Visual Behavior in a Japanese Drum Performance of *Gion* Festival Music

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Abstract. The purpose of this study was to focus on the gaze shift in a coordinated musical performance and experimentally clarify its role in the matched timing of the players. To summarize the results obtained in the present study, (1) the number of gaze shifts for the expert was less than that for the non-expert; (2) the expert's gaze shifts decreased significantly at the moment of a beat; (3) the expert did not turn his gaze on the drum surface, but turned his gaze between his drum and the opposite person's drum; and (4) the percentages of gaze location on the drum surface of the self and the drum surface of the opposite person were higher in the case of the non-expert.

Keywords: Gaze, percentages of gaze location areas, Expert, Non-expert.

1 Introduction

The "Gion Festival," which is considered to be one of Japan's three greatest festivals, is said to have begun in AD 869 in order to assuage an infectious disease that was prevalent in Kyoto at that time. When Kyoto City was devastated by the Onin War that broke out in the Muromachi period (15 century), the Gion Festival also stopped. However, citizens that later become more prosperous revived the festival. The parade of luxuriously and splendidly decorated floats, Yama-Hoko, is believed to have reached its present form around the same period, and the original style of Ohayashi (Japanese orchestras) called the Gion Festival Music is also said to have originated around this time. Of the 33 Yama-Hoko floats that currently paraded, 12 floats perform the Gion Festival Music, and the Yama-Hoko event of Kyoto Gion Festival was registered as an Intangible Cultural Heritage by UNESCO in 2009 (Figure 1).

The origin of the *Gion* Festival Music is considered to be the *Dengaku* Dance and *Rokusai Nenbutsu* Dance of the Medieval Period, but it is said that *Noh* and *Kyogen* also had a great influence on this dance, and that *Ohayashi*, incorporating a loud and cheerful gong (*Sho*) from the elegant spirit was established. The *Gion* Festival Music

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is characterized by the sound of gong, "*konchikichin*," and consists of three types of instruments, including the gong that beats a rhythm, the flute that carries the melody, and the drum that controls the tempo. The *Gion* Festival Music players are known as "*Hayashi-Kata*." Since each instrument is played by multiple *Hayashi-Kata* simultaneously, not only the high performance technique of each player, but also matching of the players' timing is required. In some music pieces of the *Gion* Festival Music, the speed of the music gradually changes, or sometimes nothing is played for several seconds in the middle of a piece, which can be very difficult to perform.

When multiple players perform together, the players need to adjust their timing by communicating with each other. A study on joint musical performances quantified the gap in timing between 2 piano players. Another study measured eye movements in a joint performances. When visual information is collected, an eye movement occurs to visually search the object or target area that contains necessary information and to capture the image of the object with the central retinal fovea. Eye movements in motion can be objectively observed, using a head mounted eye tracker, even if head movements are not restricted. A great deal of research on these shifts in the gaze has been conducted in the fields of music, including singing and playing instruments: It has been demonstrated that the scope of pre-reading a musical score, frequency of gaze fixation, and area of fixation are determined in relation to the phrases, chords, and counterpoint [1-8], and there are also studies that have examined joint violin performances.

However, with regard to performances that are passed down through oral tradition without musical scores and rules for the tempo, such as the *Gion* Festival Music, no research to date has studied the role of gaze shifts while playing from the viewpoint of timing adjustment. Therefore, the purpose of this study was to focus on the gaze shift in a coordinated musical performance and experimentally clarify its role in the matched timing of the players.

Fig. 1. Gion Festival (Kanko-Hoko)

2 Methods

2.1 Participants

Participants were 2 drum-*kata* (drum players) who belonged to the *Kanko-Hoko* Preservation Society. One of them was a 26-year-old male who had 21 years of experience in the *Gion* Festival Music with 5 years of drum experience, and the other participant was a 52-year-old male who had 42 years of experience in the *Gion* Festival Music with 34 years of drum experience. Although the former participant is a drummer at the *Gion* Festival, his 5 years of experience was the shortest of the drum-*kata* at the Festival. Therefore, he was treated as a non-expert, as opposed to the latter participant who was considered an expert. The participants had normal vision (20/20 vision or better, or corrected eyesight). We obtained the participants' informed consent prior to the experiment.

