetic intervention as an aid in character recognition. Students who learn Chinese as a second language, contrary to native readers of Chinese, do not use a primary phonological strategy in reading characters (Hayes, 1988). DeFrancis (1984) has asserted that characters somehow magically convey meaning to our minds without the intermediary of speech.

2.3 Visual Processing in Chinese Character Learning

Visual processing is believed to be an important component in Chinese character learning (DeFrancis, 1984; Ke, 1998). This view is supported by a study investigating the encoding strategies used by non-native learners of Chinese (Hayes, 1988). In this study, participants were asked to recognize a target character in a series of isolated characters and sentence contexts in a response booklet after viewing a slide showing the target character. Phonological, graphic, and semantic distracters were randomly dispersed to be presented with the target character throughout each set of responses. The results of the study indicate that the learners used both visual and graphic strategies in encoding Chinese characters in a word context, but they relied more heavily on graphic structure to recognize previously exposed character in a sentence context.

Another study conducted by Yik (1978) examined the short-term memory of Chinese characters yielded similar results. Yik (1978) assigned 80 subjects equally to four conditions: high visual-high acoustic word pairs, low visual-high acoustic word pairs, high visual-low acoustic word pairs, and low visual-low acoustic word pairs. A vocabulary of 10 words was used for each of the four experimental conditions. The word items were hand written and sequentially presented on a screen from a slide projector adjusted to present each item separately at the rate of one item per second. The subjects were told they would be shown 20 sequences, and at the end of each five-word sequence, they were asked to write down the five words they had just seen in their correct order of sequence. The results suggested that there was a strong visual encoding effect in the recall of Chinese words. It indicated that acoustic encoding also aided the short-term memory process.

2.4 Recognition and Production of Chinese Characters

Chinese character recognition and production was examined and compared in a panel study with learners of Chinese as a second language (Ke, 1996). Forty-seven first-year Chinese language students in the U.S. participated in the study. For the recognition task, thirty selected words were presented in characters, and the subjects were asked to provide both the meaning of each of the character in English and the pronunciation of each of the stimulus words in Romanization (Pinyin) to show their recognition of the stimulus words. For the production task, subjects were presented the pinyin and English meaning of a Chinese word, and were asked to write the corresponding character from memory. Data were collected once at the ends of each of two semesters. Research results suggested that the correlations between character recognition and production for both Time 1 and Time 2 were moderate. It also revealed that students performed better in the recognition tasks than in the production tasks.

To account for the finding that students performed better in the recognition tasks than production tasks, Ke (1998) hypothesizes that “the graphic as a whole provides visual context that can lead to successful character recognition even when the reader does not have knowledge of all the character’s details. However, for character production, one must have complete knowledge of the character and then transform that knowledge into a motor skill. In other words, partial information can lead to recognition, but total mastery of the character is required for accurate production.” (p.347)

2.5 Animation and Its Effects for Learning

Computer animation is defined by Caraballo (1985) as a series of rapidly changing computer screen displays that present the illusion of movement. Animation, whether on computer, film, video, or otherwise, in not real motion, but only representation. This representation takes place when the visual system perceives motion by taking and combining discrete information into a smooth and continuous set.

According to Rieber (1990a), animation in visual displays is used for three primary instructional purposes. First, it is used as a device for gaining attention and maintaining motivation. For example, special effects can be achieved with moving symbols or characters, special screen washes, and transitions between lesson parts. Second, it is used as a means to present information in direct teaching. Animation can be used with or without text to demonstrate a concept, rule, or procedure. This is described as a “learning-by-viewing approach” (Reed, 1985). Third, animation is often used in practice strategies, ranging from highly structures to discovery approaches. In structured practice activities such as question and answer, animation can be used as feedback to student response. In more interactive programs, animated graphics can change continuously over time based on student input. A review of educational computer programs indicates animation is often used with the intent to impress than to teach. The needs of the learner and the demands of the learning task are sometimes ignored (Rieber, 1990a).

Therefore, while animation can arouse learner's interest, it can also be distracting. Rieber (1990a) stressed that "animation should be incorporated only when its attributes are congruent to the learning task (p. 79)." According to him, animation adds three attributes to traditional instruction: visualization, motion, and trajectory (the direction of the path of travel of an object). The effectiveness of animation depends on the learner's need for one or more of the attributes to successfully complete a learning task.

2.6 Advantages of Animation over Static Visuals

Animation has an advantage over static visuals when used to present concepts and rules involving directional characteristics and change over time (Rieber, 1991). The motion and trajectory of an object can be represented by verbal and visual codes. Rieber (1991) suggests that if a learning task only requires learners to visualize information, then the use of visuals would be sufficient. If the task demands that learners understand that an idea changes over time or involves directional characteristics, static visuals can only prompt learners to mentally construct motion and trajectory on their own. However, animation makes this cognitive task more concrete by providing motion and trajectory attributes directly to the learner. This reduces the processing demands in short-term memory and increases the potential for successful and accurate encoding into long-term memory.

The effects of animation on learning in CBI have been investigated in many studies. The research results revealed mixed findings (Rieber, 1990b; Lin, Dwyer, & Swain, 2006). A few studies indicate that using animation does not have a significant effect on learning (Caraballo, 1985; Reed, 1985; McCloskey & Kohl, 1983; Rieber & Hannafin, 1988). For example, McCloskey and Kohl (1983) conducted a series of studies to examine whether the presentation of animated visual displays influence students' beliefs about the behavior of moving objects. In their studies, the subjects were presented of a ball on a string in dynamic visual displays and static displays and were asked to indicate the path the ball would fall if the string broke. No significant effects were found between the two display modes. However, Kaiser, Proffitt and Anderson (1985) conducted a similar study to examine the effects of animated motion in selecting the correct natural trajectory path of a ball and they found contradictory results. They concluded that both adults and children in the dynamic visual display condition chose the correct path more often than their counterparts in the static visual display condition did.

