LEARNING CHINESE HANDWRITING WITH A HAPTIC INTERFACE IN DIFFERENT VELOCITY MODE

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Abstract: This paper presents an experiment by using haptic interface for Chinese handwriting learning. Based on the strategy of “record-and-play”, this haptic interface records the teacher’s information and transfers the writing skill to users. There are two kinds of transfer methods. One is using the real speed that recorded from the teacher, called variable velocity mode. The other is using a constant speed which is re-programmed, called constant velocity mode. The objective of this experiment is to determine what kind of velocity mode **benefits the handwriting learning most. Also,** another purpose is to see if use of haptic device in learning a given Chinese character could influence learning of other characters with common strokes. The result shows that haptic device does benefit handwriting learning. In order to improve shape or decrease inair time, c-v mode (constant velocity mode first and variable velocity mode second) shows statistical significance and increases performance; separately, constant velocity mode gets better improvement than variable velocity mode with haptic learning. For writing velocity or size, no significant effect can be made. Using haptic device to learn a given Chinese character nearly cannot influence learning of other characters with common strokes.

1 INTRODUCTION

Generally, haptic interface guidance has been widely used for handwriting learning for a long time. Numerous studies have been made in order to evaluate the advantage and find a good way via virtual environment for this skill training. No matter in hieroglyphic writing or phonetic writing, researchers has proved that using haptic device benefited handwriting learning.

In 1996, Y. Yokokohji et al. (1996) investigated a possibility of skill mapping from human to human via a visual/haptic display system, based on a strategy name “record-and-play”. Although the chosen task was too easy, no remarkable result was obtained, this strategy gave a good idea. Later in 1998, Kazuyuki Henmi and Tsushikawa (1998) used this strategy on training calligraphy. After using this system, student's trajectories resembled more and more to those of the teacher's. So they judged that there was some positive effect of Japanese handwriting learning by using the haptic system. However, on this experiment, they did not give a full evaluation and statistical analysis on the training result. Solis et al. (2002) built a similar skill transfer system based on the same strategy, besides they increased the flexibility ratio of users, added a real-time capability of understanding the user movements, changed their behaviors as dynamic response to user inputs. This system is so called a bi-directional skill transfer system which can guide users dynamically. Meanwhile, Teo et al. (2002) used a 6-DOF haptic to develop a Chinese handwriting teaching system. They detailed the learning process into motion guidance and path guidance, and quantified the performance assessment included shape, motion, force and smoothness. Bluteau et al. (2008) made a further research on the effects of two types of haptic guidance-control in position (HGP) and in force (HGF), also on the basis of “play-and-record”. A statistical analysis was made to evaluate the difference of number of velocity peaks, mean

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velocity, and shape matching score before and after haptic training. Result showed that HGF improved performances whereas HGP and NHG (non haptic guidance) showed no significant improvement.

From all these researches above, the strategy of “record-and-play” has been applied extensively. All of them lay particular emphasis on either technique, or the comparison between difference learning processes. These learning processes were divided by different haptic-guidance mode, based on motion, path, position, and force. The quantitative indexes of performance assessment such as shape, motion, force and time were just used as evaluation criteria. Actually, all these quantitative indexes can be embodied in the learning process, which can vary numerically with a high level of precision. If we take these indexes as variables in haptic training process, we can study different effects on learning by changing them. Therefore, we can find a good learning method specifically with the use of haptic device.

In the training ways of using haptic guidance, according to the interaction between the user and haptic device, two general training methods can be divided: (Wu et al, 2007)

Passive mode: users use haptic device passively, the haptic device guides users to move under a pre-designed velocity, force, and path.

Active mode: users use haptic device on their own initiative and practive some movement, only when they deviate from the usual route, the haptic device will output a corrective force and compel them to go back.

In the two modes, the first one passive mode is normally used for beginners, and the second one, active mode, which gives major autonomy to users, would be better applied for intermediate or higher level.

In our experiment, our participants were all beginners to Chinese handwriting. Therefore, in the main, we used the passive mode. Specifically, we chose the velocity as variable, based on a haptic guidance control in position mode (Bluteau et al, 2008), and studied the influence on learning Chinese handwriting from changing different velocity mode. Two different velocities were designed in this haptic guidance, variable and constant velocity modes. After using this haptic device in different velocity, the results are evaluated to see which one benefit the handwriting learning better. Also, another purpose is to see if using haptic device to learn a Chinese character will influence the other characters that have the common strokes.

