

Skill of Eye-Hand Coordination in Calligraphy - Difference of Skill of Hand-Eye Coordination between Expert and Novice -

Atsuo MURATA, Goshiro YAMAMOTO and Makoto MORIWAKA
Dept. of Intelligent Mechanical Systems, Division of Industrial Innovation Sciences,
Graduate School of Natural Science and Technology, Okayama University
3-1-1, Tsushimanaka, Kita-ku, Okayama-shi, Japan
E-mail: {murata, goshiro, moriwaka}@iims.sys.okayama-u.ac.jp

Abstract— A system that can simultaneously measure the movement of a brush tip and the eye-gaze position during a calligraphy task has been developed. The system consisted of a device to measure the location of a brush tip and an eye tracker. Using this system, the skill of hand-eye coordination was measured for an expert and novices. It has been clarified that an expert of calligraphy distributes the eye-gaze over a wider area and gazes in advance a part that should be written next. In other words, an expert does not gaze at the brush tip but at the part that should be written at the next stage.

1. Introduction

In order to understand the skill in calligraphy and make use of this for the proposal of an effective instruction method, the investigation of hand-eye coordination must be essential. Although there seem to be many approaches that made an attempt to develop an effective calligraphy instruction method, few studies paid attention to a hand-eye coordination skill. In calligraphy, we are much interested in how we gaze at paper and draw characters on paper.

Tchalenko et al. ^[1] and Miall and Tchalenko ^[2] investigated eye movement and voluntary control in portrait drawing, and compared eye-hand coordination between skilled painters and novices. They concluded that such an approach would be effective for the understanding of portrait drawing skill. In Proctor and Dutta ^[3] and Singley and Anderson ^[4], it is mentioned from the viewpoint of cognitive science that the coordination of visual input, interpretation and motor system is important to acquire skills. Vickers ^[5] compared eye-gaze location between expert and novice basketball shooters, and found that mean frequency, duration, location and onset of eye-gaze differed between two groups. In Vickers ^[5], however, the eye-hand coordination has not been discussed.

In this study, a system that can simultaneously measure the movement of a brush tip and the eye-gaze position during a calligraphy task has been developed in

order to understand the calligraphy skill. Using this measurement system, the skill of calligraphy was explored from the viewpoint of eye-hand coordination using an expert and novices.

2. Development of eye-hand coordination measurement system

The system consists of an eye tracking device (Nac Image Technology, EMR-AT VOXER) and a motion tracking system using electromagnetic field (Polhemus, FASTRAK). The motion tracking system enables us to measure the position of a receiver attaches to the brush tip.

Eye movement can be classified into compensatory and voluntary ones ^[6] (See Fig.1). The compensatory eye movement, which corresponds to involuntary movement, is based on a reflex, and stabilizes an image on the retina during head movement by producing an eye movement in the direction opposite to head movement. The voluntary eye movement includes pursuit movement and saccade. The pursuit movement is necessary to smoothly pursue moving objects. The maximum movement velocity during the pursuit movement is about 30 degrees/s. The saccade is faster than the pursuit movement, and its maximum movement velocity corresponds to 700 degrees/s.

During a blink, the eye tracker cannot measure a gaze location. In such a case, the eye gaze data was created using a linear interpolation. Eye movements include not only smooth pursuit and saccade but also miniature eye movement which corresponds to a noise for calligraphy. Therefore, the effects of miniature eye movement were reduced using a moving average technique. In this study, an emphasis was not paid on saccades. Only smooth pursuit eye movements were used to clarify the eye-hand coordination characteristics during a calligraphy task.