More recent studies suggested significant positive effects of animation on learning (e.g., Rieber, 1996; Rieber& Boyce, & Assad, 1990; Baek & Layne, 1988). For example, Crooks, Verdi, and White (2005) examined the effects of fact location and feature animation on the post-test performance and en-route behavior of college students studying a computer-based reference map and text. A 3 x 2 factorial design with three levels of fact location (TC vs. TSC vs. NC) crossing two levels of display mode (animation vs. static) was used. Participants were 213 undergraduates from a large southwestern university. Six computer-based map programs consisting narrative text and map-feature animation were used for the experiment. The posttest results show that participants who viewed animated feature names recalled significantly more of the feature names than those viewed static feature names.

Different reasons have been proposed to explain why there are inconsistent results concerning the effect of animation. For example, the content materials and procedures utilized in these studies may not be comparable. Besides, it is likely that animation does not benefit learning in certain studies because it can be hard to perceive and it may be comprehended discretely.

3. Methodology

3.1 Research Design

This study employed a within-subject design created by having the all subjects viewing characters illustrated in three different modalities: the static display modality (SD), the gradual display without stroke animation modality (GD - SA), and the gradual display with stroke animation modality (GD + SA). In order to eliminate carry-over effect caused by the presentation sequence of the illustration modalities, the orders of the three display modalities were counterbalanced by adjusting the sequence of character presented. (See Table 3.1). There are two dependent variables: the Immediate Chinese Character Recognition Test Score and the Delayed Chinese Character Recognition Test Score.

3.2 Sample

The subjects were forty undergraduate students from a major southwestern University. Twenty-four of them were female (60%), and 16 were male (40%). In terms of ethnicity, twenty-eight were White, students (70%), four were Black (10%), six were Hispanic (15%), and 2 were Asian American (5%). Students' ages ranged from 18 to 28. The mean age was 20.15(*sd*= 2.34) (See table 3.3).

3.3 Materials

The experimental material was a computer-based Chinese character learning program, titled "Quick Chinese Vocabulary." This program was developed by the researcher with *Macromedia Flash Professional 8, Adobe Photoshop 7,* and *Action Script 2.0*. As an experimental program, it consisted of 15 frequently used Chinese characters (see Appendix C).All these characters are simple words, meaning each of these characters is a Chinese word by itself. These characters are low in density with the stroke numbers ranging from 2 to 5. The average stroke number of these characters was 3.6. All these characters are simple characters as well, which means each character is composed of one radical. These characters were displayed to the subjects in three illustration modalities: 1) the static display modality (SD), 2) the gradual display without stroke animation modality (GD-SA), and 3) the gradual display with stroke animation modality (GD + SA).

In order to avoid the dual coding effect (Paivio, 1986) and the potential confounding effect caused by Chinese character complexity, the characters in each group were balanced in stroke numbers and in concreteness. That is to say, each group has the same number of characters that have the same stroke numbers and same number of concrete characters and abstract characters. In addition to the character stroke illustrations, each character was also accompanied with its corresponding English translation and Romanized pronunciation (*Pinyin*).

The first interface of the program instructed subjects how to use the program for their study of the fifteen characters.(see Figure 3.1).

3.4 The Three Illustration Modalities

The Static Display Modality In this modality, all the strokes that compose the character are displayed (presented) to the subject simultaneous in different frames that is lined up horizontally. The first frame contains the first stroke, and the next frame contains the stroke that follows. The last frame contains the entire character. at one time. The next stroke is highlighted in a different color (blue) from the last stroke (black). (Figure 3.2).

The Gradual Display without Stroke Animation Modality In this modality, all the strokes that compose the character are displayed horizontally one after another in the sequence of the right stroke order. Each stroke was presented at one time, and no animated effect was added to each stroke. There is a one-second lapse between every two strokes. And after each stroke is displayed, it turns into a different color from the last stroke. According to Rieber (1991), the creation of animation requires a display of static visuals at least 15 frames per second, therefore, this gradual display should not be considered as animation.

The Gradual Display with Stroke Animation Modality differed from the *Gradual Display without Stroke Animation* modality in that while each stroke was displayed, animation effect was added to show the trajectory of that stroke. Treatment The treatments in this study included three levels of display modality The display modality was experimented as a within-subject variable.

3.5 Instruments

The measurement instruments consisted of: a) *the Demographic Survey*, b) *the Immediate Chinese Character Recognition Test,* and c) *the Delayed Chinese Character Recognition Test*. The *Demographic Survey* was used to investigate participants' general academic and language background, such as age, native language, foreign language, major study, etc. From this survey, students who had prior knowledge of oriental languages such as Chinese and Japanese were identified and data from these students were excluded from the data analysis. *The Immediate Chinese Character Recognition Test* consisted 15 items of multiple choice questions. In each question, the English translation and Chinese pronunciation (pinyin) for the target character was provided, and the subjects were asked to select the target character from a list of four Chinese characters. Among the four Chinese characters, only the target character was presented to the subjects. *The Delayed Chinese Character Recognition Test* consisted of the same questions as *the Immediate Chinese Character Recognition Test.* The only difference was that the questions in the delayed test were in a different order.

