Comparing Haptic and Visual Training Method of Learning Chinese Handwriting with a Haptic Guidance

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Abstract—**In this paper a use of haptic and visual training for Chinese handwriting learning is investigated. Participants learned a given character under three training conditions (haptic, visual, haptic-visual) and were required to write the given character plus two characters with common stokes on a tablet before and after training for improvement comparison. Performance was measured in terms of mean speed, inair time, size, order, and shape. Findings from this study indicate that visual information provides benefits for learning writing shape, while haptic information showed significant improvement in the transfer of shape learning. The combination of visual and haptic information helped to reduce air time, and showed better results than only visual information**

Index Terms—-**haptic, motor learning, human computer interaction**

I. INTRODUCTION

Motor learning is a set of processes associated with practice or experience leading to relatively permanent changes in the capability for responding [1]. Learning handwriting involves mainly two chief means of ways: through observation or through training by a teacher [2].

In the context of handwriting, learning usually means visual observation. However, some studies have shown that participants improve their performance as much with motor training than with learning by visual observation [3, 4]. Weeks and Anderson also showed that repeated observation of models before and at the start of practice improve participants' performance [5]. Training by a teacher can be termed as a handwriting skill transferred from teacher to students. In a similar way, a robotic teacher can be used to assist a real teacher, and transfer writing skills. The main idea is to record teacher's characteristics related to handwriting skills such as position and kinematics of the writing trajectories. Then you can replicate the same information to the student with a robotic arm. This strategy is called "record-and-play". Based on this strategy, a large number of researches have been done: A study deals with the possibility of skill mapping from human to human via a visual/haptic display system [6]; a robotic teacher to ensure undistorted hand-eye coordination [7]; a haptic virtual reality technology for transferring a teacher's skill to a student [8]; an interactive haptic interface to improve Japanese handwriting [9]; and a haptic guidance in position and force. [10]. All of these studies above seem to show the advantage of using haptic device. However it is important to note that they used both haptic and visual sense together and did not compare the different effects between these two information.

Based on a haptic guidance originally made by Bluteau et al. [10], we built a haptic-visual interface which record teacher's writing skill (position, speed), and apply it to students [11] (Figure 1). By using this interface, an experiment has been done to assess the respective advantages of visual, haptic, and visual-haptic training on the performance of students in learning Chinese handwriting characters. (Figure 2)

Another purpose of this experiment was to determine whether training a given Chinese character could

influence learning of other characters with common strokes in these three different training methods.
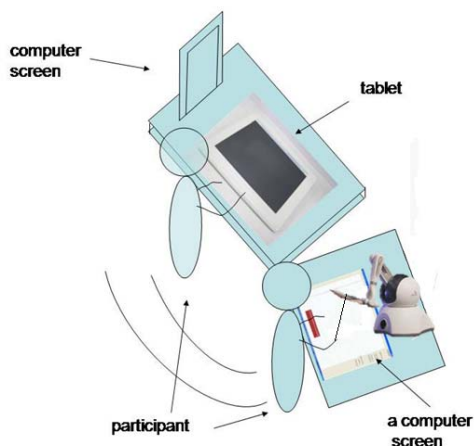

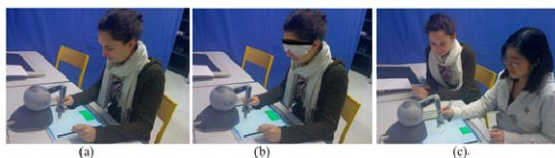Figure 1. Schematic view of the experiment

Figure 2. The three Training Methods of training 1: haptic-visual (a), haptic (b), visual (c)

II. METHOD

A. Participants

39 students between the ages of 17 and 23 years old participated in this study. All of them were engineering students from Ecole des Mines de Nantes, France. They were divided into three groups in this experiment. One group was haptic only group (h group n = 9), one group was visual only group (v group n = 10), and the other group was haptic-visual group (h-v group n= 10). All participants were naïve concerning Chinese handwriting.

B. Material

The experimental setup included a digital tablet (wacom®) to collect the writing data from participants, a computer screen in orderto display traces, a haptic arm (a phantom omni® with six degrees of freedom) to teach the writing movement of participants. 3 basic Chinese characters were used in this experiment: 歹(dai), 反(fan), 瓦(wa).

