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The effect of computer-based multimedia instruction with Chinese character recognition

Hui-Ya Chuang and Heng-Yu Ku*

Educational Technology, University of Northern Colorado, Greeley, CO, USA

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The purpose of this study was to examine second language learners' learning achievement and attitudes toward two different types of dual coding designs (text group: image plus on-screen text versus narration group: image plus narration) in Chinese character acquisition. A total of 66 college students who did not have prior knowledge of the Chinese language were randomly assigned to either the text group or narration group. The findings showed that there was no interaction between the treatments (text group versus narration group) and test occasions (immediate and delayed post-tests), and there was no significant difference between two groups in the immediate post-test and in the delayed post-test. However, there was a significant difference between the test occasions. Furthermore, the results revealed that there was no significant difference between two groups in both the tutorial design factor and the cognitive load factor. Overall, participants in both groups achieved high scores in the post-tests and showed positive attitudes toward the dual coding tutorials.

Keywords: cognitive load; Chinese characters; dual coding; multimedia

Introduction

The Chinese language has become a popular option as a second language in the world. Chinese language courses are offered in both high schools and universities in the United States. The Confucius Institute, an organization from Beijing that offers Chinese courses and promotes Chinese culture, has been established in more than 40 universities in the United States. Chinese also has become an optional test subject in the SATII in the United States (College Board, 2009). As a result, various Chinese language instructional materials and websites have been developed in the past few years.

Multimedia is a new movement in designing Chinese instructional materials, and computer-assisted language learning has been adopted in various language learning settings. With the help of technology, an instructor can create digital flash cards, reading translations, or digital dictionaries for the purpose of self-paced language learning. One implication of computer-assisted language learning is to use software to enhance learners' motivations. Learner motivation is a key concept for creating computer-assisted language learning materials (Beatty, 2003). When students have high motivation, they are more likely to achieve a higher degree of learning.

*Corresponding author. Email: heng-yu.ku@unco.edu

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Chinese is a difficult language for English speakers to learn because the structure of Chinese characters is very different from alphabetical languages. The orthography (written system) of Chinese characters, which are comprised of strokes, is a big challenge for learners with alphabetic language backgrounds (Shen, 2004). As a result, many students who are learning Chinese as a second language often run into learning and communication difficulties during the first year of their study (Chen & Liu, 2008).

For instructors who are teaching Chinese as a second language, an important consideration is to apply effective pedagogies to facilitate students' learning. Shen (2004) indicated that the instructor-guided group was significantly better in the consideration of retention of sound and meaning of Chinese characters than the rote memorization group. Ke (1998) found two effective strategies that can be implemented in a Chinese language course. These strategies are: (1) using character components (radical and phonetic components) to remember a new character, and (2) associating a new character's graphic structure with characters they already learned. Dörnyei's (1996) expressed that instructors should make learning stimulating and enjoyable in the language classroom because people are usually willing to spend more time to think and learn with content they enjoy.

Giving that the human brain can only process a certain amount of information at one time, it is a challenge for students to recognize more Chinese characters with their limited capacity of working memory. According to the information processing theory, information is stored in the working memory first before it is transferred into long-term memory. Since working memory can only process a small amount of information at one time, instructional materials should be designed to reduce the cognitive load in working memory to enhance learning effects.

There are two theories related to the topic of reducing cognitive load. The first theory is Paivio's (1971) dual coding theory, which tries to avoid the cognitive overload by dividing learners' sensors into verbal and nonverbal systems. Paivio and Lambert (1981) commented that, "Dual coding theory is based on the assumption that memory and cognition are served by two separated symbolic systems, one specialized for dealing with verbal information and the other with nonverbal information" (p. 532). By dividing the information into two separated channels, more information can be held in short-term memory.

The second theory related to the separated channels in memory and cognition is Mayer's multimedia theory. Mayer (2001) defined multimedia presentation as presentation that uses both verbal (text) and nonverbal (image) materials. His multimedia design principle stated that students learn better when corresponding words and pictures are presented simultaneously rather than successively. When the materials occurred at the same time, learners had greater capacities to retain the mental representations of both systems in working memory and integrate the information. Mayer (2001) also pointed out, "Learners who received text and illustration or narration and animation performed better on retention tests than did learners who received text alone or narration alone" (p. 63).

