Chinese Character Learning: Using Embodiment in Initial Stage

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Abstract

The purpose of the present study is to investigate a new approach, namely the use of Embodied Animations (EA), to Chinese character learning for beginning learners of Chinese as a Foreign Language (CFL). The study adopted a between-subjects experimental design to examine the effectiveness of three conditional groups: Traditional Learning (TL), Animation Learning (AL), and Embodied Animation Learning (EAL). Thirty-six college and graduate students were randomly assigned to one of the three learning groups. The programs for the three treatment groups were created using Flash. The participants were asked to try their best to learn all three features of the same eighteen Chinese characters presented in the computer-assisted programs in a given time. They also went through the same procedures. The results indicated that the EAL group outperformed the other two groups in terms of the total recall number of learned Chinese characters and the post-instruction test scores. In addition, the AL group outperformed the TL group in both total recall number of learned Chinese characters and the post-instruction test scores. There were statistically significant mean differences between these groups' learning outcomes. In addition, there were large effect sizes, as indicated by Cohen's d's, in these two tests between AL and EAL groups. The study also found practice effect to be a significant predictor of Chinese character learning outcomes. Given the positive results, this empirical study suggests the use of the new approach of using EA to Chinese character learning for beginning learners of CFL.

INTRODUCTION

Chinese is a popular but difficult language for beginning learners of Chinese as a Foreign Language (CFL) to learn. Due to the complex nature of Chinese logographs, learners of CFL show their motivational decline when learning Chinese characters. Therefore, many researchers designed and developed Chinese character learning programs in hope to better help learners of CFL learn. In this study, I proposed a Chinese character learning program using what I call the embodied animations (EA) and hypothesized that the EA design would yield better learning. To examine if the design of embodied animation learning (EAL) was effective, I conducted an experiment to compare this design to two other designs, which were traditional learning (TL) and animation learning (AL). After briefly stated the rationale, purpose, and justification of the study, I

described the research method, reported the results, and discussed the implications of the design in this paper.

BACKGROUND OF THE STUDY

Purpose of the study

The purpose of the study is to examine the effectiveness of using embodied animations in learning Chinese characters for beginning adult learners of Chinese as a Foreign Language (CFL).

Background, problem, and rationale

One of the most challenging and difficult human languages in the world is Chinese. As estimated by Lewis (2009), Chinese is the most widely spoken language in the world, with more than 1200 million native and second language speakers. For most English speakers, however, Chinese is the toughest language to learn (Moser, 1991), probably due to its irregular morphology and unsystematic morphophonemics (Everson, 1998). Though Chinese, as a macrolanguage coded *zho* under the international language code ISO 639-3 (SIL International), has 15 significantly different individual languages or dialects (Tang & Heuven, 2007), the writing system of Chinese uses the same characters across these languages. These characters, or *Hanji*, are nonalphabetic orthography words that are formed and written in a specific logographic format.

Chinese has become a popular second language to learn for college students in the United States. This can be seen from fast-rising Chinese course enrollments. The Modern Language Association (MLA) found Chinese enrollments rose 51% from 2002 to 2006. The MLA found 34,153 students in 2002, and then 51,582 students in 2006, studying Chinese language at the colleges and universities it surveyed, which are 2,795 institutions, about two-thirds of all institutions of higher learning in the United States

(Furman, Goldberg & Lusin, 2007). More and more researchers have drawn their attentions on how learners may better learn Chinese from either theoretical or practical perspectives.

However, although there is this trend of Chinese learning in U.S. colleges (Furman, Goldberg & Lusin, 2007) and in U.S. foreign language learning policy (e.g., The White House, 2009), due to the difficulty of Chinese characters, learners of Chinese still show a motivational decline in their learning after their first semester's Chinese class or when Chinese characters are introduced (Branner, 2009; Li, 1996), which indicates the need of studying and developing effective Chinese character learning (CCL).

Scientific Justification

Traditionally, in regard to CFL learning, rote memorization or constant repetition is emphasized if one is to master the target language. Therefore, CFL learners have to do a lot of repetitive writing and dictation, which make Chinese learning "very mechanical, uninteresting, and stressful" (Ki et al., 2003, p. 54). Nevertheless, I find strong technological and neuro-cognitive evidence to support the use of animation technologies along with embodiment designs for CCL.

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

In addition, neuroimaging researchers (Tan et al., 2000; Tan et al., 2001) use fMRI to examine brain's cortical activities when one is processing Chinese characters. They found Brodmann's areas 9, 46, 47, 44, 37, and 17-19 are uniquely activated for Chinese characters. What's interesting and new to the field are the Brodmann's areas 1, 3,

4, 6, and 7 that are strongly activated. The activation of these areas implies that Chinese character processing is strongly associated with human body movements, which leads to this empirical embodiment study.

With the effectiveness of instructional embodiment designs for math learning (Fadjo, Lu & Black, 2009; Fadjo et al., 2008; Fadjo et al., 2009), I therefore propose the use of embodied animation for CCL and its designs that show one's physical enactment of the attributes of a character.

Research Question

In this study, I aimed to investigate research question 1 (RQ1), which is about the effectiveness of embodied animations in CCL in comparison with other designs, but several RQs will be asked:

RQ1: Does the use of embodied animations in CCL generate better learning outcomes for CFL learners in terms of Chinese character's recognition, memorization, and application?

RQ2: Does the use of animation learning designs overall yield better learning results than traditional learning design for CFL learners in learning Chinese characters' morphology (written form), phonology (pronunciation), and semantics (meaning)?

RQ3: What are the roles of learners' attitude, confidence, and embodiment experience in CCL?

METHOD

Study Design

The present study adopted an experimental between-subject design with three treatment groups to investigate the effectiveness of different CCL programs for beginning learners of CFL. The learning outcomes across groups were examined through the use of

a One-Way Analysis of Variance (ANOVA). Post-hoc Dunnett t tests were conducted to further examine possible differences in post-instruction tests' results between any two of the three groups.

Adult participants were randomly assigned to one of the three treatment groups: (a) Traditional Learning group (TL) participants received the CCL program which contains three features of each of the eighteen Chinese characters but does not include a video in a static interface; (b) Animation Learning group (AL) participants received the CCL program which contains three features of each of the same eighteen Chinese characters plus a video that shows an animation of the character's etymological form changes; and (c) Embodied Animation Learning group (EAL) participants received the CCL program which contains three features of each of the same eighteen Chinese characters plus a video that not only shows an animation of the character's etymological form changes but also human body movements, actions, or gestures that depict both the semantic meaning and written form of the character. Figure 1, Figure 2, and Figure 3 show the screenshots of the program interfaces for TL, AL, and EAL.