2.2 Experiment

In order to re-create the actual environment of the festival as far as possible, the experiment was conducted in *Kanko-Hoko* Building of the *Kanko-Hoko* Preservation Society that is used as a practice space by festival musicians. Practice drums were used, and 4 drum-*kata*, 8 flute-*kata*, and 10 gong-*kata* were arranged so that the situation would be identical to actual practice (Figure 2). Similar to a real performance, participants were to play face to face in Drum Position 4 (See Figure 2), so that they would be able to recognize each other's body motion.

A series of music pieces with a relatively slow tempo called "*Debayashi*," which are played on *Sijo-Dori*, the first main street of the *Yama-Hoko* parade in *Gion* Festival, were used in the experiment. The six music pieces, "*Komatsu*," "*Kagura*," "*Karako*,""*Hakusan*," "*Jibayashi*," and "*Waka*" were played continuously in that order, and *Komatsu* was analyzed.

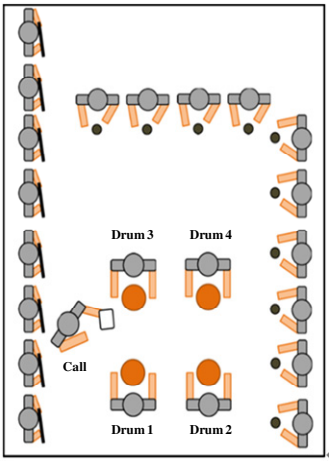
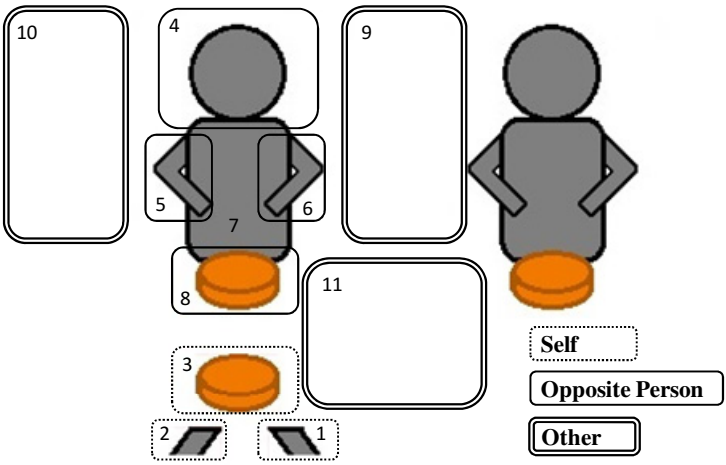


Fig. 2. Experimental environment

2.3 Acquisition and Processing of Gaze Data

Eye Mark Recorder (EMR-8, made by NAC, Tokyo) with a sampling rate of 60 fps recorded the eye movements of the participants. The viewing angle of Eye Mark Recorder was 90 degrees. The participants mounted the Eye Mark camera on their heads. A nine-point calibration was performed prior to the start of the experiment.

The gaze from the beginning till the end of the piece "*Komatsu*" was analyzed. Areas of gaze location were obtained using frame-by-frame analysis. The areas of gaze location were categorized into three major sections, "the self," "opposite person," and "others" (Figure 3). Furthermore, the self was divided into three subcategories: "right upper extremity," "left upper extremity," and "drum surface;" the opposite person was divided into 5 subcategories: "Face," "right upper extremity," "left upper extremity," "trunk," and "drum surface;" and other was grouped into 3 subcategories: "between players," "outside of players," and "between drums." In addition, we visually obtained the time when the stick hit the drum surface, using video footage.



Areas 1 to 3 are Self, Areas 4 to 8 are Facing Person, and Areas 9 to 11 are Other. Subcategories: 1 Right Upper Extremity, 2 Left Upper Extremity, 3 Drum Surface, 4 Face, 5 Right Upper Extremity, 6 Left Upper Extremity, 7 Trunk, 8 Drum Surface, 9 Between Players, 10 Outside of Players, and 11 Between Drums.

Fig. 3. Areas to be analyzed

3 Results

The performance time of the non-expert was 248.0 seconds, whereas that of the expert was 258.8 seconds. The total number of beats was 64 (45 by the right hand and 19 by the left hand). The number of beats and the right-and-left order of beating were identical for the non-expert and the expert.

3.1 Number of Gaze Shifts

The number of gaze shifts in the areas of gaze location for the non-expert was 301, whereas it was 76 for the expert. The mean time that a gaze remained in a certain area of gaze location was 0.82 second with a standard deviation of 1.02 seconds for the non-expert, whereas the mean time was 3.36 seconds with a standard deviation of 4.55 seconds for the expert.