C. Procedure

The experiment was divided in 3 periods: Pre-test, Training and Post-test. Only during training process, procedure was different in each experiment. More accurately, the experiment sequence is: ①pre-test, ② training1, ③post-test1, ④training2, ⑤post-test2, ⑥post-test3.

● ①Pre-test:

During the pre-test, participants were asked to write the three Chinese characters on a digital tablet (three times for each character). No time constraint was imposed to the participants.

● Training:

This training had two parts. Participants were divided into three groups corresponding to each training mode that based on the sensory modality used for learning (see Figure 2). One group was haptic only group (h group, 9 subjects), one group was visual only group (v group, 10 subjects), and the other group was haptic-visual group (h-v group, 10 subjects).

● ②Training 1:

In the h-v group, subjects were asked to watch the motion and write passively along with a haptic arm on a horizontal screen. The haptic arm moved under a programmed trajectory and speed (constant speed). During this part, only the first character (歹(dai)) was used. After writing this character for 20 times in constant speed, the subject could go on to do the post-test part.

In the v group, subjects had only visual training; they watched a teacher, who sat on the left side of subject and hold the haptic arm to write. Thus, subject can have a optimal view of all teacher's movement. Before continue to the post-test, they had to visually observe this motion in constant speed for 20 times.

In the v group, participants were blindfolded and her/his hand was guided through the correct motion by the haptic arm again and again for 20 times in constant speed.

● ③Post-test1:

The whole procedure was the same as in the pre-test. The subjects were asked to write three Chinese characters freely on the same digital tablet.

● ④Training2:

The same as training1, only the training speed was changed from constant to real standard writing speed recorded from a teacher. The training times are always 20 in each group.

● ⑤Post-test2:

The whole procedure was the same as in the pre-test. The subjects were asked to write three Chinese characters freely on the same digital tablet.

● ⑥Post-test3(after one week):

The same group did the same post-test again for checking retention of skills. Finally, the data can be used for analysis and evaluation.

Therefore, there were two times post-test during training process: post-test1 (after Training 1) and post-test2 (after Training 2), and one time's post-test3 after one week.

III. RESULTS

Five measures of performance were used: mean speed, inair time (pausing time in air during writing), size, order, and shape.

Repeated measured ANOVA, Mauchly's sphericity test, and One-sample t-test were used. For each analysis a significance level of 0.05 was chosen.

A. Learning character "dai"

● Shape

By using one-sample t-test in each group, some change in every group can be seen in Figure 3. The v group and h-v group got significant improvement after training (t(9)=2.890, and t(9)=3.543 respectively for post-test2-pre-test(post-test2 minus pre-test) of v group and h-v group; p<.05), and also decreased significantly after one week (t(9)=-2.272,and t(9)=-2.499 respectively for post-test3-post-test2(post-test3 minus post-test2) of v group and h-v group; all p<.05), whereas in h group, no significant improvement was found after training (t(8)=1.569; p>.05) but decreased significantly after one week (t(8)=-9.436; p<.05). Neither significant effect between groups (F(2,26)=1.586, p>.05) nor significant interaction between the period and the group (F(2,26) = 1.525, p>.05) was observed. From these statistical analyses, we can conclude that haptic plus visual and visual only showed good effect on learning writing shape, and the combination of the two sensory informations did not show better significant effect than individual only.
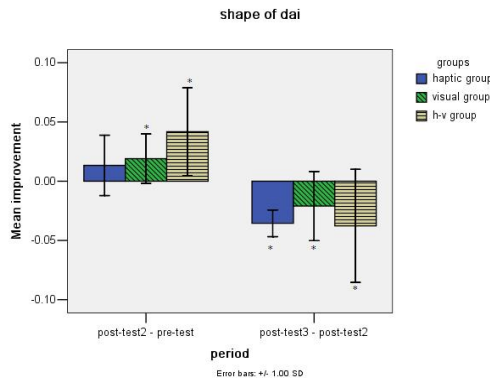

Figure 3 shape of dai change in h, v, and h-v group
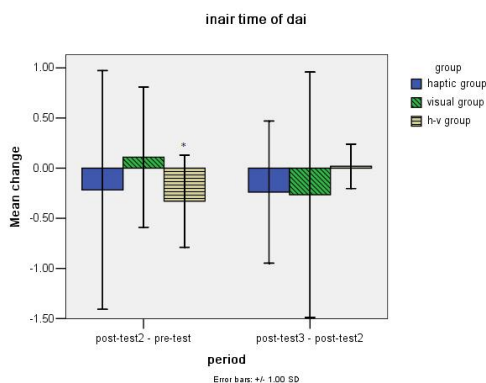*: significant result