2 METHOD

This experiment has three main parts: pre-test, haptic-training, and post-test. During the pre-test and post-test, a tablet (wacom) is used, all the writing data on the tablet are recorded. During the haptic-training, a haptic device (phantom omni) is used to help teach participants how to write Chinese characters. This haptic device moves in two different speed mode based on predefined program. The first mode is called c-v mode. In this mode, a constant velocity is first used, and then a variable velocity is secondly used. Another mode is named v-c mode. In this mode, a revise order of velocity mode is used, that is, a variable velocity at first and a constant velocity second. By analyzing and evaluating the different data collected from pre-test and post-test, we can study the influence factors of using haptic device for handwriting learning and achieve our purpose.

2.1 Participants

Seventeen adults between the ages of 20 and 44 years old participated in this study. All of them came from Ecole des Mines de Nantes, France. They were divided into two groups (8 participants and 9 participants in each group) in this experiment. One group was constant-variable-tested group (c-v group), and the other group was variable-constant--tested group (v-c group). All these Participants had never learnt Chinese writing before.

2.2 Experimental Setup

The experimental setup included a tablet (wacom) to collect the writing data from participants, a computer screen for showing traces, a haptic arm (a phantom omni with six degrees of freedom which can move in different speed based on predefined program.) to teach the writing movement of participants, and another computer screen for simulating the paper sheet. (See figure. 1) 3 basic Chinese characters were used in this experiment: 歹(dai), 反(fan), 瓦(wa).

2.3 Procedure

Mainly, this experiment contained three parts: pre-test, haptic-training, and post-test (post-test 1 and post test 2). The schematic view of this experiment can be shown in figure 1.

The first step was pre-test. During the pre-test, participants were asked to write freely on a digital tablet (Wacom) and to try their best to write. The order of strokes in each character was not given to participants. Every time when the participant was writing, a model of character was shown on the side. By observing the standard model, participant tried to write the same character on the tablet freely. Totally, there were three Chinese characters to write, and each character should be written for 3 times. These three characters were tested and verified to be proper for beginners. They were neither too hard nor too easy to learn. The criterions included the character shape, the speed and the time of writing. During the process of pre-test, the positions of the pen and the time of writing each character were recorded.

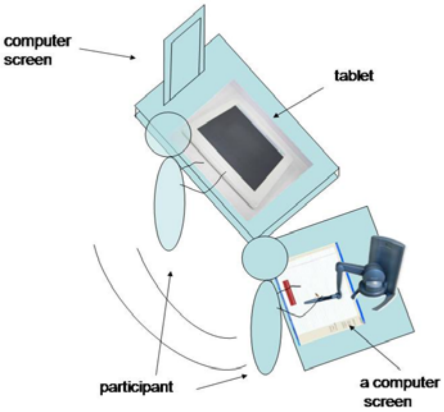

Figure 1: Schematic view of this experiment.

The second step was Haptic-training for the two groups. Participants were asked to write passively along with a haptic arm on a horizontal screen. It is note that the pen (haptic arm) nearly touched the video screen. One group was asked to choose the c-v mode and the other was asked to choose v-c mode. The haptic arm moved under a programmed trajectory and moved either in constant speed or in variable speed according to the chosen mode. Therefore, the participants' hand moved along with the haptic arm in two ways. During this part, only the first character (歹(dai)) was used. Compare to the other two ones, the character (歹(dai)) has the most common strokes. It is can be used to assay whether the haptic interface can help to learn writing different Chinese characters when the character patterns are similar. After writing this character for 20 times, the participant could go on to do the post-test part.

In the third part of post-test, the whole procedure was the same as in the pre-test. The participants were asked to write three Chinese characters freely on the same digital tablet. Then, they were asked to do haptic-training again but chose the reverse velocity mode. Therefore, the participants did the haptic-training and post-test again with different velocity mode.

After one week, the same group did the same post-test again for memory checking. Finally, we can receive all the writing data from both before and after haptic-training. Hence, the data can be used for analysis and evaluation.

3 RESULT

In both two groups of c-v and v-c, for each parameter, a paired samples T-Test was performed on the periods of pre-test and after-first-test (1vs2); pre-test and after-second-test (1vs3); pre-test and after-one-week-test (1vs4); after-first-test and after-second-test (2vs3); after-second-test and after-one-week-test (3vs4)); after-first-test and after-one-week-test (2vs4). For each parameter and period of test, an independent samples T-Test was performed on the c-v group and v-c group. For each analysis, a significance level of 0.05 was chosen.