There are several studies that combined the dual coding theory with language acquisition. Plass, Chun, Mayer, and Leutner (2003) found that students retained information about German vocabularies more efficiently when both visual and verbal information were presented together. Students in the dual (verbal and visual) annotation group had higher achievements in the post-test than students who only received one type annotation (verbal or visual) or no annotation. Kuo and Hooper (2004) used

computer-based instruction to determine the effect of visual and verbal coding mnemonics on learning Chinese characters. The result of their study showed that students in the dual coding group (text annotation and image) scored higher in the post-test than students in the translation group (no annotation or image, only the translation meaning of the character). In addition, Chuang and Ku's (2009) study confirmed that students who received the dual coding designed tutorials with Chinese pictographic characters had significant higher achievement in the knowledge test than students who received the single coding tutorial.

The utilization of audio annotation versus on-screen text is a debatable topic in multimedia learning theory. According to Mayer (2001), in the cognitive theory of multimedia learning, the sensor memory is divided into two channels: visual (eyes) and auditory (ears) channels. On-screen text is processed through the eyes; therefore, the multimedia presentation should use image (visual) with audio annotation (auditory) instead of on-screen text (visual). However, Paivio and Lambert's (1981) believed that verbal and nonverbal systems are interconnected yet independent. The interconnection function means the verbal systems can activate the nonverbal system, and vice versa. For instance, images can be transformed into words and words can be transformed into images. Even though Mayer (2001) indicated that multimedia presentation should use images with audio annotation instead of on-screen text alone, he also stated that "additional research is needed to clarify the nature of differences between the two channels" (p. 48).

Some studies investigated the usage of audio for Chinese language learning. Chen (2006) examined the effect between text–picture and audio–picture annotations for English as second language learners. The result of his study indicated that participants in the audio–picture annotation group did significantly better than the participants in the text–picture group in the immediate vocabulary post-test. In addition, Chung (2008) found a significant difference in the post-test results between the visual and audio groups. The results showed that participants in the audio group outperformed participants in the visual group.

Dual coding theory has a huge impact on instructional design and language acquisition. Several researchers (Arnold, 1999; Kuo & Hooper, 2004; Lai, 1997; Steffensen, Goetz, & Cheng, 1999) have investigated the learning effect between single and dual coding theory in language acquisition. In Steffensen et al.'s (1999) study, they used dual coding theory to analyze the nonverbal aspects of bilingual Chinese readers. Other researchers (Arnold, 1999; Kuo & Hooper, 2004; Lai, 1997) focused on verbal and nonverbal communication and the comparison of learning achievement in language acquisition. Even though some Chinese language instructors have applied dual coding theory to their instruction, there is still much to learn about linking learning theories with technologies toward Chinese language instruction.

According to Paivio (1986), dual coding is more likely to occur when the content is highly imaginable. Ancient Chinese people created written language by drawing pictures of objects according to their shape and forms, rather than their sound. A dual coding design would integrate well in Chinese language learning because many of the earliest Chinese characters were pictographs. Therefore, the combination of dual coding design and Chinese characters may be one way to enhance learning effects in language acquisition. In addition, Mayer's (2008) modality principle indicated that people learn better when images are combined with audio than with on-screen text. However, the contents of Mayer's studies (Mayer, 1989; Mayer & Anderson, 1991; Mayer & Moreno, 1998; Moreno & Mayer, 2002) did not address Chinese as a foreign

language instruction. As the result, more studies are needed for the implication and effect of audio annotation in Chinese character learning.

Inspired by the previously mentioned studies that compared the different types of multimedia instructions in language acquisition, the purpose of this study was to examine second language learners' learning achievement and attitudes toward two different types of dual coding designs (text group: image plus on-screen text versus narration group: image plus narration) in Chinese character acquisition. The following research questions were investigated in this study:

(1) Do participants in the narration group demonstrate higher achievement than participants in the text group in the immediate post-test?
(2) Do participants in the narration group demonstrate higher achievement than participants in the text group in the delayed post-test?
(3) Do the dual coding designed tutorials have different effects on participants' attitudes toward the tutorials?

Method

Participants

The target population was English-speaking undergraduate students (aged 18–22). The participants in this study were 66 undergraduate students who were enrolled in a university in a western state of the United States. All participants were English speakers and had no prior knowledge of the Chinese language.