Figure 4 inair time of dai change in h, v, and h-v group

● Inair time:

By using one-sample t-test in each group, some change in every group can be seen in Figure 4. Concerning the haptic and v groups, no significant improvement had been found after each training period, (all p>.05) whereas in h-v group, only after post-test2, the writing of inair time decreased significantly (t(9)=-2.261; p=.05). Neither significant effect between groups (F(2,26)=0.149, p>.05) nor significant interaction between the period (F(2, 26) = 1.011, p>.05) and the group was observed. From these

statistical analyses, we can conclude that haptic only or visual only showed no effect on learning writing fluency, while the combination of these two had significant effect on learning.

● Velocity:

By using one-sample t-test in each group, some change in every group can be seen in Figure 5. In h group, the writing speed changed significantly after post-test2 and one week after training (t(8)=-2.729, and t(8)=3.695 respectively for post-test2-pre-test and post-test3-post-test2; all p<.05), in v group and h-v group, the speed only changed one week after training (t(9)=-3.629, and t(9)=4.535 respectively for post-test3-post-test2 of v group and h-v group; all p<.05) but no changed after training (t(9)= -0.083, and t(9)=0.480 respectively for post-test2-pre-test of v group and h-v group; all p>.05). Neither significant effect between groups (F(2,26)=1.638, p>.05) nor significant interaction between the period and the group (F(2, 26) = 3.231, p>.05) was observed. We cannot simply say that h group had better result than visual and h-v group, because the average change in h group was less than zero, which resulted in no improvement but even retroaction. None of the three groups had significant improvement immediately after training. Then after a rest period of one week, the writing speed in all groups increased. Thus, haptic only or visual only showed no effect on learning writing speed immediately after training; even the combination of these two sensory was the same. After a rest period of one week, the three groups had the same improvement.
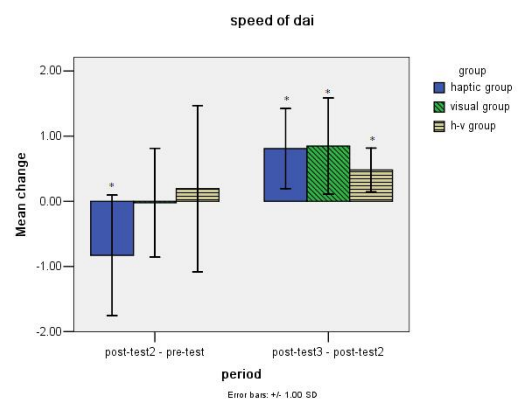

Figure 5 speed of dai change in h, v, and h-v group

● Size:

By using one-sample t-test in each group, some change in every group can be seen in Figure 6. No significant change of size were found in all the three groups instantly after training (t(8)=-0.019, t(9)=-0.783, t(9)=0.889 respectively for post-test2-pre-test of h group, v group, and h-v group; all p>.05). After one week, the size of character only increased significantly in v group (t(9)=2.551; p<.05), but not in haptic or h-v group (t(8)=-0.509and t(9)=-0.041 respectively for post-test3-post-test2 of haptic and h-v group; all p>.05). Thus, haptic only or visual only showed no effect on learning writing size instantly after training; even the combination of these two sensory was the same. Neither significant effect between

groups ($F_{(2,26)}$=1.186, p>.05) nor significant interaction between the period and the group ($F_{(2, 26)}$ = 2.44, p>.05) was observed.
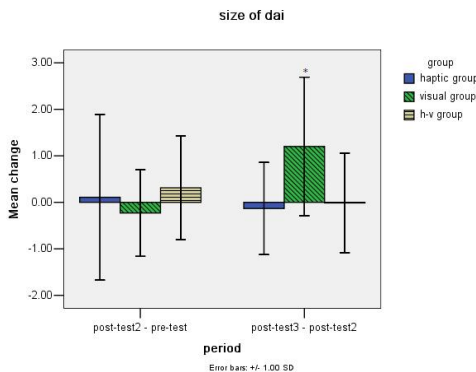

Figure 6 size of dai change in h, v, and h-v group

● Order:

Neither significant effect between groups ($F_{(2,26)}$=0.235, p>.05) nor significant interaction between the period and the group ($F_{(2, 26)}$ = 1.292, p>.05) was observed.