3.6 Procedures

The experiment was conducted in two university computer labs. There were twenty-four desktop computers in each lab. Prior to the experiment, all the computer-based materials for this experiment were installed on the computers. The program was turned on and the monitors were turned off before the experiment started. Ten minutes before the study started, the proctor checked in the participants and randomly assigned them to the workstations. Then, the proctor welcomed the participants and instructed them not to touch the computer and the worksheet until they were instructed to do so. The proctor then read the protocol to the participants and asked them if they had any questions about it. After that, the proctor instructed the participants to turn the monitors on and to start the studying of the characters. Each subject had 20 minutes to study the 15 characters presented by the *Fast Chinese Character* program. After that, they took the *Immediate Chinese Character Recognition Test*. This test took eight minutes. After that, the proctor thanked the subjects for their participation and reminded them to come back at the same time in a week. The same time one week later, the subjects came back to the lab to take the delayed posttest. The posttest took eight minutes. It had the same questions but in different orders.

3.7 Data Analyses

Data collected from this experiment were analyzed with SPSS for windows, version 16.0. *Independent Variables* The independent variables (IVs) were the three display modalities (static, gradual display without stroke animation, and gradual display with stroke animation), and the dependent variables were the *Immediate Chinese Character Recognition Test scores and the Delayed Chinese Character Recognition Test scores.*

3.8 Statistic Analysis

Descriptive statistics such as percentages and frequencies of demographic variables were analyzed to gather relevant information about the sample. The correlations among the dependent variables were also examined. As Tabachnick and Fidell (2000) suggested, two t-tests were conducted to test the main effects. All statistical tests were conducted with alpha level at .05.

4. Results

4.1 Results on the Immediate Recognition Test

Internal Consistency and Descriptive Statistics The internal consistency for the immediate recognition test was computed. The coefficient alpha was .83. The internal consistencies for the five Chinese characters in each of the three different display modalities were also computed. The reliability coefficients were .60, .68, and .51 respectively for static display modality (SD) subtest, gradual display without stroke animation (GD-SA) subtest, and gradual display with stroke animation (GD+SA) subtest. Table 4.1 displays the means and standard deviations of the subtests scores and total test scores in different treatment conditions.

4.2 Paired-samples t test

Following the significant Modality effect, paired-samples t tests were conducted to compare the mean scores of the three recognition scores across subsets of the Chinese characters displayed with different modalities. There were significant differences between the SD subtest scores and the GD-SA subtest scores, $t\ (40) = 2.28$, $p < .05$, and between the GD-SA subtest and the GD+SA subtest, $t\ (40) = -3.59$, $p < .001$. A review of the mean scores indicated that both the SD subtest scores (M = 3.66, SD = 1.37) and the GD+SA subtest scores (M = 3.81, SD = 1.23) were significantly higher than the GD-SA subtest scores(M = 3.44, SD = 1.51). Although the GD+SA subtest scores were slightly higher than those of the SD subtest scores, there was no significant difference between them. The results are summarized in Table 4.2.

4.2 Results on the Delayed Recognition Test

Internal Consistency and Descriptive Statistics The coefficient alpha for the internal consistency of the delayed recognition test was .86. The reliability coefficients were .62, .68, and .63 respectively for SD subtest, GD-SA subtest, and GD+SA subtest. Table 4.3 displays the means and standard deviations of the subtests scores and total test scores in different treatment conditions.

4.4 Paired-samples t test

Following the significant main effect of modality, Paired-samples t tests were conducted to compare the mean scores of the three subtests.

There were significant differences between the SD subtest scores and the GD-SA subtest scores, t (40) = 3.59, $p< .001$, and between the GD-SA subtest and the GD+SA subtest, t (40) = -5.56. $p< .001$. A review of the mean scores indicated that both the SD subtest scores (M= 3.57, SD = 1.42) and the GD+SA subtest scores (M = 3.75, SD = 1.35) were significantly higher than the GD-SA subtest scores (M = 3.20, SD = 1.56). Although the GD+SA subtest scores were slightly higher than those of the SD subtest scores, there was no significant difference between them. The results are summarized in Table 4.4.

4.5 Compare the Mean Scores of the Immediate Test and the Delayed Test

Four paired-samples *t* tests were conducted to examine if there were significant differences on the mean scores of both the subtest scores and the total scores of the immediate and the delayed recognition test. The means and standard deviations of the mean scores are presented in Table 4.5. The four pairs of mean scores included in the paired-samples *t* tests were: the immediate SD subtest score and the delayed SD subtest score (pair 1), the immediate GD-SA subtest score and the delayed GD-SA subtest score (pair 2), the immediate GD+SA subtest score and the delayed GD+SA subtest score (pair 3), the total immediate test score and the total delayed test score (pair 4). The paired-samples *t* test results are displayed in Table 4.6. The only significance was found between the immediate GD-SA subtest score and the delayed GD-SA subtest score, t (40) = 2.45, $p< .05$, the students' performance on the immediate recognition test better than that of the delayed recognition. No significance was found for other pairs of scores.

4.6 Students' Preference of the Illustration Modalities

The participants were asked to respond to three statements to assess their preference of the three illustration modalities. The first statement was "I prefer the strokes that compose a character to be presented at one time." "I prefer the strokes that compose a character to be presented one after another, without showing the motion of each stroke." "I prefer the strokes that compose a character to be presented one after another, with the motion of each stroke being shown."