Instruments

Tutorials

The tutorials used animated pictures to show the transformation of the 20 Chinese pictographic characters. The animation design was based on Mayer's (2008) three multimedia design principles: (1) the redundancy principle, which indicates people learn better from animation and narration than from animation, narration, and on-screen text; (2) the spatial contiguity principle, which suggests people learn better when corresponding elements of the animation and on-screen text are presented near rather than far from each other on the screen; and (3) the voice principle, which proposes people accept the narration as social conversation easier when the narration is spoken in a standard-accented human voice rather than a machine voice or heavy accented human voice.

The designs of the two tutorials (text group: on-screen text and image versus narration group: narration and image) were very similar. These two formats include:

(1) Text group tutorial (on-screen text and image) – each Chinese character, its English translation, and a corresponding picture were presented simultaneously. Within the tutorial, short text descriptions of each character's etymology as well as a corresponding picture were presented on the screen. The on-screen duration of each Chinese character was 15 seconds.
(2) Narration group tutorial (audio and image) – similarly to the text group, each Chinese character, its English translation, and a corresponding picture were presented simultaneously in the tutorial. However, instead of showing the

short text description, the character's etymology was presented in audio format. The narration was repeated twice for each character to ensure students have another opportunity to listen to the script. The script of the accompanying audio was the same as the text description in the text group. A female native-English speaker's voice-over was recorded for the audio narration. The duration of each Chinese character was 15 seconds.

A direction page was inserted in the beginning of both tutorials to clarify the design. The direction page explained the number of Chinese characters, stated the duration of each character, indicated that the tutorial moves automatically from character to character, pointed out if participants needed to use headsets or not (the headset is only needed for the narration group), and asked participants to press the start button when they were ready to begin. In order to make sure each student spent an equal amount of time in viewing the tutorial, no other control buttons were added to the tutorials. The comparison of text group and narration group tutorials is shown in Figure 1.

Knowledge test

Two post-tests, an immediate post-test and a delayed post-test, were designed to measure students' retention of the Chinese characters. They were both paper-based tests that contain 20 multiple-choice questions to examine students' performance in recognizing the Chinese characters. Each question contained multiple-choice answers, which included four Chinese characters with similar shapes. For example, "Which Chinese character below represents RIVER? Answer:1. 水 2. 川 3. 三 4. 彡". One point was given for a correct answer and zero was given for an incorrect answer. The score range was from zero to 20. The questions on the two knowledge tests were identical except for the order of questions was different.

Attitude survey

In order to measure students' attitudes toward the tutorial, a 16-item attitude survey was developed. The survey included 13 Likert-type questions and three open-ended questions. The 13 Likert-type survey items were measured on a 5-point Likert-type scale, ranging from 1 (strongly disagree) to 5 (strongly agree), and Cronbach's alpha reliability value was .89. Examples of attitude survey items were the following: "It was an interesting experience to learn some Chinese characters", "The descriptions of Chinese characters helped me understand the characters", "I was confident in my performance while answering the knowledge test questions", and "The Chinese characters in the tutorial were memorable for me". In addition, three open-ended questions were asked:

(1) What did you like the most about this tutorial?
(2) What did you like the least about this tutorial?
(3) Any suggestions on how to improve the tutorial?

Procedures

The first author developed two different versions of tutorials using Macromedia Flash 8.0 program and all of the images in the tutorials were purchased and downloaded