By using the formula of paired samples t-test, the result of t and S_d can be calculated, and then p can be observed. If $p>0.05$, we can say that there are no differences statistically significant between the two samples.

In this test, in c-v group, we have 9 participants; in v-c group, we have 8 participants. Therefore, by using formula of independent samples T-Test, $n_1=9$, $n_2=8$. If $|t| < t_{0.05,\ 15}=2.131$, there is no significant difference between the two groups.

3.1 Shape

We evaluated the shapes by analyzing all strokes in each character. The perfect score of each character is defined as 1. The closer to 1, the better score of writing shape is.

By using independent samples T-Test, compare the writing of "dai" between the c-v group and v-c group, we get the result that, at the time of pre-test (condition 1), $|t| =0.276328545< t_{0.05,\ 15}=2.131$, there is no significant difference between c-v group and v-c group. Therefore, we can consider that the two groups are the same in condition 1; they are the samples from the same population.

Then by using paired t-test function in Excel, tables can be shown

Table 1: Paired t-test result of "dai" in c-v group.

t test	1 vs2	1 vs3	1 vs4	3 vs4	2 vs3	2 vs4
dai	0.31216	0.012374	0.873495	0.059838	0.076089	0.05983

Table 2: Paired t-test result of "dai" in v-c group.

t test	1 vs2	1 vs3	1 vs4	3 vs4	2 vs3	2 vs4
dai	0.364505	0.278837	0.291005	0.801831	0.884975	0.89517

In the two tables, all the values below 0.05 are coloured in red, which indicate the significant difference between two paired samples.

From the two tables above, comparing condition 1 and condition 3, the c-v group has a distinct increase, which has statistical significances in the conditions ($p=0.012374<0.05$). While at the same situation, there is no significant difference between condition 1 and condition 3 in v-c group. Therefore, after second-test, we can say that the c-v group increases more performance than v-c group. In pre-test, the average score of shape was 0.9 and 0.915625 for the c-v group and v-c group. After second-test, the average score was 0.947222 for the c-v group and 0.93125 for the v-c group.

In the same way, by using independent samples T-Test, compare the writing of "fan" between the c-v group and v-c group, we get the result that, at the time of pre-test (condition 1), $|t| = 2.32474 > t_{0.05, 15}=2.131$, there is a significant difference between c-v group and v-c group. That is to say, the starting values of two groups are quite different. Therefore, we do not compare these conditions anymore; instead, we compare the difference between every two conditions. Specifically, we compare condition2-condition1 (c2-c1), condition3-condition1 (c3-c1), condition4-condition1 (c4-c1), condition3-condition2 (c3-c2), condition4-condition3 (c4-c3) in the two groups. The two groups have been compared on the base of the difference between every two conditions.

Table 3: Paired t-test result of "fan" in c-v group.

t	c2-c1	c3-c1	c4-c1	c3-c2	c4-c3
fan	0.529841	1.611441	0.586308	1.967912	-1.72276

Because from all the t values in the table, $|t| < t_{0.05, 15}=2.131$. Therefore, we can say that there are no significant differences of between-conditions in c-v group and v-c group. In another word, no matter what kind of training is made, there is no significant effect on shape of writing "fan".

Then, by comparing the two groups of writing "wa", same result is gotten. No matter what kind of training is made, there is no significant effect on shape of writing "wa".

To sum up, when the participant writes "dai", considering the shape of characters, the first constant then variable velocity training mode is better than the reverse mode. For the other two characters, by using the haptic device, no significant effect has been made.

3.2 Velocity

For all the three characters: "dai", "fan", "wa" (歹，反，瓦), at pre-test, by using independent samples T-Test to compare the two groups, the t= -0.90729, -1.83878, -1.9627. All the $|t|$ are smaller than $t_{0.05, 15}=2.131$. There are no significant differences between the group c-v and group v-c at the beginning, no matter which character is written. Therefore, we can consider that the writing velocity of two groups is the same in condition 1; they are the samples from the same population. Then in the test conditions, all these conditions were tested paired. We can find out that all the p value are bigger than 0.05. That is to say, there is no significant difference between any two conditions.

To sum up, by testing velocity, no statistical significant result can be found. In another word, the two velocity modes haptic training methods have no significant effect on changing velocity of handwriting.