Three one-sample t tests were conducted on the mean scores of the three statements. Four was chosen as the test value because it was the middle figure in the 1 to 7 Likert scale used to measure students' preference with 1 indicating "Not at all true" and 7 indicating "Very true."The means and standard deviations of the scores of the three statements are presented in Table 4.7. The sample means on these three statements were significantly different from 4. The results suggested the students did not prefer the static display modality or the gradual display without stroke animation modality. Instead, they preferred the gradual display with stroke animation modality. The test statistics are displayed in Table 4.8.

5. Discussion and Conclusion

Major Findings of the Study

Significant difference was found between the immediate gradual display without stroke animation (GA-SA) subtest score and the delayed gradual display without stroke animation (GD-SA) subtest score.

5.1 Research Question 1

Research question one examined "*How do the Chinese character illustration modalities (static vs. gradual display without stroke animations vs. gradual display with stroke animations) affect learners' achievement in the immediate and the delayed Chinese character recognition tests?*" Test results suggests that illustration modalities had a significant effect on the test scores of the immediate recognition test, F (2, 40) = 6.38, $p< .01$, partial η^2 = .08. It also has a significant effect on the test scores of the delayed recognition test, F (2, 40) = 26.28, p < .001, partial η^2 = .17.

A Paired-samples t test was conducted with the immediate and the delayed recognition test respectively to compare the mean scores of the three subtests. Test results yielded similar findings. There were significant differences between the static illustration subtest scores and the GD-SA subtest scores, and between the GD-SA subtest and the GD + SA subtest scores. A review of the mean scores indicated that both the SD subtest scores and the GD+SA subtest scores were significantly higher than the GD-SA subtest scores. Although the GD+SA subtest scores were slightly higher than those of the SD subtest scores, there was no significant difference between them. Explanations for the effect of illustration modality on students' achievement could be drawn from the cognitive load theory (Sweller, 1998), the cognitive theory of multimedia learning (Mayer, 1994, 2005), and previous literature on effects of animation in CBI.

It was hypothesized that Chinese characters illustrated with stroke animation in the GD+SA group would be better memorized and recalled than those illustrated in the static and in the gradual display without stroke animation subgroups. This assumption was based on the literature and previous research findings. Rieber (1991) pointed out that animation should aid learning if the learning task requires the visualization of a concept or a rule over time, or in a certain direction, or a combination thereof (Rieber, 1991). Animation is also believed to enhance students' attention in learning (Rieber, 1990). This hypothesis was supported by the results of this study. Students scored higher on the characters illustrated with stroke animation than on the characters illustrated without stroke animation and slightly higher than on the static characters.

Animation not only made the illustrations of the Chinese character more engaging to the students, but also facilitated the process of this cognitive task by providing motion and trajectory attributes to the learner, thus reducing the processing demands in short-term memory and increasing the successful and accurate encoding into long-term memory. This result supports the general notion that animation, when appropriately designed, aids learning. Previous research on animation in CBI has produced mixed results. Some reported significant effects for the animation treatment under certain conditions (e.g., Rieber, 1990a, 1990b, 1991; Blankenship & Dansereau, 2000; Catrambone & Seay, 2002), while others reported insignificant effects for the animation treatment (e.g., Chanlin, 2001; Koroghlanian & Klein, 2000; Lowe, 2003). The present study yielded significant main effect for animation, which was consistent with previous findings that significant effects were revealed for animation.

The result that the students achieved significantly higher on the Chinese characters in the static illustration modality than on those in the GD-SA modality was opposite to hypothesis. It was assumed that Chinese characters illustrated in the GD-SA mode would be better retained and recalled than those in the Static modality. This hypothesis was based on the assumption that Chinese characters illustrated stroke by stroke (gradual display) would help learners to understand how a Chinese character was constructed, and therefore retained better. This stroke by stroke gradual display was designed in accordance with the Interaction theory. This theory argues that modifying input makes the language more comprehensible (Gass and Mackey, 2007) and that that only the input that is noticed can become beneficial (Chapelle, 2003); therefore, the design of instructional material should contain features that enhance input through modifications such as change of the input mode.

Cognitive load theory (Sweller, 1988) could be applied to explain the reversed result. Cognitive load theory states that extraneous cognitive load occurs when the structure of information creates unnecessary cognitive load. In the GD-SA condition, each Chinese character was displayed in such a way that the strokes that compose the character were presented one after another and the whole character was displayed in the last screen. The elapse interval between two screens (strokes) was roughly 1.5 seconds. It took 4 to 16 seconds; depending on the number of strokes, the Chinese character has, for the subjects to get to see the final complete character.

This stroke by stroke gradual display might have caused an extraneous cognitive load for the subjects because they had to follow the entire display process to get to the final character. The cognitive processing of these strokes might have consumed working memory which might have been spared in the static display modality. In addition, this gradual display process also reduced students' time to interact with the Chinese character and its pronunciation and English translation. By contrast, in the static display mode, each Chinese character and the strokes that compose it were presented in entirety on one screen at one time. Therefore, the subjects were exposed to the characters in static illustration modality longer than those in the GD-SA illustration modality were. This enabled the subjects to have more time to interact with the Chinese characters.