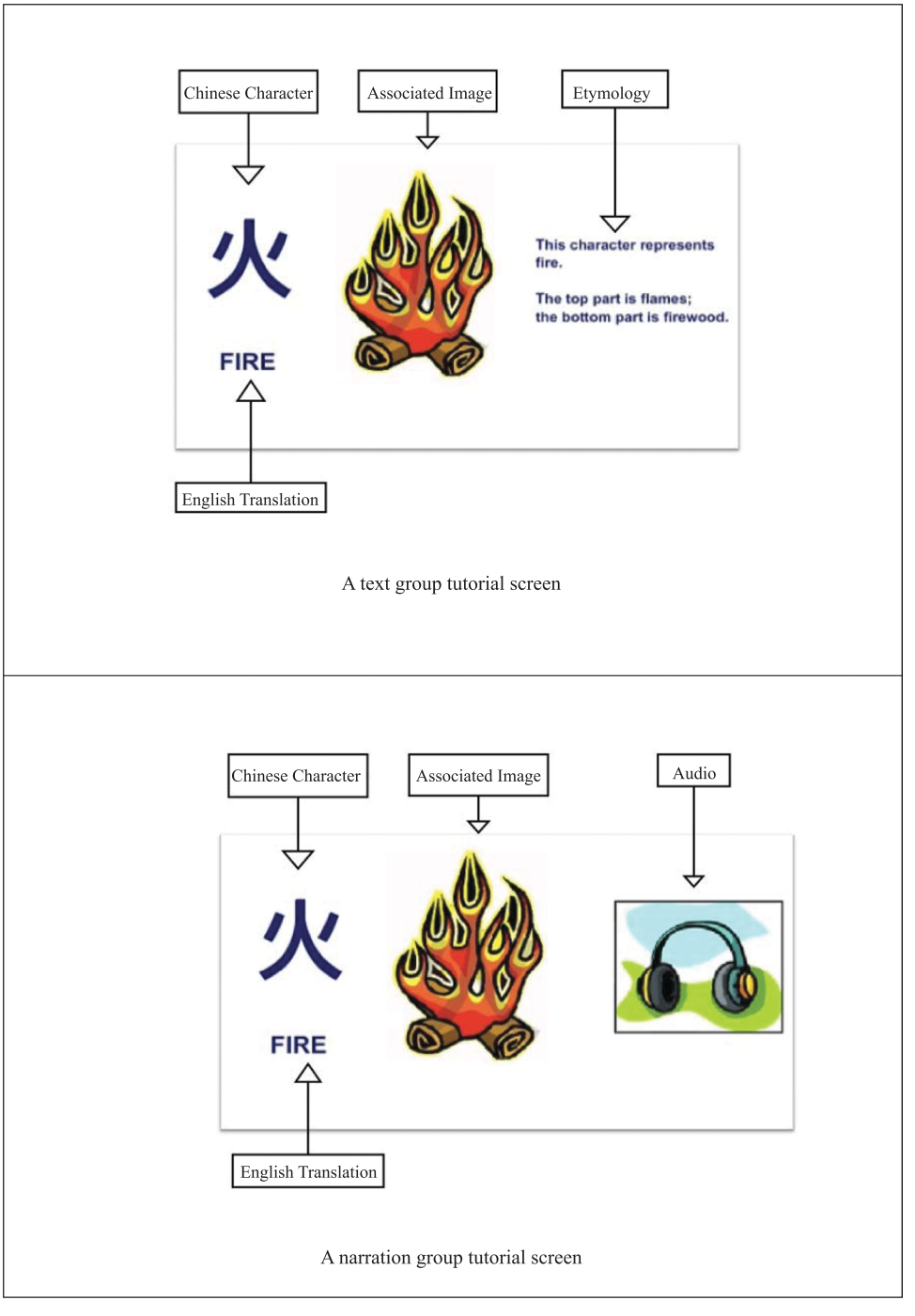

Figure 1. The comparison of text group and narration group tutorials.

from the clipart.com website. One tutorial contained images and on-screen texts (for the text group) while another tutorial contained images and narrations (for the narration group), and each tutorial included 20 Chinese characters. An instructor who teaches basic Chinese language courses reviewed the etymology and annotation of each Chinese character and verified these characters fit the entry-level Chinese language learners' needs.

The Institutional Review Board approval was obtained prior to conducting the study. Students who agreed to participate in the study signed a consent form and scheduled a meeting with the authors in the computer lab. A total of 80 sheets of paper containing the web addresses of the tutorials were prepared before participants entered the computer lab: 40 sheets of paper contained the web address of the text group tutorial and the other 40 sheets of paper contained the web address of the narration group tutorial. Participants randomly received one sheet of paper containing either the text group or narration group's tutorial web address.

On day one of the study, participants arrived in the computer lab at a scheduled time. Each computer station was equipped with a headset and participants used a computer to view the online tutorial. The procedure of the study was projected onto a screen at the front of the room and the steps were announced. These steps were:

Step 1: Log onto the computer and make sure the volume is on;
Step 2: Open the tutorial website and read the directions;
Step 3: View the tutorial and close the web browser when you finish the tutorial;
Step 4: Complete the post-test; and
Step 5: Complete the attitude survey.