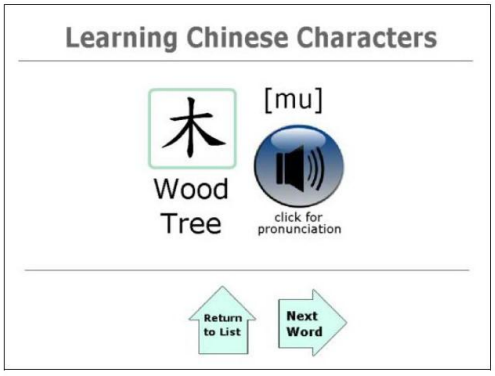

Figure 1. The Chinese character individual learning page of "Tree" for the TL group

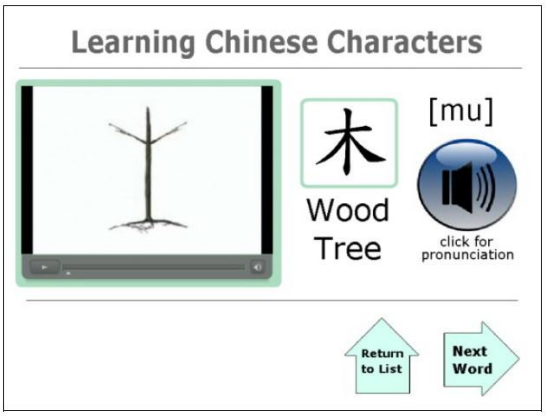

Figure 2. The Chinese character individual learning page of "Tree" for the AL group

Figure 3. The Chinese character individual learning page of "Tree" for the EAL group

Participants

Thirty-six undergraduate and graduate students from Columbia University, Teachers College, and other colleges voluntarily participated in the study. All participants did not know any Chinese characters at the time of the experiment and were pre-tested to show no prior knowledge of Chinese language before any instruction. In addition, from the pre-instruction questionnaire, none of the participants indicated that they knew any Chinese characters or spoke any Chinese at the time of the experiment. The participants were quite homogeneous such that there were no group differences concerning prior

knowledge of Chinese, age (F (2, 33) = .200, p = .82[1]), level of confidence in CCL (F (2,33) = .061, p = .941), and attitude toward learning new things (F (2, 33) = .569, p = .572).

Table 1 shows the demographic information by groups, including the number of cases, gender, means of chronological ages, pre-instruction level of confidence in CCL (scale from 0-5; 0: not at all confident, and 5: very confident), and pre-instruction attitude toward learning new things (scale from 1-5; 1: do not like to learn new things at all, and 5: like to learn new things very much). Among all the participants, 19 were female and 17 were male. The mean chronological age across groups is 31.31, with a standard deviation of 8.13. When asked "Do you think that you can learn Chinese characters well?" before the instruction, the participants yielded an overall confidence level of 3.14, with a standard deviation of .83. When asked "Do you like to learn new things" before the instruction, the participants yielded an overall attitude toward learning new things of 4.67, with a standard deviation of .59.

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

Table 1 *Demographic Data of Groups*

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

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

Apparatus and Materials

The apparatus we used were IBM compatible Dell laptops with 15 inches monitor. All laptops were installed with Adobe Flash CS4 Professional and Scratch programs. Earphones and speakers were tested to ascertain their proper functions before use. Participants learned characters with the CCL programs and with the Scratch game run on Flash and Scratch using these apparatus. In addition, two pieces of blank paper and two pens were provided during the learning activity time.

The materials include the Informed Consent/ Participant's Rights form, the Pre-instruction Questionnaire, the General Instruction Sheet, the specific Instruction Sheet for each group, the video instructions video clip for AL and EAL groups, the CCL programs for each group, the identical immediate and delay tests, the Scratch game, the Scratch game interview sheet, and the Post-instruction Questionnaire which contains a demographic survey.

When participants started the computer-based CCL program, they first saw the Table of 18 Characters page where all the to-be-learned target characters were listed (see Figure 4). These characters include 7 pictographs (木， 火， 山， 心， 人， 魚， 犬), 5 indicatives (上， 下， 中， 大， 小), and 6 ideographs (看， 比， 告， 舟， 長， 去).

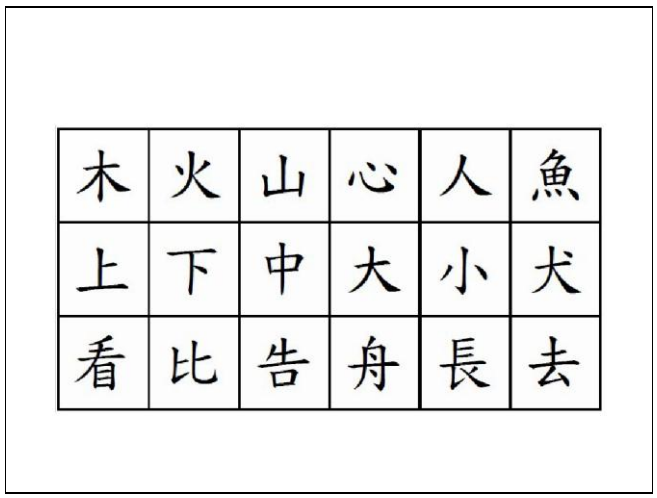

Figure 4. The screenshot of the Table of 18 Characters page

Table 2- *The Three Features of the 18 Characters*

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

Table 2 shows each of the 18 character's character type and the three features of the 18 characters: written form, semantic meaning, and pronunciation. The written forms

presented here are in Standard Kai Scripts and the pronunciations are in Pinyin Phonetic Symbols.

Procedures

Prescreening

The study was introduced to participants as research about Chinese character learning. Each participant was told that he or she would be completing a Pre-Instruction questionnaire, an immediate test, a language learning game, a delay test, and a Post-Instruction questionnaire in addition to a learning activity where he or she learns 18 Chinese characters using a computer-based CCL program. They were told to try to do their best to learn. From the Pre-instruction Questionnaire, I made sure that all the participants did not know anything about Chinese language and have not learned Chinese at all through pre-screening. Also, I ascertained that all participants could use a computer mouse or touchpad which is necessary for the study.