3. Method

3.1 Participants

One skilled and three novices took part in the experiment. The skilled participant has been teaching

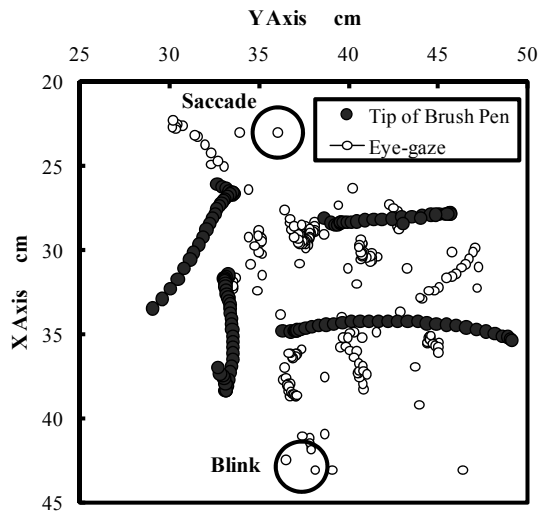


Fig.1 Problem of Saccade and Blink.

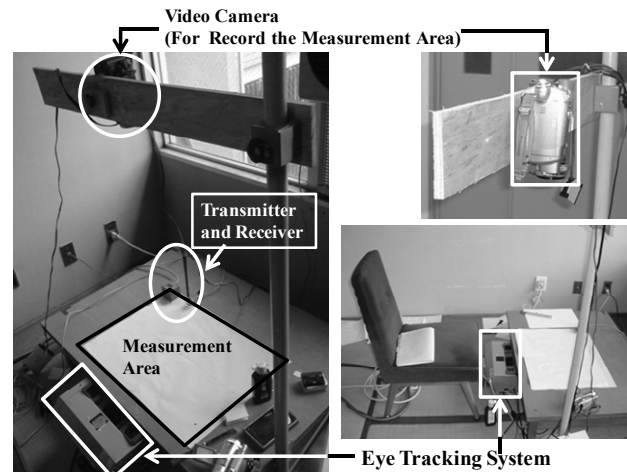


Fig.2 Outline of Experimental System.

calligraphy for 47 years. All were Japanese, and accustomed to writing Chinese characters (Kanji). All had normal vision, and were right-handed. Their dominant eye was right.

3.2. Apparatus

The same brush was used for all participants. The receiver of the motion tracking system (Polhemus, FASTRAK) was attached to the tip of brush. The location of brush tip was measured at the sampling frequency of 30 Hz. The eye-gaze location of eye tracking system (Nac Image Technology, EMR-AT VOXER) was measured at the sampling frequency of 60 Hz. The outline of experimental system is depicted in Fig.2.

3.3 Design and procedure

The task was to write predetermined six kinds of Kanji using a brush. Writing Kanji requires us to compose some strokes according to the type of Kanji.

First, participants were given some instructions about the experimental task. Before experiment started, the calibration of the eye tracking system was carried out. Then, a practice session was carried out so that the participants could get used to the experimental task. After the practice session, the experimental measurement started. The locations of eye-gaze and the brush tip were measured using the system outline above. The participants were not allowed to take a rest until all tasks (writing six Kanji characters) were completed.

3.4 Data analysis

The locations of each stroke and eye-gaze were plotted on the paper as shown in Fig.3-Fig.6. The location of each stroke was calculated on the basis of the end location of the brush and the location where the

paper is placed. When the location of the brush tip was lower than that of the paper, we can judge that the brush touches the paper. In other words, the participant is writing Kanji. The locations of brush tip when writing Kanji were extracted from the measured data series. The extracted data constitute the outline of a Kanji character as shown in Fig.5 and Fig.6.

The locations of eye-gaze before and after the Kanji writing task were examined in order to explore where the participant is looking at.

4. Results

4.1 Before a writing task

Fig.3 shows the locations (depicted by an open circle) of eye-gaze before writing a Kanji character for skilled expert. As a reference, the locations of brush tip during the writing task were also added to the scatter diagram. The skilled participant looked at the paper for about 4 s before he began to write a Kanji character. The location spreads over a wider area.

Fig.4 shows the similar data of eye-gaze for a novice participant. The novice participants, on average, looked at the blank paper for about 10-11s before beginning to write a Kanji character. Different from the skilled expert, the location of eye-gaze of a novice participant spread only a narrow area, that is, the starting point of 1st stroke. Similar tendencies were observed for other novice participants.