We explained the procedures before participants viewed the tutorial and informed them that taking notes was not allowed while viewing the tutorial.

All participants logged onto a computer, opened the web browser, and typed in assigned tutorial's web address that they received to view the tutorial. After participants finished viewing the tutorial, they were asked to turn off the web browser. Participants then received a paper-based immediate post-test and were given five minutes to complete the test. After participants completed the immediate post-test, we collected the papers and then distributed an attitude survey. Participants were given another five minutes to complete the attitude survey. Finally, we informed participants about the location and on what date the delayed post-test would take place. After one week, participants received a paper-based delayed post-test during their regular classes and spent five minutes completing the post-test in the classroom.

Data analysis

This study was a true experimental quantitative research design, which included two types of tutorials (image plus on-screen text versus image plus narration), two post-tests (immediate and delayed), and an attitude survey for examining the different effects of dual coding designs in learning Chinese characters. The independent variable in this study was the treatment (image plus on-screen text versus image plus narration); the dependent variables were the immediate post-test, the delayed post-test, and the attitude survey.

For research questions one and two, which intended to determine any difference in learning achievement between text and narration groups in the immediate and delayed post-tests, a repeated-measured analysis of variance (ANOVA) analysis was

performed to examine the differences of the two main effects (treatments and test occasions) and the interaction of the variables. For research question three, which tried to identify participants' attitudes toward the tutorials, a pattern coefficients analysis was used to verify the factors in the 13 Likert-type questions followed by a multivariate analysis of variance (MANOVA) analysis to measure different factors. The three open-ended questions were analyzed via content analysis to understand what participants liked the most, what they liked the least, and their suggestions for improving the tutorials.

Results

Student learning achievement

A 2 (treatment)×2 (test occasion) repeated-measures ANOVA was used to measure the main effects (image-text and image-audio treatments) and test occasion (immediate and delayed post-tests). Based on the ANOVA results, there was no interaction between the treatments (text group versus narration group) and test occasions (immediate and delayed post-tests), $F(1, 64)=2.47$, $p=.12$. In addition, there was no significant difference between the treatment groups, $F(1, 64)=.46$, $p=.50$. However, there was a significant difference between the test occasions, $F(1, 64)=72.39$, $p<.001$.

Research question one examined students' performance in the immediate post-test between the text group and narration group, which students completed right after they viewed the tutorials. The original immediate post-test was scored on a 20-point scale and one point was assigned to each of the 20 test items. After running Cronbach's reliability test, the SPSS system removed question six automatically because there was no variance in this item. Therefore, the immediate post-test contained a 19-point scale and Cronbach's alpha reliability coefficient value for the immediate post-test was .66. The average scores were 16.00 (SD=2.54) for the text group and 16.03 (SD=2.57) for the narration group. There was no significant difference between these two groups, $F(1, 64)=.444$, $p=.51$.

Research question two investigated students' performance in the delayed post-test between the text group and narration group, which students completed a week after they viewed the tutorials. Since question six was removed from the immediate post-test, the same question was removed from the delayed post-test as well. Therefore, the delayed post-test had a 19-point scale and Cronbach alpha reliability coefficient value for the delayed post-test was .79. The average scores were 13.73 (SD=3.64) for the text group and 12.73 (SD=3.84) for the narration group. There was no significant difference between these two groups, $F(1, 64)=.247$, $p=.62$.

In terms of task occasions, there was a significant difference in the test occasion (between the immediate post-test and delayed post-test). Participants' average score in the immediate post-test (16.02) was significantly higher than the delayed post-test (13.23), $F(1, 64)=72.39$, $p=< .05$. The average scores and standard deviations of both immediate and delayed post-tests are shown in Table 1.

Student attitudes

The 13 Likert-type attitude survey items were analyzed by running a principal component analysis – pattern coefficients analysis. The rotation method was Varimax with Kaiser Normalization. The standard criteria used to decide how many factors seemed adequate to explain the variables were based on Cattell's scree plot, Kaiser–Gutteman

Table 1. Mean scores by treatment and test occasion.