Table 3- *Experimental Procedures by Groups*

Time	**TL group**	**AL group**	**EAL group**
~1 min	Consent	Consent	Consent
~1 min	Pre-Instruction Questionnaire	Pre-Instruction Questionnaire	Pre-Instruction Questionnaire
~1 min	General Instruction	General Instruction	General Instruction
~1 min	Instruction-TL	Instruction-AL	Instruction-EAL
Up to 40 min	CCL program-TL.swf	CCL program-AL.swf	CCL program-EAL.swf
10 min	Immediate Test	Immediate Test	Immediate Test
10 min	Scratch game + interview	Scratch game + interview	Scratch game + interview
10 min	Delay Test	Delay Test	Delay Test
~5 min	Recall Test	Recall Test	Recall Test
~5 min	Post-Instruction Questionnaire	Post-Instruction Questionnaire	Post-Instruction Questionnaire
Total: ~85 min			

Process

Table 3 shows the experimental procedures for all three groups. Participants were first randomly assigned to one of the three groups: TL, AL, or EAL. Then they started by reading the Informed Consent and by signing the Participant's Rights form. Afterwards, the participants were first given the Pre-instruction Questionnaire to fill out. Those who could speak any Chinese or have learned any Chinese were excluded from our study. Secondly, all three groups of the participants could take their time and read over the General Instruction Sheet, which contained basic information about introduction to Chinese characters. On the sheet, participants were told that they were going to learn some Chinese characters. After reading the sheet, participants were asked to proceed by reading the next Instruction Page. Thirdly, the TL and AL group participants were then asked to take their time and carefully read the 5 points on the specific Instruction Sheet for their group (for EAL group participants, 6 points). They were asked to make sure that they fully understood by placing a check every time after they had read each of the points. On the sheet, participants were asked to try their best to learn and to learn all the 18 characters. Fourthly, participants could spend up to 40 minutes to learn those 18 Chinese characters using their assigned group-specific Chinese Character Learning Program. Two pieces of blank paper were provided during this learning phase should any participants wish to practice writing or to facilitate their memorization. Fifthly, participants took the Immediate Test for no more than 10 minutes. Sixthly, they were told to take a short break to play the Scratch game for 3 minutes where they were asked to use the 4 arrow keys and the space key to observe and explore both the program and the three Chinese characters. Seventhly, a 7-minute interview was conducted with the interview

questionnaire. Eighthly, they then took the identical Delay Test for no more than 10 minutes. Ninthly, in the Recall Test, participants were asked to write down all the characters they could still remember on a blank sheet. Tenthly, participants filled out the Post-instruction Questionnaire where they entered their opinions, thoughts, and demographic information. Finally, participants received $15 remuneration and were told to feel free to ask any questions regarding this study.

Data Analysis

Quantitatively, a one-way analysis of variance was conducted to investigate the effectiveness of different CCL programs for beginning learners of CFL. Post-hoc Dunnett t tests were conducted to further examine possible differences in post-instruction tests' results between any two of the three groups. Qualitatively, character's written forms from participants were rated based on our grading guideline rubrics in the codebook.

Table 4 shows the grading guidelines for any characters' written forms participants wrote either in the Recall Test or in the *TestW*.

Table 4- *Grading Guideline Rubrics for Written Forms*

Score assigned	Description of the character written by participant
0	No writing; Completely wrong; Entirely unrecognizable
1	Hardly recognized; Keep some shape; Guessable; Seems like it
2	Recognizable; With several misses; Still keep the shape
3	Easily recognized; With only 1-2 misses; Near perfect
4	Perfect; Completely correct

RESULTS

This study aimed to investigate the effectiveness of different CCL programs for beginning learners. Specifically, I examined if Embodied Animation Learning was better than Traditional Learning or Animation Learning.

Pre-Instruction Questionnaire

All 36 participants indicated that they did not know and speak any Chinese at the time of experiment (with both 0s for No. 1.1 and No. 1.2 in the Pre-instruction Questionnaire). Therefore, there was no group difference in prior knowledge of Chinese. Pre-instruction level of confidence in Chinese character learning and pre-instruction attitude toward learning new things are listed in Table 1. The omnibus one-way ANOVA for pre-instruction level of confidence in Chinese character learning and pre-instruction attitude toward learning new things shows that there were no group differences concerning level of confidence in CCL ($F(2,33) = .061$, $p = .941$) and attitude toward learning new things ($F(2, 33) = .569$, $p = .572$).

Test Means and Standard Deviations

Table 5 shows tests' mean scores and their standard deviations for Immediate Test (Post), Delay Test, Recall Test, and *RecallPerfect* from Traditional Learning (TL, n = 13), Animation Learning (AL, n = 10), and Embodied Animation Learning (EAL, n = 13) groups. These variables' possible score ranges are also listed. To examine the effect of embodied animations from that of common etymological animations in Chinese character learning, effect sizes (ES) r and Cohen's *d* between the AL group and the EAL group were reported in Table 5.

Table 5- *Test Means and Standard Deviations*

Variable (possible range)	TL's Mean (SD)	AL's Mean (SD)	EAL's Mean (SD)	ES r (Cohen's d, b/t AL & EAL)
Pre	0	0	0	
Post (0-34)	24.08 (5.299)	27.1 (4.408)	30.54 (2.961)	0.416 (0.934)
Delay (0-34)	24.62 (5.895)	27.4 (4.648)	30.77 (2.743)	0.404 (0.883)

Recall (0-72)	40.08 (9.987)	48.00 (12.824)	57.54 (12.218)	0.356 (0.762)
RecallPerfect (0-18)	7.77 (2.242)	9.40 (3.688)	11.54 (4.719)	0.245 (0.505)
N	13	10	13	

All three groups' participants did not have any prior knowledge of Chinese language and therefore they yielded an equal 0 for Pre. For Immediate Test (Post), the TL group's M = 24.08 (SD = 5.299), the AL group's M = 27.1 (SD = 4.408), and the EAL group's M = 30.54 (SD = 2.961). The Cohen's *d* = 0.934 (r = 0.416) indicated a large effect size between the AL and EAL groups. For Delay Test, TL group's M = 24.62 (SD = 5.895), AL group's M = 27.4 (SD = 4.648), and EAL group's M = 30.77 (SD = 2.743). The Cohen's *d* = 0.883 (r = 0.404) indicated a large effect size between the AL and EAL groups. For Recall Test, the TL group's M = 40.08 (SD = 9.987), the AL group's M = 48.00 (SD = 12.824), and the EAL group's M = 57.54 (SD = 12.218). The Cohen's *d* = 0.762 (r = 0.356) indicated a medium to large effect size. For *RecallPerfect*, the TL group's M = 7.77 (SD = 2.242), the AL group's M = 9.40 (SD = 3.688), and the EAL group's M = 11.54 (SD = 4.719). The Cohen's *d* = 0.505 indicated a medium effect size.

Graphs for Test Results

To clearly illustrate different group means from these tests, I further graphed a bar chart, Figure 5, to show group mean comparisons in the pre-test, the immediate test, and the delay test and tests' comparisons in the TL, AL, and EAL groups. From Figure 5, it seemed EAL outperformed both AL and TL in both immediate test and delay test. Also, it seemed AL outperformed TL in both tests. In addition, it seemed there were no differences between immediate test result and delay test result for all three groups. I therefore chose to only further examine the immediate test results by graphing a box-plot

diagram.

Figure 6 shows the box-plot of comparison of the immediate test results (*TestTotal*) across three groups. Two obvious outliers were detected: No. 26 in AL group and No. 14 in EAL group. I included these cases in our final analysis as the inclusion or exclusion of these cases did not dramatically affect the analysis results.