While the skilled expert tended to look at the wider area of the paper, the novices tended to look at only the area around 1st stroke.

4.2 During a writing task

The locations of eye-gaze (depicted by an open circle) and brush tip (depicted by a filled circle) during a

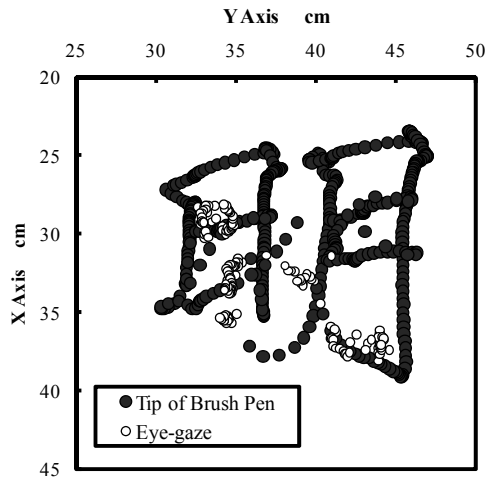


Fig.3 Skilled Subject's Measured Result before Skilled Task.

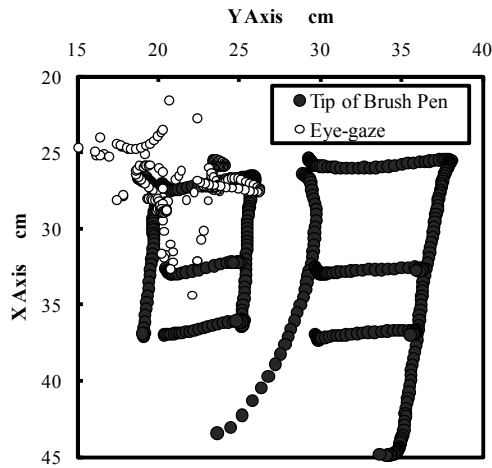


Fig.4 Unskilled Subject's Measured Result before Skilled Task.

writing task for skilled expert are shown in Fig.5. Here, the first, 3rd-4th and 5th strokes are depicted. It took about 1.8 s, 1.9 s, and 2.5 s to complete the first, 3rd-4th and 5th strokes, respectively. From Fig.5, it is clear that the skilled participant doesn't look at the stroke which he is trying to write, but look at the next stroke.

In Fig.6, similar locations of eye-gaze (depicted by an open circle) and brush tip (depicted by a filled circle) during a writing task for a novice participant are shown. It took about 2.3 s, 3.2 s, and 3.0 s to complete the first, 3rd-4th and 5th strokes, respectively. Different from the skilled participant shown in Fig.5, the novice consistently looks at the start point of each stroke.

5. Discussion

As pointed out by Pelz et al. [7], in skilled tasks such as portrait drawing and calligraphy, eye-hand coordination must play an important role in skill acquisition. Vickers [5]