	Immediate post-test		Delayed post-test	
Test occasion and treatment	*M*	*SD*	*M*	*SD*
Text group (*n*=33)	16.00	(2.54)	13.73	(3.64)
Narration group (*n*=33)	16.03	(2.57)	12.73	(3.84)
Overall	16.02	(2.56)	13.23	(3.74)

Note: The minimum score is zero and the maximum score is 19.

rule, percent common variance, and salient loading of ≥.32 (Reinard, 2006). The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy was an acceptable value of .81. The attitude scores for student responses to 13 Likert-type questions on the attitude survey were scored from 1, the least positive response, to 5, the most positive response.

The 13 survey items initially loaded into three components, accounting for 71% of the total variance. Six items (Questions 1, 2, 3, 8, 10, and 13) had multiple factor loadings across the three factors. However, the scree plot showed two components only. Based on this result, another principal component analysis was conducted by increasing the salient loading to ≥.40 to reduce the overloading items. The results indicated that items loading on two components accounted for 60% of the total variance. Three items (Question 2, 3, and 13) were removed from the data because they did not reach the salient loading ≥.40 standard. The final factor solution supported two factors: tutorial design (Question 1, 8, 9, 10, 11, and 12) and cognitive load (Question 4, 5, 6, and 7). Cronbach's alpha coefficients value for items in factor 1 was .89 and factor 2 was .87.

After the factor analysis, a MANOVA test was conducted to determine if there is a difference in factor one or two between two groups. The average scores of factor 1 (tutorial design) were 4.47 (*SD*=.71) for the text group and 4.28 (*SD*=.89) for the narration group; the average scores of factor 2 (cognitive load) were 3.98 (*SD*=.85) for the text group and 3.66 (*SD*=.91) for the narration group. Based on the MANOVA results, there was no significant difference between two groups in both tutorial design factor, $F(1, 65)=1.54$, $p=.22$, and cognitive load factor, $F(1, 65)=2.82$, $p=.10$. The average scores and standard deviations of treatment groups on the two factors are shown in Table 2.

The attitude survey also contained three open-ended questions regarding what students liked the most, what students liked the least, and their suggestions for improving the tutorial. The descriptive statistics and themes from the two treatment groups are listed in Table 3 and only responses that derived from three or more participants were reported.

When participants in the text group were asked what they liked the most about the tutorial, their responses were ranked based on number of positive responses: 1=Images associated with characters (12 responses or 36%), 2=Images associated with descriptions (six responses or 18%), 3=An interesting learning experience (three responses or 9%), 3=Learning Chinese characters (three responses or 9%), and 3=Easy to learn (three responses or 9%). The themes on what participants liked the most in the tutorial from the narration group were the following: 1=Images associated with characters (16 responses or 48%), 2=Learning Chinese characters (seven

Table 2. Descriptive statistics for the treatment groups on the two factors for the attitude survey [*M* (*SD*)].

	Text group (*n*=33)	Narration group (*n*=33)
Factor 1: Tutorial design		
1. The tutorial was easy to understand.	4.85 (0.36)	4.52 (0.91)
8. The images in the tutorial helped me to memorize the characters.	4.48 (0.57)	4.55 (0.87)
9. The descriptions of Chinese characters helped me to understand the characters.	4.30 (0.81)	4.24 (1.03)
10. I learned a lot from the tutorial.	4.36 (0.70)	3.94 (0.83)
11. I liked the tutorial.	4.39 (0.56)	4.24 (0.83)
12. The tutorial was interesting.	4.42 (0.56)	4.21 (0.89)
Overall	4.47 (0.71)	4.28 (0.89)
Factor 2: Cognitive load		
4. The Chinese characters in the tutorial were difficult for me to remember.	3.88 (0.74)	3.79 (0.78)
5. I was able to recognize all the Chinese characters in the knowledge test.	3.61 (1.14)	3.18 (1.04)
6. I was confident in my performance while answering the knowledge test questions.	4.00 (0.87)	3.73 (0.84)
7. The duration of each character was enough for me.	4.42 (0.66)	3.94 (1.03)
Overall	3.98 (0.85)	3.66 (0.91)

Note: 1=the least positive response; 5=the most positive response.

responses or 21%), 3=Visual plus audio design (four responses or 12%), and 4=Images associated with descriptions (three responses or 9%)

When participants in the text group were asked what they liked the least about the tutorial, the responses were ranked based on number of responses: 1=None (13 responses or 39%), 2=Long duration of the character (three responses or 9%), and 2=No sound (three responses or 9%). The themes about what participants liked the least in the tutorial from the narration group were ranked based on number of responses: 1=None (17 responses or 51%), 2=Too many characters (six responses or 18%), 3=The monotone (four responses or 12%), 4=The audio repeats twice (three responses or 9%), and 4=Long duration of the character (three responses or 9%).