B. Transfer skills ("fan" & "wa")

● Shape
  ● Fan:

Regarding the writing shape of "fan" during the training period, a significant interaction between the period and groups was observed ($F_{(2, 26)}$ = 4.838, p<.05). Only h-v group had better improvement than v group after training and after one week ($F_{(2,26)}$=3.683 and $F_{(2,26)}$=3.883 respectively for post-test2-pre-test and post-test3-post-test2; all p<.05). However, by using one-sample t-test in each group, the improvements of them can be seen. In details, the writing shape of "fan" improved significantly after haptic only training and h-v training ($t_{(8)}$=2.556,and $t_{(9)}$=2.410 respectively for post-test2-pre-test of haptic and h-v group; p<.05) and also changed for the worse significantly after one week ($t_{(8)}$=-3.921, and $t_{(9)}$=-2.449 respectively for post-test3-post-test2 of haptic and h-v group; p<.05), whereas after visual only training it had no significant improvement ($t_{(9)}$=-0.552, and $t_{(9)}$=-0.331 respectively for post-test2-pre-test and post-test3-post-test2; all p>.05).(Figure 7) From these statistical analyses, we can conclude that haptic only showed significant effect on transferring skills of writing shape concerning character "fan", and visual only even had negative effect on this transfer of skills. We can also suspect that the combination of the two reinforced the effect of haptic only and thus showed better performance than visual only. The transfer of skill cannot last long term after haptic only and h-v training. It would be forgotten after one week.

  ● Wa:

Regarding the writing shape of "wa" during the training period, a significant interaction between the period and groups was observed ($F_{(2, 26)}$ = 3.496, p<.05). h-v group got better effect than v group and h group ($F_{(2,26)}$=5.357, p<.05). However, by using one-sample t-

test in each group, the improvements of them can be seen in Figure 8. In details, the writing shape of wa improved significantly after training in h group and h-v group ($t_{(8)}$=5.292,and $t_{(9)}$=2.967 respectively for h group and h-v group; all p<.05), but no significant improvement in v group ($t_{(9)}$=0.156; p>.05). After one week, the score of writing shape only changed significantly in h group ($t_{(8)}$=-3.688; p<.05), but no significant change in visual and h-v group ($t_{(9)}$=-1.108,and $t_{(9)}$=-1.445 respectively for post-test3-post-test2 of visual and h-v group; all p>.05) From these statistical analyses, we can conclude that haptic only and haptic+visual showed significant effect on transferring skills of writing shape concerning character "wa", whereas visual only showed no significant effect. We can also suspect that, the combination of these two sensory reinforced the effect of single, which made haptic+visual the best one.
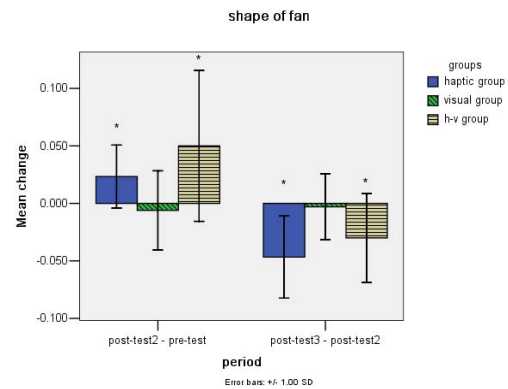

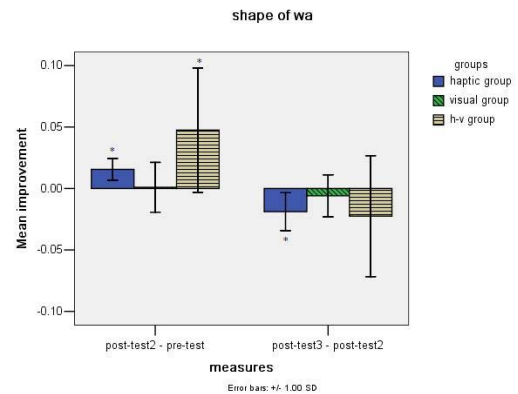Figure 7 shape of fan change in h, v, and h-v group

Figure 8 shape of wa change in h, v, and h-v group

● Inair time
  ● Fan:

By using one-sample t-test in each group, no significant changes of inair time were found in all the three groups after training(all p>.05) . Thus, haptic only or visual only showed no effect on transferring writing skill of inair time; even the combination of these two sensory was the same.