Although the students scored higher on the characters in the GA+SA modality ($M = 3.83$, $SD = 1.22$) than on those in the static modality ($M = 3.64$, $SD = 1.37$) the difference between the mean scores of the two groups was not significant at the .05 level. This may be due to the fact that only simple Chinese characters are selected for this study. Therefore, the advantage of displaying stroke sequences with animation was not fully demonstrated. As Rieber (1991) pointed out, if the learning task only requires learners to visualize information, then the use of static visuals would be sufficient. The main task examined in this study was for students to recognize the Chinese character with its corresponding pronunciation and English translation. The static illustration may have provided sufficient information for the subjects to achieve this task. Both the GD-SA and the GD+SA illustrations may have redundant information for this task. These display modalities might have an advantage in educating students in Chinese character spatial sequences and motor skill in writing the characters.

5.2 Research Question 2

To address research question 2, "*Is there any difference between students' achievement on the immediate recognition test and their achievement on the delayed recognition test?*" Four paired-samples *t* tests were conducted to examine if there were significant differences on the mean scores of both the subtest scores and the total scores on the immediate and the delayed recognition test. The four pairs of mean scores included in the paired-samples *t* tests were: the immediate SD subtest score and the delayed SD subtest score, the immediate GD-SA subtest score and the delayed GD-SA subtest score, the immediate GD+SA subtest score and the delayed GD+SA subtest score, the total immediate test score and the total delayed test score. The only significance was found between the immediate GD-SA subtest score and the delayed GD-SA subtest score, t (133) = -5.56, p< .001. The immediate GD-SA subtest score is significantly higher than the delayed GD-SA subtest score.

The significant difference between the mean scores in the GD-SA subtest indicated that in this modality the students' learning significantly deteriorated after one week. This result indicated that the Chinese characters illustrated in the gradual display without stroke animation were not turned into the subjects' long-term memory as well as those characters in the static and gradual display with stroke animation modalities.

5.3 Research Question 3

Research Question 3, "*Which illustration modality do the learners prefer to use to learn Chinese characters?*" examined learners' preference of the three types of Chinese character illustration modalities. The results suggested that the students preferred the gradual display with stroke animation modality. This finding was consistent with the commonly shared view that animation can increase students' interest in learning (Rieber, 1990, 1991). This conclusion was also reflected in the students' performance in the recognition tests. Across all three modalities, students scored the highest on the Chinese characters illustrated with stroke animation.

5.4 Conclusion

Computer based multimedia learning has been widely integrated in learning across many disciplines. Numerous studies have been conducted on the effects of graphics, especially animated graphics, in many domains. In the field of teaching and learning Chinese language as a foreign language, although animation has been integrated in Chinese character education, research study in this respect is limited. The present study was one of the first attempts to fill the gap.

In terms of the results from the study, significant main effects were found for the modality factor. Animation was found to be helpful for students in learning Chinese characters. This finding conforms to the claim that animation has been used to fulfill one of three functions: attention-gaining, presentation, and practice (Rieber, 1990a). The pictographic feature of the Chinese written script (character), as well as the spatial sequence required in writing the character, offers great potential for the application of animation in Chinese character instruction. As Rieber (1991) has pointed out, animation would be expected to help students to visualize a dynamic process that is difficult or impossible for them to visualize on their own. It is expected that more research studies in the CFL domain would be conducted to provide theoretical and practical guidelines for technology application in Chinese language learning.

5.5 Implications

This study investigated the effects of Chinese character illustration modalities on CFL learners' memorization of character words in a computer-based setting. Findings from this seminal study have important pedagogical and practical implications for Chinese language educators, learners, researchers, instructional designers, and multimedia developers. Computer- Assisted Language Learning (CALL) has reached a stage where digital devices such as computers have become tools in language learning. Digital instructional materials need to be designed more effectively, basing on sound theories, to take advantage of the functions digital devices provide. Meanwhile, scientifically designed experimental studies are needed to test the effectiveness of the digital instructional materials. The current study serves as an ice-breaker to inspire more researchers' interest in the design and study of language materials in the digital age.

5.6 Limitations

Quantitative experimental studies in the field of language education often face obstacles that are beyond researchers' control, and therefore affect the generalizability of the research findings.

For example, digital experimental materials often times require special computer skills; subjects with desired language proficiency are hard to find in sufficient numbers, etc. This study has several limitations. First of all, the characters selected for the experiment are limited in number. Only fifteen Chinese characters are included as target characters in this study. Second, the characters selected for this study are low in density (number of strokes, mean stroke number = 3.6). And the majority of the selected characters are simple characters rather than compound characters (characters composed of two radicals). These two factors may affect the generalizability of the findings to all Chinese characters words. Third, the treatment time might not be long enough. It would be ideal if the subjects were allowed longer, time to study the characters provided to them in the study. Fourth, due to the convenient sampling, only students without any prior knowledge of the Chinese language are included in the data analyses. Studies involving participants with prior knowledge of the Chinese language would make this research more complete.

5.7 Recommendations for Future Research

Based on the above mentioned limitations, the following are recommended for future research:

1. The current study utilized program control of the computer-based instructional material. Subjects in this study did not have a choice to control the program; therefore, they were only able to view the program as it automatically advanced. This lack of user control of the computer-based instructional program poses a concern about whether learner achievement and motivation was affected. A user-control option is expected to increase the interaction between the learner and the CBI instructional material. Therefore, future research is recommended to include a user-control option in the CBI program.
2. The Chinese characters used in this study were all simple words (words composed of only one character) and low in density (mean stroke number = 3.6). Research studies on compound Chinese words (word consisting of more than one character) and/or high density Chinese characters would make the investigation more comprehensive.
3. This study involved participants who did not have any prior knowledge in either spoken or written Chinese. Similar study with students who have prior knowledge of Chinese may help answer the research questions fully. Research studies as such would also help to identify whether phonological knowledge of the Chinese language is a factor in Chinese character recognition.
4. Closely related to knowledge of the Chinese character stroke sequence is the writing of Chinese characters. Although the writing of Chinese characters was not tested in this study, a test on the effect of this program on Chinese character writing would provide additional information for interested practitioners.