When the participants in the text group were asked if they had any suggestions for the tutorial, the suggestions included the following: 1=None (18 responses or 54%) and 2=Would like to hear some narrations (three responses or 9%). The suggestions from the narration group included: 1=None (15 responses or 45%), 2=Add a review section (four responses or 12%), and 3=Change the voice (three responses or 9%).

Discussion

For research question one, the results showed that no significant difference was found between the text and narration groups in the immediate post-test, which was not consistent with Mayer's (2001) modality principle and Kalyuga, Chandler, and Sweller's (1999) research findings. Mayer's modality principle (2001) indicated that

Table 3. Descriptive statistics and themes from the two treatment groups.

Text group (n=33)			Narration group (n=33)		
Liked the most	*n*	%		*n*	%
1. Images associate with characters	12	(36)	1. Images associate with characters	16	(48)
2. Images associated with descriptions	6	(18)	2. Learning Chinese characters	7	(21)
3. An interesting learning experiences	3	(9)	3. Visual plus audio design	4	(12)
3. Learning Chinese characters	3	(9)	4. Images associated with descriptions	3	(9)
3. Easy to learn	3	(9)			
Liked the least	*n*	%		*n*	%
1. None	13	(39)	1. None	17	(51)
2. Long duration of the character	3	(9)	2. Too many characters	6	(18)
2. No sound	3	(9)	3. The monotone	4	(12)
			4. The audio repeats twice	3	(9)
			4. Long duration of the character	3	(9)
Suggestions for improvement	*n*	%		*n*	%
1. None	18	(54)	1. None	15	(45)
2. Would like to hear some narration	3	(9)	2. Add a review section	4	(12)
			3. Change the voice	3	(9)

Note: Only responses that derived from three or more participants were listed.

the combination of narration and animation works better than the combination of on-screen text and animation because text and picture are processed via the visual channel (eyes), but narration is processed through the nonvisual channel (ears). When the information is separated into two channels instead of one, the cognitive load of each channel will be reduced. In Kalyuga et al.'s (1999) study, the audio group had significantly higher scores than the visual group in the post-test.

In contrast, the results of the immediate post-test in this study were coherent with the findings of Dunsworth and Atkinson's (2007) study, which showed no significant differences in the recall test between the narration and text groups. Therefore, the nonsignificant results and the high average scores in the immediate post-test in this study could infer that both treatments (image-text and image-audio) were effective in Chinese character recognition.

Miller (1956) explained that humans' brains could only hold seven plus or minus two units of information in the short-term memory at one time. Although participants in this study did not have experience in learning Chinese language prior to the study, participants in the text group recognized an average of 16 out of 19 (84%) Chinese characters, whereas participants in the narration group recognized an average of 16.03 out of 19 (84%) Chinese characters in the immediate post-test. The number of Chinese characters that participants could recognize was much higher than Miller's assumption of 7±2 units of information at one time. This result also confirmed Paivio's (1971) dual coding theory that when information is transferred into both verbal and nonverbal elements, it can be processed via two channels (verbal and nonverbal) instead of one to further reduce the cognitive load in each channel.

In the cognitive learning theory, the capacity of working memory is limited; therefore, various learning strategies were developed to reduce the cognitive load of

working memory (Baddeley, 1996). According to Sadoski and Paivio (2001), memory is served by the encoding of information in both verbal and nonverbal forms. Therefore, the combination of verbal and nonverbal information in the tutorial may not only help participants to understand the structure of Chinese characters, but it also may reduce the cognitive load by separating information into two channels and increased participants' ability to memorize those characters.

Image plays an important role in the dual coding theory. Paivio (2007) stated that although imagery instruction works better with concrete objects and textual instruction works better with abstract objects, it is encouraging to add image in the textual instruction as visual aids. Image also has a significant connection with learning achievement in language acquisitions because words are easier to remember when they are encoded with images (Arnold, 1999). In this study, when participants were asked what they liked the most in the tutorial, the top ranked responses from both groups were the following: images associated with Chinese characters (ranked number 1 in both text and narration groups) and images associated with the Chinese characters' descriptions (ranked number 2 in the text group and number 4 in the narration group).