  ● Wa:

By using one-sample t-test in each group, no significant changes of inair time were found in all the three groups after training(all p>.05). Thus, haptic only or visual only showed no effect on transferring writing

skill of inair time; even the combination of these two sensory was the same.

- Speed:
  - Fan:

By using one-sample t-test in each group, some change in every group can be seen in Figure 9. The writing speed changed significantly after training only in h group (t(8)=-2.340; p<.05) whereas non-significantly in visual and h-v group (t(9)=-1.726,and t(9)=-0.476 respectively for post-test2-pre-test of visual and h-v group; all p>.05). One week after training, v group and h-v had significant change (t(9)=2.958,and t(9)=2.620 respectively for post-test3-post-test2 of visual and h-v group; all p<.05) whereas h group had non-significant change (t(8)=1.847; p>.05). However, we cannot say the training effect of haptic was better than visual or h-v, because none of these changes was good. All the groups decreased the speed after training. As to one week after training, h-v and v group speeded up compared to the decrease before. From these statistical analyses, we can conclude that haptic only or visual only showed no effect on transferring writing skill of speed; even the combination of these two sensory was the same.
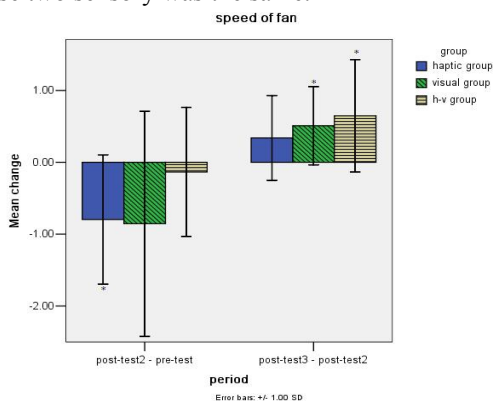

Figure 9 speed of fan change in h, v, and h-v group

- Wa:

By using one-sample t-test in each group, some change in every group can be seen in Figure 10. The writing speed changed significantly after training only in h group (t(8)=-2.778; p<.05) whereas non-significant improvement were found in visual and h-v group (t(9)=-1.552,and t(9)=0.333 respectively for post-test2-pre-test of visual and h-v group; all p>.05). One week after training, all the groups had significant change (t(8)=2.518, t(9)=2.257,and t(9)=2.982 respectively for post-test3-post-test2 of haptic, visual and h-v group; all p<.05) However, we cannot say the training effect of haptic was better than visual or h-v, because that change was below zero, which means there is also no improvement for writing speed in h group. As to one week after training, the three groups speeded up compared to the decrease before. From these analyses, we can conclude that haptic only or visual only showed no effect on transferring writing skill of speed; even the combination of these two sensory was the same. .

- Size:

- Fan:

By using one-sample t-test in each group, also no significant change of size was found in all groups after every trainings (all the p>.05).Thus, haptic only or visual only showed no effect on transferring writing skill of size; even the combination of these two sensory was the same.
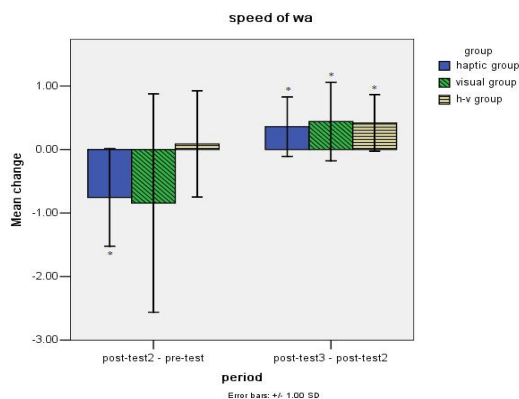

Figure 10 speed of wa change in h, v, and h-v group
*: significant result

- Wa:

By using one-sample t-test in each group, also no significant change of size was found in all groups after every trainings (all the p>.05). Thus, haptic only or visual only showed no effect on transferring writing skill of size; even the combination of these two sensory was the same.

- Order
  - Fan:

By using one-sample t-test in each group, no significant improvement was found in all groups after every trainings (all the p>.05). Thus, haptic only or visual only showed no effect on transferring writing skill of order; even the combination of these two sensory was the same.