References

Baek, Y. K., & Layne, B. H. (1988). Color, graphics, and animation in a computer-assisted learning tutorial lesson. *Journal of Computer-Based Instruction*, 15(4),131-135.

Besner, D., & Humphreys, G. W. (1991). Basic processes in word recognition and Identification: An overview. In D. Besner& G. W. Humphreys (Eds.), Basic Processes in reading: Visual word recognition (pp. 1-9). Hillsdale, NJ: Erlbaum.

Blankenship, J., & Dansereau, D. F. (2000). The effects of animated node-link displays On Information recall. *Journal of Experimental Education, 68(4),* 293-398.

Caraballo, A. (1985). *An experimental study to investigate the effects of computer animation on the understanding and retention of selected levels of learning outcomes*. Unpublished doctoral dissertation, The Pennsylvania State University

Catrambone, R., & Seay, A. F. (2002). Using animation to help students learn computer Algorithms. *Human Factors, 44(3*), 495-511.

Chanlin, L. J. (2001). Formats and prior knowledge on learning in a computer-based lesson. *Journal of Computer Assisted Learning*, 17(4), 409-419.

Chapelle, C. A. (2003). *English language learning and technology: Lectures on applied linguistics information and communication technology*. Amsterdam: John Benjamins.

Crooks, S. M., Verdi, M. P., & White, D. R. (2005). Effects of contiguity and feature animation in computer-based geography instruction. *Journal of Educational Technology Systems*, 33(3), 259-281.

DeFrancis, J. (1984). The Chinese language: Fact and fantasy. Honolulu: University of Hawaii Press.

Everson, M. E. (1998). Word recognition among learners of Chinese as a foreign language: Investigating the relationship between naming and knowing. *The Modern Language Journal*, 82(2), 194-204.

Foreign Service Institute (2015), tracked September 8, 2015 online: http://www.atlasandboots.com/foreign-service-institute-language-difficulty/.

Gass, S. M. & Mackey, A. (2007). Input, interaction, and output in second language acquisition. In VanPatten & Williams (Ed.). *Theories in Second Language Acquisition*. London: Lawrence Erlbaum Associates, Inc.

Hayes, E. B. (1988). Encoding strategies used by native and non-native readers of Chinese Mandarin. *The Modern Language Journal*, 72(2), 188-195.

Hayes, E. B. (1990). The relationship between Chinese character complexity andcharacter recognition. *Journal of Chinese Language Teachers Association*, 12(2),45-57.

Kaiser, M., Proffitt, D., & Anderson, K. (1985). Judgments of natural and anomalous trajectories in the presence and absence of motion. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 11, 795-803.

Ke, C. (1996). An empirical study on the relationship between Chinese character recognition and production. *The Modern Language Journal*, *3*, 340-350.

Ke, C. (1998). Effects of strategies on the learning of Chinese characters among foreign language students. *Journal of the Chinese Language Teachers Association*, 33,93-112.

Lin, H., Dwyer, F., & Swain, J. (2006). The effect of varied cognitive strategies used to complement animated instruction in facilitating achievement of higher order

learning objectives. *International Journal of Teaching and Learning in Higher Education*, 18(3), 155-167.

Liskin-Gasparro, J. (1982). ETS Oral Proficiency Testing Manual. Educational Testing Service, Princeton, NJ.

Lowe, R. K. (2003). Animation and learning: Selective processing of information in Dynamic Graphics. *Learning and Instruction, 13(2)*, 157-176.

Mayer, R. E. (2005). *The Cambridge Handbook of Multimedia Learning*. Cambridge University Press.

McCloskey, M. & Kohl, D. (1983). Naïve physics: the curvilinear impetus principle and Its role in interactions with moving objects. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 9, 146-156.

Patterson, K., & Coltheart, V. (1987). Phonological processes in reading: A tutorialre view. In M. Coltheart (Ed.), Attention and performance XII: The psychology of reading (pp. 421-427). Hillsdale, NJ: Erlbaum.

Reed, S. K. (1985). Effects of computer graphics on improving estimates to algebra word problems. *Journal of Educational Psychology*. *77(3)*, 285-298.

Rieber, L. P., & Hannafin, M. J. (1988). Effects of textual and animated orienting Activities and practice on learning from computer-based instruction. *Computersin the School*, *5*, 77-89.

Rieber, L. P. (1990a). Animation in computer-based instruction. *Educational Technology Research & Development*, *38*, 77-86.

Rieber, L. P. (1990b). Using computer animated graphics in science instruction with children. *Journal of Educational Psychology*, *82(1)*, 135-140.

Rieber, L. P. (1991). Animation, incidental learning, and continuing motivation. *Journal Of Educational Psychology, 83(3)*, 318-328.

Shen, H. H. (2004). An investigation of Chinese character learning strategies among on-native speakers of Chinese. *System*, 33, 49-68.

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science, 12(2)*, 257-258.