For research question two, the results showed no significant difference between the text and narration groups in the delayed post-test. This result was not consistent with Mayer's (2001) modality principle, which indicated that the combination of narration and animation works better than text and animation. Mayer (2009) defined an effective multimedia presentation as follows: (1) the presentation should contain both words and pictures, (2) corresponding elements should be presented simultaneously, (3) only content-related elements (e.g., images, words, or sounds) should be presented on the screen, and (4) dual-channels (verbal and nonverbal) design should use audio instead of printed text to represent the verbal channel. The design of the narration group's tutorial (image plus audio) in this study was based on Mayer's descriptions of the dual-channels design principle. For this reason, participants in the narration group should have significantly higher recognition abilities of the Chinese characters than participants in the text group (image plus on-screen text). Nevertheless, the results showed that there was no significant difference between the two groups in the delayed post-test.

Moreover, the average scores of the delayed post-test showed that participants' abilities to recognize Chinese characters were considerably high in both text and narration groups one week after the treatment. Participants in the text group could still recognize an average of 13.73 out of 19 (72%) Chinese characters, whereas, participants in the narration group could recognize an average of 12.73 out of 19 (67%) Chinese characters. The nonsignificant difference and considerably high average scores in the delayed post-test revealed that the image plus on-screen text design was as effective as the image plus narration design in Chinese character acquisition.

On the other hand, the results showed that there was a significant difference between the test occasions (immediate and delayed post-tests). Participants' performance in Chinese characters recognition in the delayed post-test (13.23 or 70% retention rate) was significantly lower than their performance in the immediate post-test (16.02 or 84% retention rate). This reduced retention rate in the delayed post-test was consistent with the findings of previous studies (Kuo & Hooper, 2004; Wang, 2005), in which a retention test was conducted one week after the treatments, and participants had lower achievement scores in the retention test compared to the immediate test. A possible explanation for this situation is that after a period of time, the items that were

held in the working memory could be lost because of the limited capacity of working memory (Surprenant & Neath, 2009).

For research question three, there were no significant differences concerning participants' attitudes between the text and narration groups in both tutorial design factor and cognitive load factor. The nonsignificant result of the tutorial design factor was consistent with the finding of Quealy and Langon-Fox's (1998) study that showed no significant difference between the three dual coding treatment groups' (text, audio, and video) attitudes toward the lesson. The average scores of the tutorial design factor for the text group and narration group were high in this study, 4.47 and 4.28 respectively. The positive attitudes from both groups can also be found from responses to the open-ended questions. When participants were asked what they liked the most about the tutorial, the top ranked response from both groups was images associated with the characters. In addition, the nonsignificant result of the cognitive load factor was consistent with the findings in the immediate and delayed post-tests, which indicated that there was no difference between these two groups in learning achievements. A possible reason for the nonsignificant result in the cognitive load factor was that these two tutorials were both based on the dual coding design and the cognitive load in both groups was reduced.

Overall, participants in both text and narration groups showed positive attitudes toward both the tutorial design factor and the cognitive load factor. In the open-ended questions, more than 39% of the participants from each group stated that the tutorial was well designed and there was nothing they did not like, and more than 45% of the participants from each group indicated that nothing should be improved in the tutorial. In addition, when participants were asked what they liked the most in the tutorial, some themes that emerged from participants' responses included: learning Chinese characters, an interesting learning experience, and easy to learn. Gardner (1985) emphasized the important role of motivation and indicated that motivation is the primary factor for obtaining goals in second language learning. Schmidt and Watanabe (2001) also stated that if students believe learning a language is worthwhile, they will be more willing to exert a certain amount of effort and apply different strategies to achieve their goal.

This study has provided useful information about the effectiveness of dual coding designs and multimedia principles regarding student learning achievement and attitudes in Chinese character instruction. However, two limitations were identified. First, this study only focused on the dual coding effects on pictographic Chinese character recognition, other forms of Chinese characters may elicit different learning results. Second, the target population of this study was English speaking undergraduate students in the United States; therefore, the results may not be applicable to learners with other language backgrounds and from other age groups. In addition, future researchers may consider adding a pre-test in the research design to measure participants' prior knowledge in Chinese characters and postponing the delayed post-test to a longer duration, which may result in different effects on student learning retention between the groups.

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