- Wa:

By using one-sample t-test in each group, no significant improvement was found in all groups after every trainings (all the p>.05) . Thus, haptic only or visual only showed no effect on transferring writing skill of order; even the combination of these two sensory was the same.

IV. CONCLUSION

This pilot study seems to show that haptic information and visual information lay particular emphasis on learning different writing properties. Whereas Visual information provides benefits for learning writing shape, haptic information does not. However, in the transfer of shape learning, haptic information showed significant improvement while visual information did not. The combination of visual and haptic information helped to reduce air time, while the use of a single kind of sensory information had no significant effect. As for transferring the learning of shape, the use of bi-sensory input showed better results than only visual information .

In conclusion, the combination of these two types of sensory information is at least equal to the use of each on

its own. The effects of single sensory information suggest that visual information is useful to extract the shape properties of an object as a whole. It could be possible that, when the visual sense is used, the whole shape of character is shown to the learner. It is easy for people to consider the result of the movement alone, for example, the final writing shape, but not the dynamic process. Haptic information, in contrast, can be better for creating an internal model of the shape of each stroke separately in the brain that can then be used to do a new different character but with similar strokes, which is consistent with results showing significant transferring skills of writing shape concerning character "fan".

These results also indicate that the combination of both visual and haptic sensory information seems to be at least equal to the use of only one. It is important to note that this supposition has to be precise. However it seems that vision is suitable for considering the static result of a movement, while the haptic sense benefits the dynamic process of movement. When the two sensory inputs are used together, not only the process but also the result of movement can be learned. In addition, it is obvious from the results presented here that, while there is significant improvement after training using the bi-sensory approach, the improvement from at least one of the single sensory input is small. Presumably, when two types of sensory information are used together, the approach represents more than a simple sum of unisensory input; it is an enhanced integration. As unisensory performance levels were not equal in these experiments, the major benefit of bi-sensory integration was seen.

REFERENCES

[1] Richard A Schmidt, *Motor Control and Learning: A Behavioral Emphasis*. United States of America: Human Kinetics Publishers, 1988.

[2] Govindarajan Srimathveeravalli and Kesavadas Thenkurussi, *"y,"* in *World Haptics* 2005., 18-20 March 2005, pp. 452- 457.

[3] C M Heyes and C L Foster, *"Motor learning by observation: Evidence from a serial reaction time task,"* in *The Quarterly Journal of Experimental Psychology*, vol. 55, pp. 593 - 607, 2002.

[4] J H Howard, S H Mutter, and D V Howard, *"Serial pattern learning by event observation,"* in *Journal of Experimental Psychology: Learning, Memory and Cognition*, vol. 18, pp. 1029-1039, 1992.

[5] D L Weeks and L P Anderson, *"The interaction of observational learning with overt practice: effects on motor skill learning,"* in *Acta Psychologica*, vol. 104, pp. 259-271, 2000.

[6] Yasuyoshi Yokokohji, Ralph L Hollis, Takeo Kanade, Kazuyuki Henmi, and Tsuneo Yoshikawa, *"Toward Machine Mediated Training of Motor Skills-Skill Transfer from Human to Human via Virtual Environment,"* in *IEEE International Workshop on Robot and Human Communication*, 1996, pp. 32-37.

[7] E. Burdet,HP Lim CL Teo, *"A Robotic Teacher of Chinese Handwriting,"* in *Haptic Interfaces for Virtual Environment and Teleoperator Systems*, 2002.

[8] K Henmi and T Yoshikawa, *"Virtual lesson and its application to virtual calligraphy system,"* in *Robotics and Automation*, vol. VOL 2, 1998, pp. 1275-1280.

[9] Jorge Solis, Carlo A Avizzano, and Massimo Bergamasco, *"Teaching to write Japanese characters using a haptic interface,"* in *Haptic Interfaces for Virtual Environment and Teleoperator Systems*, pp. 255-262, 2002.

[10] Jeremy Bluteau, Sabine Coquillart, Yohan Payan, and Edouard Gentaz, *"Haptic Guidance Improves the Visuo-Manual Tracking of Trajectories,"* 2008.

[11] Min Xiong, Isabelle Milleville-Pennel, Cedric Dumas, and Richard Palluel-Germain, *"Learning Chinese handwriting with a haptic device,"* in *SCEDU2010- Proceedings of the 2nd International Conference on Computer Supported Education*, Valencia, Spain, 2010.

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