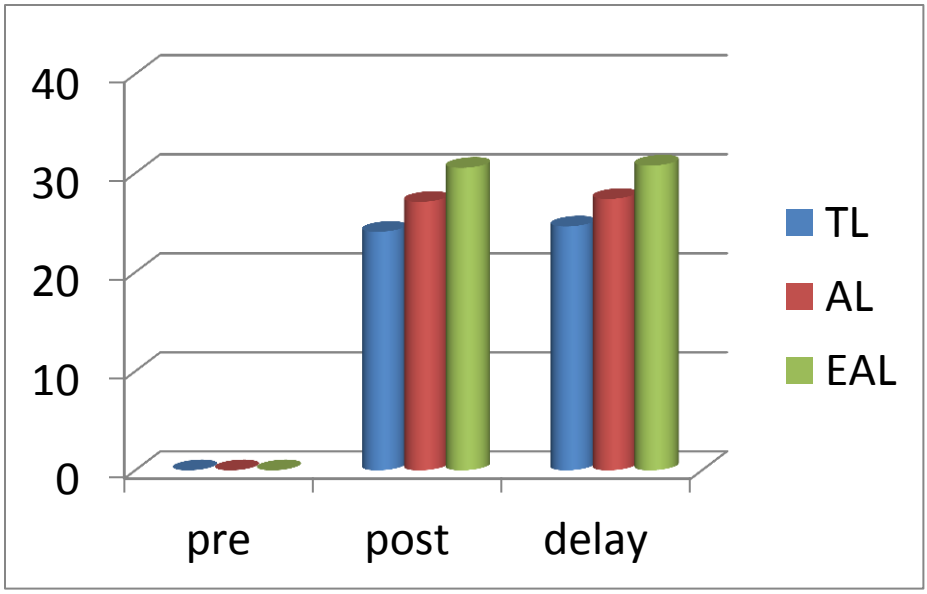

Figure 5. Group comparisons in pre-test, immediate test, and delay test

Figure 7 shows the comparisons of the total number of Chinese characters written by participants (*Recall*) across groups. A similar pattern is shown that in Recall Test, EAL outperformed both AL and TL and AL outperformed TL. I chose to further examine the *Recall* by graphing a box-plot diagram (Figure 8).

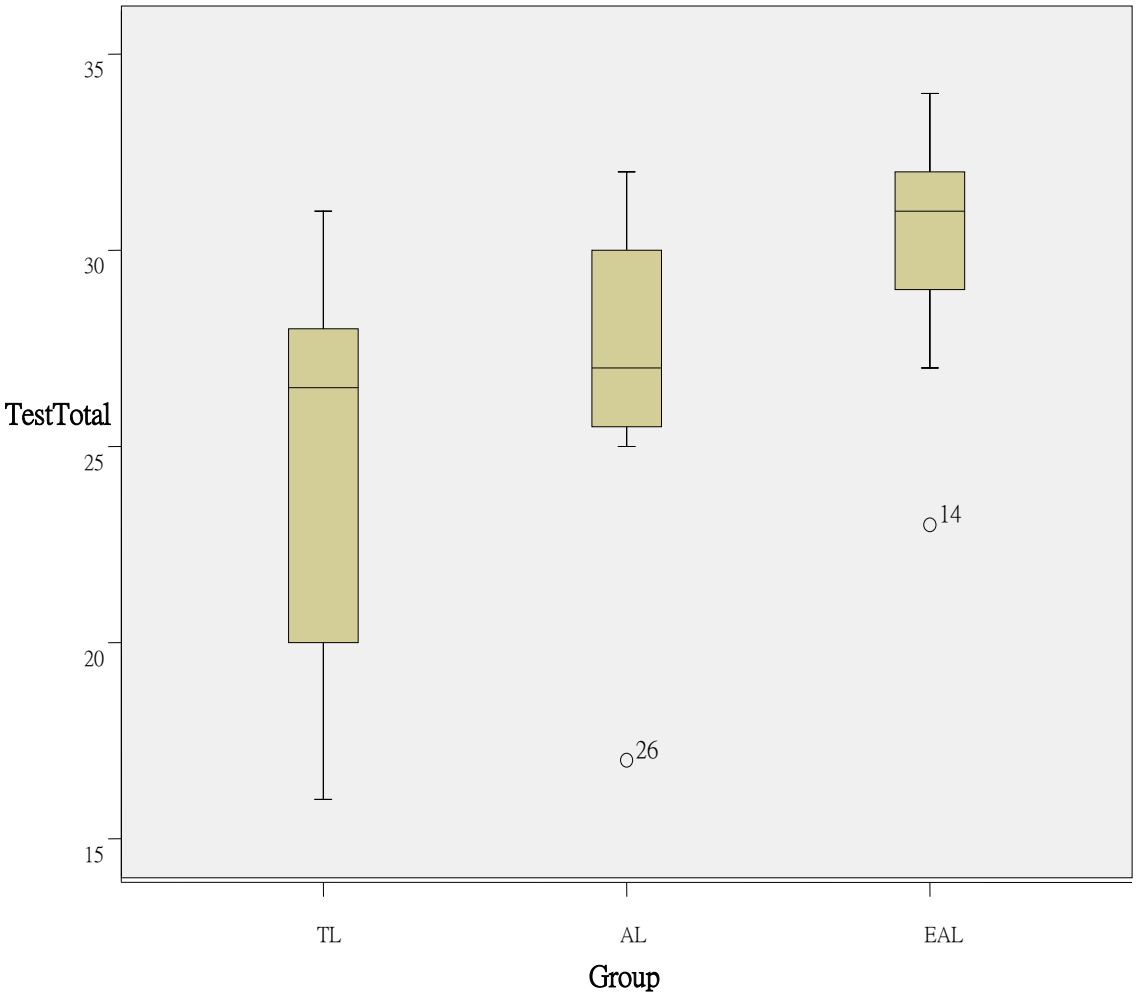

Figure 6. Box plot- comparison of the *TestTotal* (Immediate Test scores) across groups