3.3 Size

For all the three characters: "dai", "fan", "wa" (歹，反，瓦), at pre-test, by using independent samples T-Test to compare the two groups, the t= 0.704133, -0.28657, 0.599112; all $|t| < t_{0.05, 15}=2.131$. There are no significant differences between the group c-v and group v-c at the beginning, no matter which character is written. Therefore, we can consider that the writing size of two groups is the same in condition 1; they are the samples from the same population. Then in the test conditions, all these conditions were tested paired. All these p values are bigger than 0.05. That is to say, there is no significant difference between any two conditions.

To sum up, by testing size, no statistical significant result can be found. In another word, the two velocity modes haptic training methods have no significant effect on changing size of handwriting.

3.4 Order

Every Chinese character has many strokes, only when all the strokes are written in right order, we can say that the order of the character is good.

Therefore, we define the good order as 100%, the score of order is equal to $n_{right\ strokes}/n_{all}*100\%$ ($n_{right\ strokes}$=number of all strokes in one character, n_{all}=the whole number of strokes in one character).
For the training of writing "dai":

Table 4: Paired t-test result of "dai" in c-v group.

t test	1vs 2	1vs 3	1vs 4	3vs 4	2vs 3	2vs 4
dai	0.10378	0.10378	0.10378	-	-	-

Table 5: Paired t-test result of "dai" in v-c group.

t test	1vs 2	1vs 3	1vs 4	3vs 4	2vs 3	2vs 4
dai	0.10355	0.10355	0.10355	-	-	-

All the p>0.05, it seems that there is no significant difference between every two conditions. However, if we have a look at the original data, it is clear that, at the very beginning, there were just a little participants wrote "dai" in wrong order, but no matter what order was at pre-test, after the first training, it turns to 100%, which is the good order. After, it stays the same. We can tell that, the first-test is good. However, we cannot find if the following tests are even better because all the data stays the same as 100%.
For the training of "fan":

At pre-test, by using independent samples T-Test to compare the two groups, the t= -0.66323, |t|= 0.66323< $t_{0.05,\ 15}$=2.131. There is no significant difference between the group c-v and group v-c at the beginning. Therefore, we can consider that the writing order of two groups is the same in condition 1; they are the samples from the same population. Then in the test conditions, all these conditions were tested paired. We can find out that all the p value are bigger than 0.05. That is to say, there is no significant difference between any two conditions. In another word, the two velocity modes haptic training methods have no effect on improving the writing order of "fan".

For the training of "wa", the exactly same test was done, the result is the same: the two velocity modes haptic training methods have no effect on improving the writing order of "wa".

To sum up, the training has good effect on improving the order of "dai", but no effect on the other two characters.

3.5 Inair Time

By using independent samples T-Test, compare the writing of "dai" between the c-v group and v-c group, we get the result that, at the time of pre-test (condition 1), |t| =1.063509< $t_{0.05,\ 15}$=2.131, there is no significant difference between c-v group and v-c group. Therefore, we can consider that the two groups are the same in condition 1; they are the samples from the same population.

Then by using paired t-test function in Excel, tables can be shown:

Table 6: Paired t-test result of "dai" in c-v group.

t test						
p	1vs 2	1vs 3	1vs 4	2vs 3	3vs 4	2vs 4
dai	0.05291	0.03750	0.08882	0.70922	0.87224	0.98271

Table 7: Paired t-test result of "dai" in v-c group.

t test						
p	1vs 2	1vs 3	1vs 4	2vs 3	3vs 4	2vs 4
dai	0.41000	0.16435	0.09308	0.03659	0.64397	0.09843

By using paired t-test in each group, compare condition 1 and condition 2, the c-v group almost has a significant increase, with p=0.052916 approach to 0.05. While at the same situation, there is no significant difference between condition 1 and condition 3 in v-c group. Therefore, after first-test, we can say that constant velocity mode gets significant improvement. In pre-test, the average inair time was 3.35 and 2.41 for the c-v group and v-c group. After second-test, the average score was 1.95 for the c-v group and 1.95 for the v-c group. Compare condition 1 and condition 3, the c-v group has a distinct increase, which has statistical significances in the conditions (p=0.037507<0.05). While at the same situation, there is no significant difference between condition 1 and condition 3 in v-c group. Therefore, after-second-test, we can say that the c-v group gets significant improvement.. In pre-test, the average inair time was 3.35037 and 2.414167 for the c-v group and v-c group. After second-test, the average score was 1.905 for the c-v group and 1.635208333 for the v-c group. Again, by using paired t-test in each group, compare condition 2 and condition 3, the v-c group has a distinct increase, which has statistical significances in the conditions ($p=0.036594<0.05$). While at the same situation, there is no significant difference between condition 2 and condition 3 in c-v group. Considering the condition 2, $|t|=0.00089< t_{0.05, 15}=2.131$, there is no significant difference between c-v group and v-c group at that time. In condition 2, the inair times of two groups are almost the same. Therefore, from condition 2 to condition 3, we can say that the v-c group gets better results, compared to c-v group. After second-test, the average inair time was 1.949074074 and 1.949375 for the c-v group and v-c group. After second-test, the average score was 1.905 for the c-v group and 1.635208333 for the v-c group. Specifically, since in condition 2, the c-v group and v-c group are almost the same, from condition 2 to condition 3, the c-v group chose variable velocity mode, while at the same time, the v-c group chose constant velocity mode, therefore, the difference shows that constant velocity mode increased more performance than variable velocity mode in this situation.