Tzeng, O. J. L. & Hung, D. L. (1988). Cerebral organization clues from scriptal effectson lateralization. In I. M. Liu, H. C. Chen & M. J. Chen (Eds.), *Cognitive aspects of the Chinese language, vol. 1.* Hong Kong: Asian Research Service, 119-139.

Yik, W. F. (1978). The effect of visual and acoustic similarity on short-term memory for Chinese word. *Quarterly Journal of Experimental Psychology*, 30, 487-494.

Tables and Figures

Table 3.1 Display Sequences of the Selected Characters

1	Static, GD - SA, GD + SA
2	Static, GA + SA, GA - SA
3	GD - SA, Static, GA + SA
4	GD - SA, GD + SA, Static
5	GD + SA, Static, GD - SA
6	GD + SA , GD - SA, Static

Static: Static Display
GA – SA: gradual display without stroke animation
GA + SA: gradual display with stroke animation

Table 3.2: Participants Demographic Statistics

Participants	(*n* = 40)
Gender	
Male	16
Female	24
Missing	0
Ethnicity	
White	28
Black	4
Hispanic	6
Asian	
American	2
Missing	0

Table 3.3: Means and Standard Deviations of Participants' Age

Participants	(*n* = 40)
Age	
Mean	20.55
SD	2.17

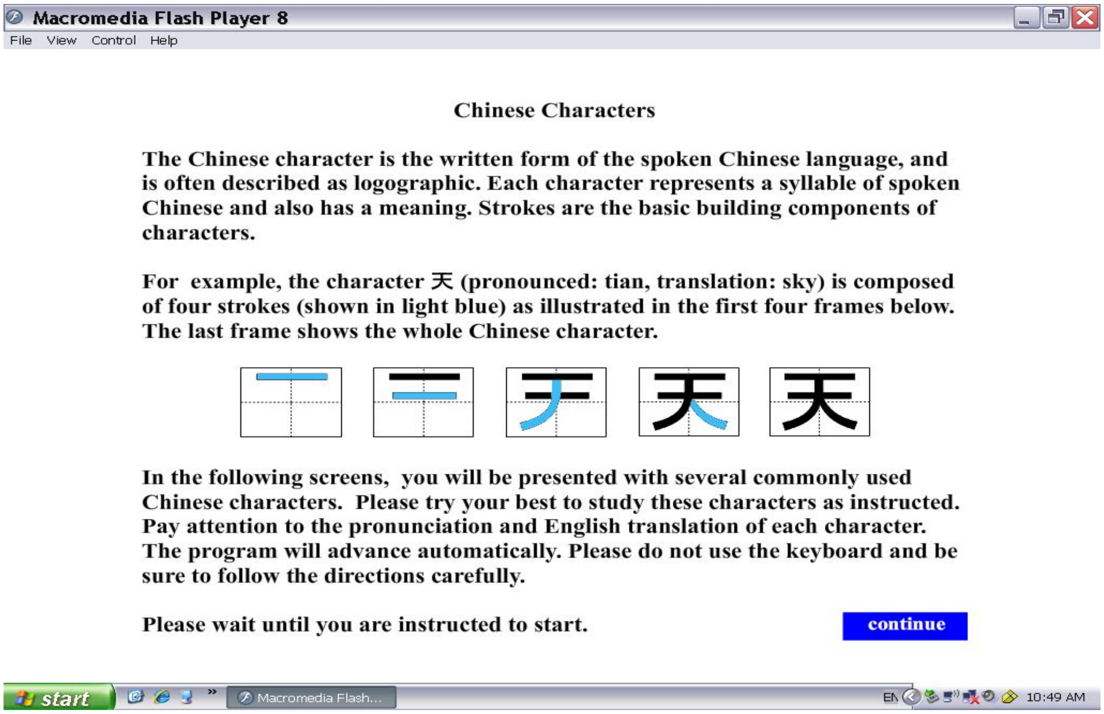

Figure 3.1 Screenshot of the "Introduction to Chinese character" page

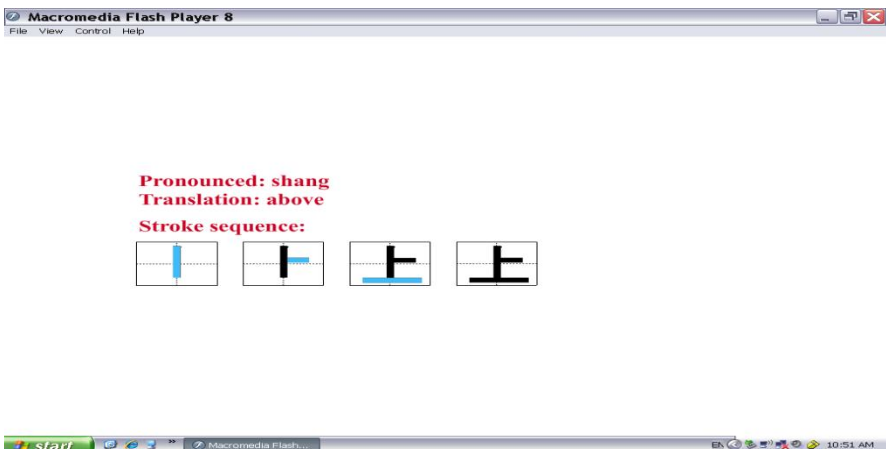

Figure 3.2 Screenshot of the *Static Display* mode

Table 4.1: Descriptive statistics of the immediate recognition test scores (n = 40)