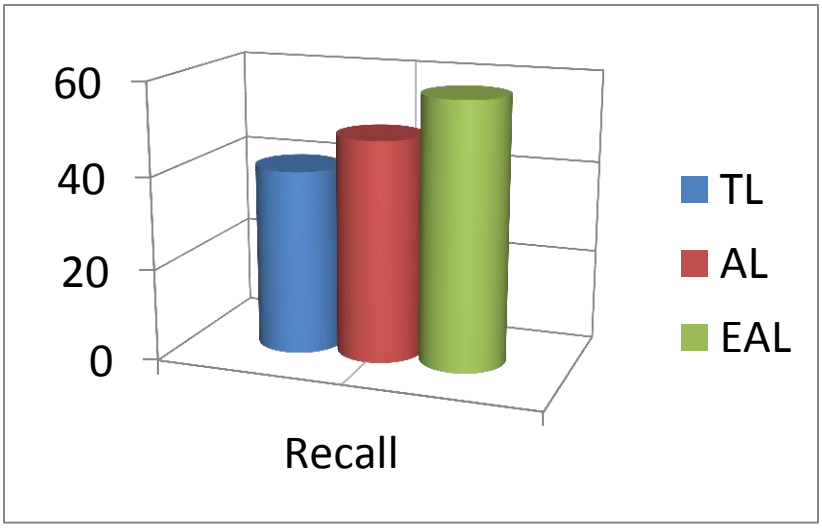

Figure 7. Bar chart- comparison of the *Recall* across groups

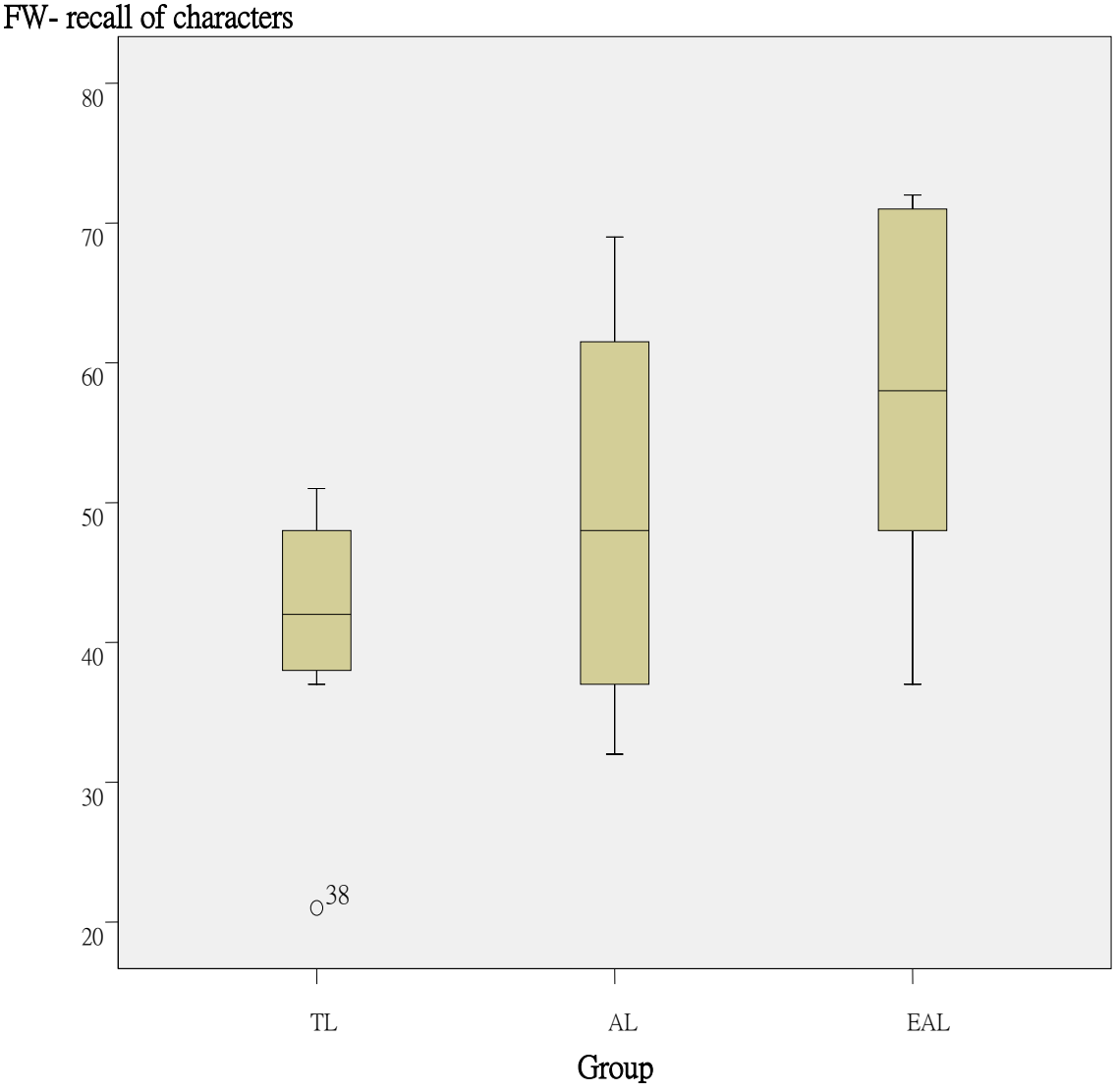

Figure 8. Box plot- comparison of the *Recall* (the total number of Chinese characters written by participants) across groups

Figure 8 shows the box-plot of comparison of the total number of Chinese characters written by participants (*Recall*) across three groups. One obvious outlier was detected: No. 38 in the TL group. I included this case in our final analysis as the inclusion or exclusion of the case did not dramatically affect the analysis results.

Group Comparisons

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

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

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

Table 6- *Post-hoc Dunnett t Test for TestTotal*

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

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

Table 6 shows the post-hoc Dunnett t test for the Immediate Test (*TestTotal*). In

TestTotal, EAL significantly outperformed both AL by 3.438 points (SE = 1.819) at .10 level of significance, and TL by 6.462 points (SE = 1.696) at .01 level of significance.

Table 7- *Post-hoc Dunnett t Test for DeTotal*

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

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

Table 7 shows the post-hoc Dunnett t test for the Delay Test (*DeTotal*). In *DeTotal*, EAL significantly outperformed both AL by 3.369 points (SE = 1.940) at .10 level of significance, and TL by 6.154 points (SE = 1.809) at .01 level of significance.

Table 8- *Post-hoc Dunnett t Test for Recall*

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

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

Table 8 shows the post-hoc Dunnett t test for the Recall Test (*Recall*). In *Recall*, EAL significantly outperformed both AL by 9.538 points (SE = 4.894) at .10 level of significance, and TL by 17.462 points (SE = 4.564) at .01 level of significance.

Practice effect

I checked the practice effect and found that initially there was no group difference among the three treatment groups (F (2, 29) = .022, p = .978). Table 9 shows the descriptives of the mean of total number of practices (*PracT*) participants in different groups generated on the blank practice sheets during the learning phase.

Table 9- *Descriptives for Number of Practices by Groups*

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

However, the overall practice effect stands as a significant predictor of *TestTotal*. Table 10 shows the ANOVA table of the simple linear regression model with *PracT* as an independent variable (IV) and *TestTotal* as a DV. The model is significant with $R^2 = .196$, MS = 143.64, F (1, 30) = 7.30, $p < .05$. This simple regression model can explain 19.6% of the variance in *TestTotal*. *PracT* is a significant predictor of *TestTotal* with standardized ß = .442, t = 2.70, $p < .05$.