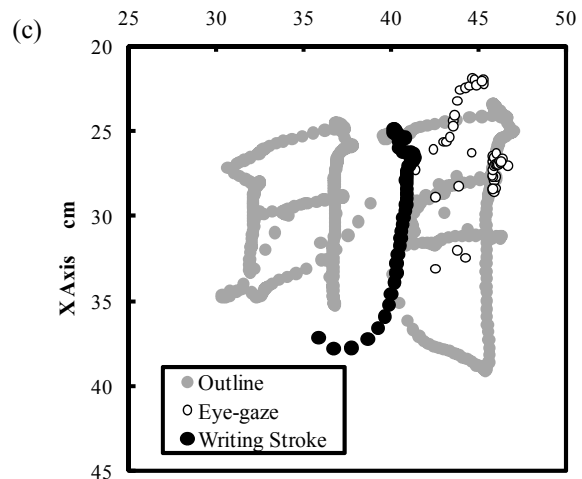
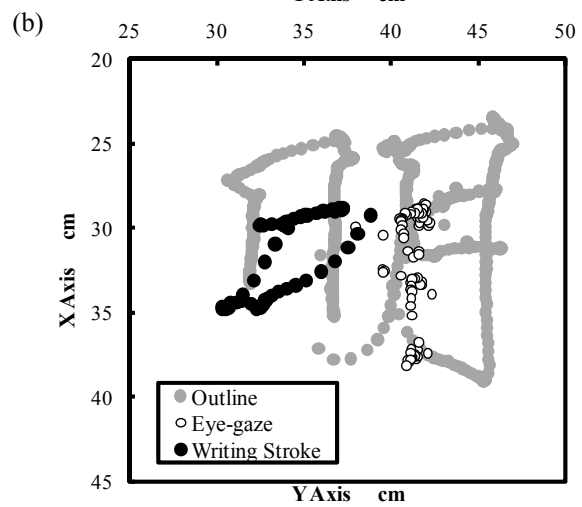
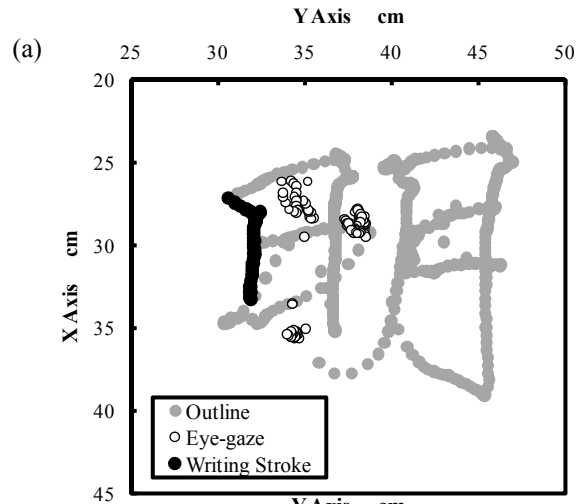


Fig.5 Skilled Subject's Measured Result during Skilled Task. (a) 1st Stroke, (b) 3rd and 4th Stroke, (c) 5th Stroke.

pointed out that eye movement characteristics of skilled player is different from that of novice players. Unfortunately, Vickers [5] did not discuss the hand movement. On the other hand, Tchalenko et al. [1] and