In the same way, by using independent samples T-Test, compare the writing of "fan" between the c-v group and v-c group, we get the result that, at the time of pre-test (condition 1), $|t|=1.412317<t_{0.05, 15}=2.131$, there is no significant difference between c-v group and v-c group. Therefore, we can consider that the two groups are the same in condition 1; they are the samples from the same population.

By using paired t-test function in Excel, tables can be shown

Table 8: Paired t-test result of "fan" in c-v group.

t test						
c-v	1vs 2	1vs 3	1vs 4	2vs 3	3vs 4	2vs 4
fan	0.734949	0.123727	0.117448	0.260535	0.42913	0.28699

Table 9: Paired t-test result of "fan" in v-c group.

t test						
v-c	1vs 2	1vs 3	1vs 4	2vs 3	3vs 4	2vs 4
fan	0.013806	0.152893	0.194225	0.47573	0.624437	0.35279

And then, by using paired t-test in each group, compare condition 1 and condition 2, the v-c group has a distinct increase, which has statistical significances in the conditions ($p=0.013806<0.05$). While at the same situation, there is no significant difference between condition 1 and condition 2 in c-v group. Therefore, after first-test, we can say that the v-c group gets significant improvement, compared to c-v group. That is to say, the variable velocity mode training increases performance in this situation for reducing inair time. In pre-test, the average inair time was 3.33 and 1.66 for the c-v group and v-c group. After first-test, the average score was 2.77 for the c-v group and 1.12 for the v-c group.

For the three character of "wa", at pre-test, by using independent samples T-Test, t= 1.462937, $|t|1.462937< t_{0.05, 15}=2.131$. There is no significant difference between the group c-v and group v-c at the beginning. Therefore, we can consider that the inair time of writing in the two groups is the same in condition 1; they are the samples from the same population. Then in the test conditions, all these conditions were tested paired. All these p values can be seen in the following tables.

By using paired t-test function in Excel, tables can be shown

Table 10: Paired t-test result of "wa" in c-v group.

t test						
p	1vs 2	1vs 3	1vs 4	2vs 3	3vs 4	2vs 4
wa	0.70851	0.17525	0.29843	0.37326	0.76007	0.42091

Table 11: Paired t-test result of "wa" in c-v group.

t test						
p	1vs 2	1vs 3	1vs 4	2vs 3	3vs 4	2vs 4
wa	0.49737	0.14663	0.62358	0.21675	0.86009	0.73816

From the two tables above, we can find out that all the p value are bigger than 0.05. That is to say, there is no significant difference between any two conditions. In another word, the two velocity modes haptic training methods have no significant effect on reducing inair time of handwriting "wa".

4 CONCLUSIONS

Our purpose of this study is to evaluate the advantage of using haptic device on learning, to determine what kind of velocity mode benefits the handwriting learning, and to see if use of haptic device in learning a given Chinese character could influence learning of other characters with common strokes. Therefore, a good Chinese handwriting learning method with haptic interface may be found. In order to answer these questions, a haptic interface including a haptic device (phantom omni) and tablet was used to teach beginners to write. By comparing all the five parameters in section 3 and three Chinese characters, we can get the result that, when the haptic device is used to learning a specific Chinese character, in order to improve shape or decrease inair time, c-v mode shows statistical significance and increases performance; separately, constant velocity mode gets better improvement than variable velocity mode with haptic learning. For writing velocity or size, no significant effect can be made. Using haptic device to learn a Chinese character writing nearly cannot influence the other characters that have the common strokes. Only after variable velocity mode training, the inair time of writing similar characters may reduce.

This experiment is using visuo-haptic interface under different velocity mode. The test of non-visual will be evaluated in future experiment.

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