Table 10- *ANOVA Table for the Simple Regression Model with PracT as an IV for TestTotal*

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

** p < .05

Post-Instruction Questionnaire

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

Do you like the Chinese character instruction program?

When asked "Do you like the Chinese character instruction program?" after the learning phase, participants yielded a 1.58 score on average (SD = .50), indicating high

positive feedback on using the program. Though the mean differences were not statistically significant among groups (F (2, 33) = 1.46, $p > .05$), Table 11 shows that on average all three groups expressed positive feedback.

Table 11- *Descriptives for Liking the Chinese Character Instruction Program*

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

Do you think the Chinese character instruction program is effective?

When asked "Do you think the Chinese character instruction program is effective?" after the learning phase, participants yielded a 1.58 score on average (SD = .77), indicating high positive feedback on the effectiveness of the program. Though the only difference lies between the TL group and the EAL group (mean difference = -.846, SE = .268, $p < .05$) in that the overall mean differences were statistically significant among the three groups (F (2, 33) = 5.67, $p < .01$), Table 12 shows that on average all three groups expressed positive feedback.

Table 12- *Descriptives for Effectiveness of the Chinese Character Instruction Program*

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

The responses to other questions in the Post-instruction Questionnaire also yielded similar results. For example, questions such as: "Does the video (or *the program*, for the TL group) make Chinese characters easier to learn?" "Does the video (or *the*

program, for the TL group) help you in understanding and remembering the Chinese characters?" "Does the video (or *the program*, for TL group) help arouse your interest in learning Chinese?" "Does the video (or *the program*, for TL group) help maintain your motivation in character learning?" all yielded similar results in that there were no mean differences among groups but with overall positive responses. Table 13 shows that on average all three groups expressed positive opinions toward these variables.

Table 13- *Descriptives for Learners' Opinions about the Chinese Character Instruction Program*

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

What do you think about Chinese characters?

I asked this same question before and after the learning phase in the Pre-instruction Questionnaire and the Post-instruction Questionnaire. Participants could circle all of the ten provided answers that apply. I intended to examine if participants in the pilot study held certain attitudes or had specific thoughts about Chinese characters. In addition, I intended to explore if there were possible changes in their responses before and after their learning phase using the Chinese character instruction program. Table 14 shows frequencies of the answers to this question from participants' responses of general idea and attitude about Chinese characters.

Table 14- Frequencies for Participants' Idea and Attitude about Chinese characters

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

From answer a in Table 14, it seemed that learners felt they had learned some Chinese characters after using the Chinese character instruction program. From answers d and e, none of the participants thought Chinese characters are not interesting or are meaningless lines and dots. From answer f and h, learners tended to think Chinese characters are possible to learn and can be mastered with efforts. From answer g, it seemed the number of those who thought Chinese characters are difficult to learn decreased. The only participant that indicated that Chinese characters are easy to learn was from the EAL group in the Post-instruction Questionnaire. From one-way ANOVAs, there were no statistically significant group differences in their responses of these answers from both the Pre-instruction Questionnaire and the Post-instruction Questionnaire.

Bivariate Correlation Data Analysis

It is worth mentioning that there were no statistically significant correlations

between participants' learning outcomes (*TestTotal*) and many other variables collected in the Post-instruction Questionnaire such as gender, age, number of languages spoken, post-instruction level of confidence, if learners liked the program, if learners thought the program was effective, if learners thought the program made Chinese character learning easier, if learners thought that the program helped learners better remember characters, if learners thought that the program aroused learners' interest and if learners thought that the program maintained their motivation to learn. There were a couple exceptions: 1. Those who thought the test was easy tended to perform better in *TestTotal* (Pearson's r = -.449, $p = .006$); and 2. Those in the AL and EAL groups who liked the video feature of the program tended to perform better in *TestTotal* (Pearson's r = .353, $p = .038$).

In addition, learners who indicated they exercise, watch sports, liked the Chinese character learning program, or liked the videos in the program tended to think the program was effective (r = .638, $p < .001$; r = .427, $p < .0$; r = .501, $p < .01$; and r = .421, $p < .05$, respectively). Learners who exercise also tended to think that the program helped them better remember Chinese characters (r = .349, $p < .05$). Those who liked the program as a whole tended to like the videos in the program (r = .364, $p < .05$) and those who liked the program also tended to think the program is effective (r = .501, $p < .01$). For those who liked the videos provided in the program, they also tended to think the program was effective, made learning Chinese characters easier, helped them learn better, and maintained their motivation to learn (r = .421, $p < .05$; r = .339, $p < .05$; r = .410, $p < .05$; and r = .444, $p < .01$, respectively). Table 15 shows the bivariate correlations of variables investigated in the Post-instruction Questionnaire.

Table 15- *Bivariate Correlations of Variables in the Post-Instruction Questionnaire*

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

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

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

Open-Ended Questions

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

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

Positive learning experience in Chinese logographs

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

Positive learning attitude

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

DISCUSSION

Limitations and Future Directions

Limitations

Due to the limitation of time, the study was not able to be carried out over a longer period of time for more participants (for better power and for more variables' investigation) and for better instrument and measurement development (e.g., the inclusion of all the target characters in the measurement and maybe of all the tests in the program). Ideally, I ought to recruit more participants for each group for some other interesting variables' investigation and to carefully collect participants' retention and transfer data after at least one day or maybe 1 to 2 weeks of the treatment. Also, I ought to design and develop pre-tested reliable and valid instrument and measure for the testing of the program. It is a pity that I fail to do so in this study. However, the statistically significant results undoubtedly encouraged me in believing in the use of embodied animations in Chinese character learning.

Future Directions

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

Immediate Test and Delay Test

Among the 22 questions on the Immediate Test, 3 were meaning-form mapping questions, 3 were written form questions, 3 were form-sound mapping questions, 3 were form-meaning mapping questions, 5 were inference questions, and 5 were morphology awareness questions. To increase variability of learners' answers and to better test learners' real retention and near-transfer abilities, it should be essential to increase the number of questions on the test. For example, I should include questions for all target

characters. I may also include more measures to examine learners' learning outcomes, such as a blank sheet for recall of meaning, a blank sheet for recall of written form, and a blank sheet for recall of pronunciation. For near-transfer or far-transfer items, I may put in more phonetic-morpheme compounds. In addition, I used identical parallel test as the Delay Test and it turned out that the results from the Delay Test were highly similar to the results of the Immediate Test. A similar but different parallel test for delay test should be developed and implemented.

Distraction Design

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

For the purpose of distraction, the distraction design I may use in the future can be totally irrelevant to CCL. For instance, I could use simple arithmetic problems such as addition or subtraction for distraction.

Questionnaire

I should adopt a 9-point or 10-point Likert scale for most of the variables in the questionnaire. Currently, the 4-point scale made many of the variables not discernible.