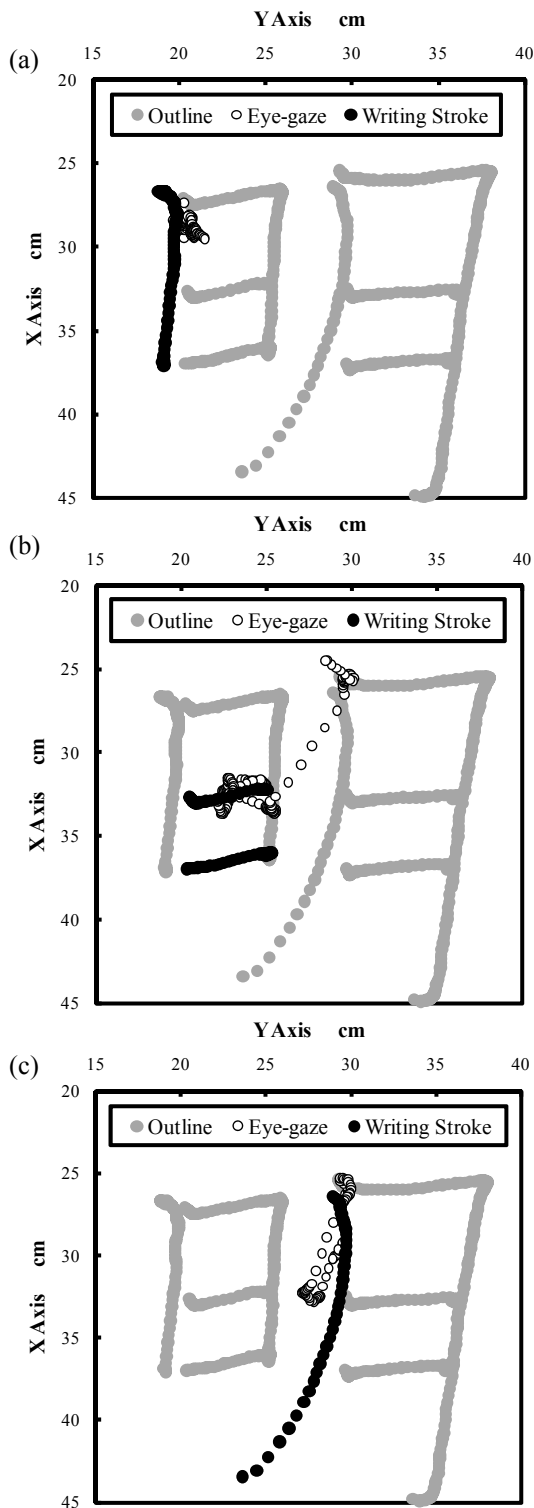


Fig.6 Unskilled Subject's Measured Result during Skilled Task. (a) 1st Stroke, (b) 3rd and 4th Stroke, (c) 5th Stroke.

Miall and Tchalenko ^[2] pointed out the importance of eye-hand coordination and examined eye movement characteristics during portrait drawing. Inferring from these studies, we assumed that effective eye-hand

coordination is essential in calligraphy, and developed a systems that can simultaneously measure the locations of eye-gaze and brush tip. Such a system enabled us to explore the characteristics of eye-hand coordination in more detail and systematically.

It seems that the eye-hand coordination strategy differs between the skilled and the novice participant (See Fig.3-Fig.6). The eye movement characteristics between skilled and novice participants differs not only during the writing task but also before the writing task. The skilled expert tends to look at the wider area of the paper before beginning to write a Kanji character. The novices, on the other hand, tend to look at only the area around 1st stroke. From this finding, we can conclude that skilled experts image the output of a Kanji character before starting to write, and such a skill may lead to skilled Kanji calligraphy.

Moreover, the skilled participant doesn't look at the stroke which he is trying to write, but look at the next stroke. In other words, experts seem to have a more predictive skill in calligraphy. In the area of baseball, it seems that skilled infielder or outfielder have such a predictive skill, and can catch up with a ball faster than novice players. Different from the skilled participant, the novice consistently looks only at the start point of each stroke. This is indicative of the less predictive characteristics of novices.

Future research should propose a method to master such a predictive skill in a short time. Saccade eye movements should be incorporated into the present research framework to obtain further insight into eye-hand coordination.

References

- [1] J.Tchalenko, L.Dempere-Marco, X.P.Hu and G.Z.Yang, Eye movement and voluntary control in portrait drawing, In J.Hyona, R.Radach, and H.Deubel (eds), *The Mind's Eye-Cognitive and Applied Aspects of Eye Movement Research*, Elsevier, 705-727, 2003.
- [2] R.C.Miall and J.Tchalenko, A painter's eye movements: A study of hand and eye movement during portrait drawing, *Leonard*, 34(1), 35-40, 2001.
- [3] R.W.Proctor and A.Dutta, *Skill Acquisition and Human Performance*, SAGE Publications, 1995.
- [4] M.K.Singley and J.R.Anderson, *The Transfer of Cognitive Skill*, Harvard University Press, 1989.
- [5] J.Vickers, Gaze Control in Basketball Foul Shooting, In J.Finley, R.Walker, and R.Kentridge (eds.), *Eye Movement Research: Mechanisms, Processes, and Applications*, Elsevier, 527-541, 1995.
- [6] R.H.S.Carpenter, *Eye Movements*, Macmillan Press, 1991.
- [7] J.Pelz, M.Hayhoe, and R.Loeber, The coordination of eye, head, and hand movements in a natural task, *Experimental Brain Research*, 139(3), 266-277, 2001.