	Illustration Modality			
	SD	GD-SA	GD+SA	TOTAL
Mean	4.08	4.20	4.30	12.58
sd	0.92	1.11	0.85	2.31

SD: Static Display
GD-SA: Gradual Display without Stroke Animation
GD+SA: Gradual Display with Stroke Animation

Table 4.2: Paired-samples T Test Results for the subtests of the Immediate Recognition Test

Pairs	Paired Differences M	SD	t	df	*p*
SD[1] and GD-SA[2]	.22	1.15	2.28	148	.02*
GD-SA and GD+SA[3]	-.36	1.23	-3.59	148	.00**
SD and GD+SA	-.15	1.06	-1.70	148	.09

*p < .05, **p < .001
1: Static Display
2: Gradual Display without Stroke Animation
3: Gradual Display with Stroke Animation

Table 4.3: Descriptive statistics of the Delayed Recognition Test (n=40)

	Illustration Modality SD	GD-SA	GD+SA	TOTAL
(n=40)				
Mean	3.97	3.66	4.13	11.76
SD	1.26	1.28	1.14	3.19

SD: Static Display
GD-SA: Gradual Display without Stroke Animation
GD+SA: Gradual Display with Stroke Animation

Table 4.4: Paired-samples T Test Results for the subtests of the Delayed Recognition Test

Pairs	Paired Differences M	SD	t	df	*p*
SD[1] and GD-SA[2]	.38	1.22	3.60	40	.000**
GD-SA and GD+SA[3]	-.55	1.14	-5.56	40	.000**
SD and GD+SA	-.16	1.02	-1.86	40	.065

*p < .05, **p < .001
1: Static Display
2: Gradual Display without Stroke Animation
3: Gradual Display with Stroke Animation

Table 4.5: Means and Standard Deviations of the Subtest Scores and the Total Scores on the Immediate and the Delayed Recognition Test (n = 40)

	Mean	SD
Immediate Test		
SD	3.64	1.37
GD-SA	3.47	1.50
GD+SA	3.83	1.22
Total Score	11	3.54
Delayed Test		
SD	3.59	1.39
GD-SA	3.21	1.56
GD+SA	3.78	1.31
Total Score	10.62	3.81

SD: Static Display
GD-SA: Gradual Display without Stroke Animation
GD+SA: Gradual Display with Stroke Animation

Table 4.6: Paired-samples T Test Results for of the Subtest Scores and the Total Scores on the Immediate and the Delayed Recognition Test

	Paired Differences				
Pairs	M	SD	t	df	*p*
Pair 1	.05	1.06	.57	40	.57
Pair 2	.26	1.23	2.45	40	.02*
Pair 3	.05	1.16	.45	40	.67
Pair 4	.38	2.36	1.87	40	.06

**$p < .001$

Table 4.7: Means and Standard Deviations of the Participants' Scores on the Statements to Measure Their Preference of the Display Modalities (n = 136)

	SD	GD-SA	GD+SA
Mean	3.34	3.53	4.99
SD	1.91	1.95	1.94

SD: Static Display
GD-SA: Gradual Display without Stroke Animation
GD+SA: Gradual Display with Stroke Animation

Table 4.8: One-sample T Tests Results for the Participants' Scores on the Statements to Measure Their Preference of the Display Modalities (n = 40)

	df	t	mean difference	*p*	effect size
SD[1]	40	-4.03	-.66	.000**	.35
GD-SA[2]	40	-2.81	-.47	.006*	.21
GD+SA[3]	40	5.97	.99	.000**	.51

**p* < .01, ***p* < .001

1: Static Display
2: Gradual Display without Stroke Animation
3: Gradual Display with Stroke Animation

Appendix

Appendix 1: Chinese Characters Used in this Study

Stroke Number	Display Mode		
	Static	GD – SA	GD + SA
2	人, people; ren	入, enter; ru	八, eight; ba
3	上, above; shang	大, big; da	下, below; xia
4	木, wood; mu	水, water; shui	云, cloud; yun
4	日, day; ri	月, month; yue	中, middle; zhong
5	右, right; you	玉， jade; yu	左, left; zuo
Average: 3.6			

Appendix 2: The Immediate Chinese Character Recognition Test

Instruction: Please circle the Chinese character that corresponds to the English translation.

1. Above 止 土 上 正
2. Jade 丰 玉 巨 主
3. Below 寸 卞 干 下
4. Day 旦 日 星 明
5. Water 水 永 朱 公
6. Cloud 去 云 失 运
7. Wood 林 本 木 术
8. Enter 欠 入 义 厂
9. Eight 千 分 八 六
10. Right 古 右 吊 苦
11. Month 月 用 早 朋
12. Left 生 佐 左 差
13. People 光 人 又 认
14. Big 犬 天 大 龙
15. Middle 吕 中 申 冲

Appendix 3: The Delayed Chinese Character Recognition Test

Instruction: Please circle the Chinese character that corresponds to the English translation.

1. Jade 丰 玉 巨 主
2. Water 水 永 朱 公
3. Wood 林 本 木 术
4. Middle 吕 中 申 冲
5. Below 寸 卞 干 下
6. Month 月 用 早 朋
7. Enter 欠 入 义 厂
8. Cloud 去 云 失 运
9. People 光 人 又 认
10. Eight 千 分 八 六
11. Left 生 佐 左 差
12. Big 犬 天 大 龙
13. Above 止 土 上 正
14. Right 古 右 吊 苦
15. Day 旦 日 星 明