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

Chinese Character Learning Program

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

character learning videos.

For character's etymology animations in the videos, I should use more changes of morphs instead of changes of fades because morphs make better connections between different forms of the same Chinese character. For some characters, learners may have to guess those connections when we use fades-in and fades-outs.

Participants in this pilot study expressed their feedback that they total time of the learning phase was very long and also they were not aware of the time for each Chinese character's individual learning page. I therefore should time each character's individual pages and maybe make the timer obvious to see on the screen so that when the time is up the currently viewed page would automatically change to the next page. This way, learners would know exactly how much time they have left. I should also make each page to show for a shorter time, such as 45 seconds per character instead of 2 minutes so that learners would not feel bored in the learning phase.

I should also consider emphasizing the imagination reinforcement by reminding the EAL group learners each time before they view the EAL videos so that learners would remember to perform the imagined embodiment when viewing the videos.

As to the learning of Chinese characters' pronunciations, I may consider using the present click-for-pronunciation buttons or having the pronunciation play automatically by embedding the audio sounds as background at the same time when the videos are playing. That way, learners do not have to click the button each time they want to hear the sound of the character's pronunciation and may focus more on other features of the character. However, I should also be cautious as this kind of design may interfere with learner's attention to learning other features of the character.

Future Directions

I may add two more groups in the study design: one control group that is with mere paper-and-pencil instruction and has no computer-based instruction programs, and the other succinct-Embodied Animation Learning (EAL) group that views shortened videos instead of the current longer version of videos. The control group serves to compare computer-based programs to traditional paper-and-pencil only instruction. The succinct-EAL group serves to compare videos that are with more thorough character's etymological information to videos that are with only essential information. By comparing these five groups, I will get a clearer idea of why and how the EAL groups may be better than the other groups.

I may also include Chinese children as participants in the future study. The reason why I may want to study Chinese children in the future is because I would like to examine how they learn Chinese characters and see if they view Chinese differently. In addition to studying them, I may investigate the question: Will embodied animation learning program help native Chinese speaking children learn Chinese characters? The results from this study show that the approach of using embodied animations to Chinese character learning for beginning learners of Chinese *as a foreign language* works, and therefore it should be interesting to see if the approach also works for native Chinese speaking beginning learners. Moreover, it should also be interesting to investigate the use of the program for non-native Chinese speaking children to compare with beginning adult learners in order to uncover if children learners of CFL benefit from the program.

General Discussion

Levels of Embodiment and Practical Implications

Are there different types, or levels, of embodiment? And if there are, how should teachers apply different designs of embodiment for Chinese character learning?

Researchers and educators have created different types of embodiment used for science and language learning and teaching in classrooms. All five types of embodiment are tightly linked to computer technologies: Direct (or Full) Embodiment (DE), Surrogate Embodiment (SE), Imagined Embodiment (IE), Reflected Embodiment (RE), and Haptic Embodiment (HE).

The design of DE (see Fadjo, Lu, & Black, 2009; Fadjo, et al., 2008) entails that learners obtain proprioceptive experience by meaningfully moving their torsi and thus full-bodily enacting what they are learning, such as embodying Chinese characters that contain 'water' or 'fire' radicals. The DE is effective as evidenced by the iWorld Team related studies. The design of SE (see Glenberg, 2004; Fadjo, Hallman, Harris, & Black, 2009) uses a surrogate's actions to replace torso movements; yet, it is effective in language teaching and learning (Glenberg, 2004; Glenberg, 2008). In practice, teachers may create different radicals' manipulatives as surrogates for learning activities. The design of HE (see Lu, Lin, & Wu, 2008) is effective when learners obtain both 1st and 2nd -hand experiences in the learning activity phase. In addition to learners' clicking the mouse and hearing the target words' pronunciations, active rule-generating actions provide deeper processing in vocabulary recognition and memorization (Lu, et al. ibid.). When teaching CFL using HE, teachers can provide selected Chinese characters on a Smart Board, computers, or on cards as stimulation, and then ask learners to self-generate and group common morphemes (ex. radicals) or common phonemes. The design of RE (see Hong, 2009) has a unique feature that learners see themselves through a webcam and hence also see themselves move (mostly their hands) on the computer screen when they interact (mostly using their hands) with the computer in a game. Hong (2009) develops the interactive flash player media in hope that learners would enhance their motivation

and learning effects. He has found positive results in that the design indeed intrigues learners more with game components that require identification and active recall skills, with interactive components that show rich-information, and with competitive racing function. Teachers of CFL may design animation-based or interactive games to allow learners use RE for learning different Chinese characters. For example, RE can be used in a word discerning game for word recognition or character differentiation. The design of IE (see Fadjo, Lu, & Black, 2009; Black, 2007) emphasizes learner's imaginary ability and thus can be used when learners are inferring new rules, morphology, or phonetics in Chinese characters. Teachers of CFL should implement IE in the learning activity phase in their instructional designs for deeper learning. For example, during the beginning learning phase of a class, teachers of CFL can ask learners to encode (after seeing certain words) then decode (by thinking and imagining quietly without seeing these words) these Chinese characters.

Though research regarding some of the designs of embodiment is not specifically related to CFL or Chinese character learning, I believe future research will provide more affirmative details in their uses and applications in Chinese language classrooms. With the use of embodiment for language learning and teaching, future Chinese language classes will no longer be tedious repetition and relatively meaningless memorization of words. For character learning, I then should ask: Is imagination of viewing videos sufficient? Or should learners be told to embody themselves physically?

Embodied Animations

The study suggests that the approach of using embodied animations to Chinese character learning for beginning learners of Chinese as a foreign language work. Why do embodied animations work?

I find possible evidence from neurological research. When examining the unique Brodmann's areas that were significantly activated in the Chinese character experiments Tan et al. (2001) and Tan et al. (2000) did, I find many of these areas are movement-based or action-related. Specifically, areas such as BA 4 (Primary Motor Cortex), BA 6 (Premotor Cortex and Supplementaty Motor cortex), BA 3 (Primary Somatosensory Cortex), and BA 7 (Somatosensory Association Cortex) were all strongly activated during both Chinese semantic and Chinese homophonic tasks. Moreover, BA 1 (Primary Somatosensory Cortex) was also strongly activated during the covert Chinese word generation tasks in addition to other motor-related areas aforementioned. These are not conventional areas that would be strongly activated when an alphabetic language is being processed. Tan et al. (2000) even stated that, "… the reason why the right parietal regions (BAs 3 and 1) were strongly activated is not clear" (p. 23).

Why would these movement-based or motor-related areas be activated when processing Chinese characters? There are 3 possible explanations. Firstly, the processing and representation of Chinese characters require some of these unique areas to be activated. Some characters may be embodied and processing these characters is thus embodied. Unlike viewing an alphabetic word such as English in which words are formed in linear and orderly configuration, when we see certain Chinese characters, we see, or feel, more than a plain word but maybe a picture, a scenario, or even a motion picture in a square-shape space that can be packed with up to seven dozen various types of strokes. Secondly, when encoding and decoding Chinese characters, there is significant assistance to activate these brain areas. In other words, we humans tend to activate more of these areas that are supposed to be helpful to assist with our encoding Chinese logographs. Thirdly, the traditional classification of the brain areas is not entirely thorough or

completely accurate. That is to say, these Brodmann areas still denote language processing areas, or language-related visual-spatial areas. This third point, however, may be highly unlikely since a lot of research has revealed the functional specifications of human brain's areas, especially the Brodmann's areas through many different types of brain and imaging studies.

Therefore, embodied animations work. By triggering motor- and body movement-related cortices, learners may better encode or process Chinese logographs. In fact, the design of embodied animations echoes our human's capability of imagination and the positive impact of technologies. Black (2007) and Schwartz and Black (1999) revealed the importance of imagination and imagined actions as Black (2010) spoke at the 2010 Teachers College Academic Festival about the magic of experience plus simulation, "having experiences that relate to what you are learning can make a big difference. Technology exists that provides these kinds of experiences." With the computer-based Chinese character learning program, it is easier to imagine and experience the relationship between characters and movements. It further helps learners generate forms when presented with meanings, or derive meanings when characters are presented. In sum, the program helps learners imagine and experience the relationship between characters and movements and that leads to deeper and better Chinese character learning.

REFERENCES

Black, J.B. (2007). Imaginary Worlds. In M.A. Gluck, J.R. Anderson and S.M. Kosslyn (Eds.) Memory and mind. Mahwah, NJ: Lawrence Erlbaum Associates.

Black, J.B. (2010). Speech at TC Academic Festival 2010. Teachers College Columbia University, NY, New York on April 24th, 2010.

Branner, D. P. (2009). Personal communication with Prof. Branner on Oct. 29th, 2009.

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

Fadjo, C., Lu, M. & Black, J. (2009). Instructional Embodiment and Video Game Programming in an After School Program. In *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2009* (pp. 4041-4046). Chesapeake, VA: AACE.

Fadjo, C., Shin, J., Lu, M., Chan, M. & Black, J. (2008). Embodied Cognition and Video Game Programming. In *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2008* (pp. 5749-5756). Chesapeake, VA: AACE.

Fadjo, C., Hallman Jr., G., Harris, R. & Black, J. (2009). Surrogate Embodiment, Mathematics Instruction and Video Game Programming. In *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2009* (pp. 2787-2792). Chesapeake, VA: AACE.

Furman, N., Goldberg, D. & Lusin, N. (2007). Enrollments in Languages Other Than English in United States Institutions of Higher Education, Fall 2006. Web publication. Modern Language Association.

Gibbs, R. (2006). *Embodiment and Cognitive Science.* New York: Cambridge University Press.

Glenberg, A.M., Gutierrez, T., Levin, J.R., Japuntich, S., Kaschak, M.P. (2004). Activity and Imagined Activity Can Enhance Young Children's Reading Comprehension. *Journal of Educational Psychology, 96,* 424-436.

Glenberg, A.M. (2008). *Toward Integration of Bodily States, Language, and Action*. In. Semin, G.R. & Smith, E.R. (Eds.) Embodied Grounding: Social, Cognitive, Affective, and Neuroscientific Approaches. Cambridge Univ. Press, NY, NY.

Hong, J. (2009). Designing Animation and Interactivity to Attract Young Players. In *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2009* (pp. 3619-3640). Chesapeake, VA: AACE.

Kennedy, G. (1964). A Minimum Vocabulary in Modern Chinese, in *Selected Works of George Kennedy*, Tien-yi Li (ed.), New Haven: Far Eastern Publications.

Ki, W., Lam, H., Chiung, A. L. Tse, S., Ko, P., Lau, C., Chou, P.W., Lai, A.C., & Lai, S.M (2003). Structural awareness, variation theory and ICT support. *Educational Studies in Language and Literature, 3,* 53-78.

Lam, H.C., Ki. W.W., Law, N., Chung, A.L.S., Ko, P.Y., Ho, A.H.S., & Pun, S.W. (2001). Designing CALL for learning Chinese characters. *Journal of Computer Assisted Learning, 17,* 115-128.

Lewis, M. P. (ed.). (2009). *Ethnologue: Languages of the World, Sixteenth edition.* Dallas, TX.: SIL International.

Li, X. (1996). HyperCharacters: A pilot study in computerized learning of Chinese characters. *CALICO Journal, 14 (1)*, 77-94.

Lu, M., Lin, Y., & Wu, C. (2008). The DKE Model Revisited: The Influence of Multimedia-triggered 1st- and 2nd-hand Experiences on L2 Learning. *The Proceedings of 2008 International Conference on Language Teaching and Learning*. Taipei, Taiwan: Crane Publishing Co., Ltd., 197-224.

Moser, D. (1991). Why Chinese is so Damn Hard. In Mair, V.H. (eds.) Schriftfestschrift: Essays on Writing and Language in Honor of John DeFrancis on His Eightieth Birthday. *Sino-Platonic Papers, 27*, 59-70.

Nakajima, K. (1988). On developing HyperCard stacks for the study of Chinese characters: KanjiCard. *CALICO Journal, 6 (2),* 75-87.

Schwartz, D. L., & Black, T. (1999). Inferences through imagined actions: knowing by simulated doing. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 25,* 116-136.

SIL International. (2009). Scope of denotation. Retrieved Oct. 15th, 2009, from http://www.sil.org/iso639-3/scope.asp#M

Tan, L.H., Liu, H., Perfetti, C., Spinks, J.A., Fox, P.T. & Gao, J. (2001). The neural system underlying Chinese logograph reading. *NeuroImage, 13*, 836-846.

Tan, L.H., Spinks, J.A., Gao, J., Liu, H., Perfetti, C., Xiong, J., Stofer, K., Pu, Y., Liu, Y., Fox, P. (2000). Brain activation in the processing of Chinese characters and words: A functional MRI study. *Human Brain Mapping, 10,* 16-27.

Tang, C. & Heuven, V.J. (2007). Predicting mutual intelligibility in chinese dialects from subjective and objective linguistic similarity. *Interlinguistica, 17,* 1019-1028.

The White House (2009). Remarks by President Barack Obama at Town Hall Meeting with Future Chinese Leaders. Retrieved Dec 1st, 2009, from

http://www.whitehouse.gov/the-press-office/remarks-president-barack-obama-town-hall-meeting-with-future-chinese-leaders

Wang, L. (2005). The impact of multimedia on Chinese learners' recognition of characters: A quantitative and qualitative study. ProQuest Dissertations and Theses database.