Figure 4 shows the total number of gaze shifts that occurred every 15 frames (250 ms) during 2 seconds around the beat time. When the numbers before and after the beat were compared, the non-expert shifted his gaze more often after the beat than before, in particular, between 0.75 second and 1.0 second after the beat. On the other hand, the expert shifted his gaze more frequently before the beat, particularly between 1.0 second and 0.5 second before the beat. Additionally, the number of gaze shifts by the expert was considerably low during 0.5 second around the beat time.

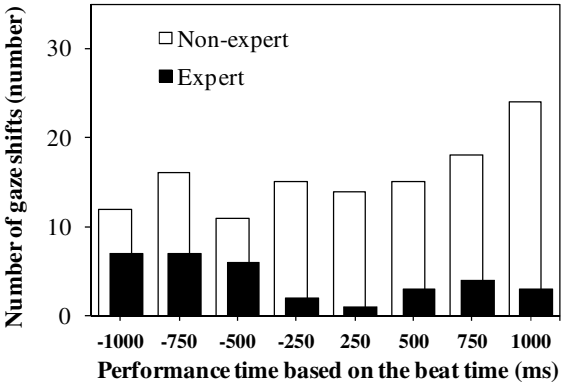


Fig. 4. Numbers of gaze shifts based on the beat time

3.2 Percentage of Gaze Location

Figure 5 shows the areas of gaze location and the beat times during the entire performance in chronological order. The results of calculating the percentages of gaze location by area (Figure 6, Table 1) for the non-expert indicated that the percentages of time in which his gaze was on the self, on the opposite person, and on Other areas were approximately 40%, 45%, and 15% of the total, respectively. During the first minute from the start of performance, gaze on the opposite person and other was observed frequently, and gaze on the self was more often observed after the first minute. When we focused on the subcategories of the areas, he turned his gaze particularly on drum surface of self and opposite person, and the percentage of time in which his gaze was on the drum surface was more than 60% of the total.

In contrast, in the case of the expert, the percentage of time in which his gaze was on the self and the opposite person were 12% and 2%, respectively, and his gaze was on the Other areas over 85% of the time. His gaze was most often on other areas, consistently from the start of the performance, and his gaze shifted to the opposite

person only a few times. With regard to the subcategories of areas, his gaze was particularly focused on the drum surface, on the self and on the opposite person, similar to the non-expert; however, the percentage of time in which his gaze was on the drum surface was a little less than 15% of the total. As for the other area, the expert's gaze was between drums, which accounted for over 85% of the total.

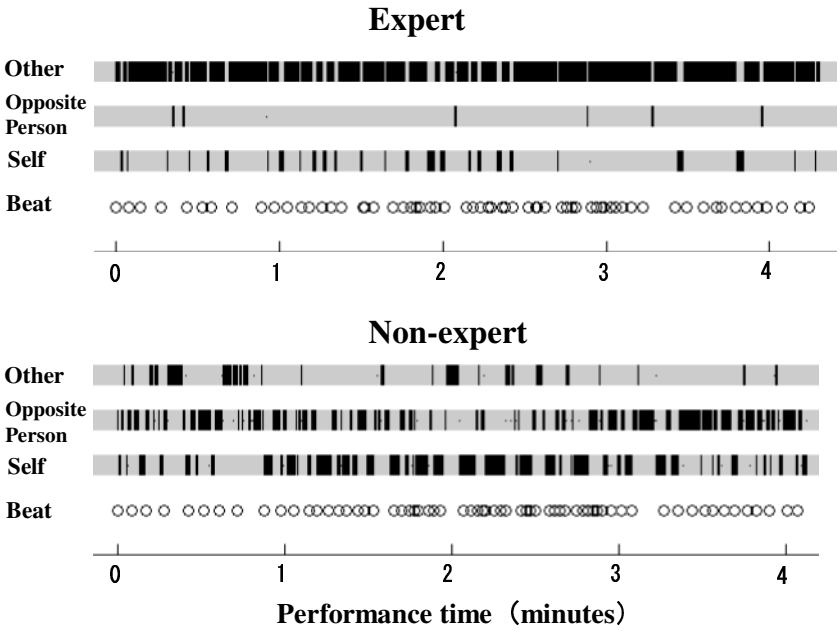


Fig. 5. Beat times and areas of gaze location

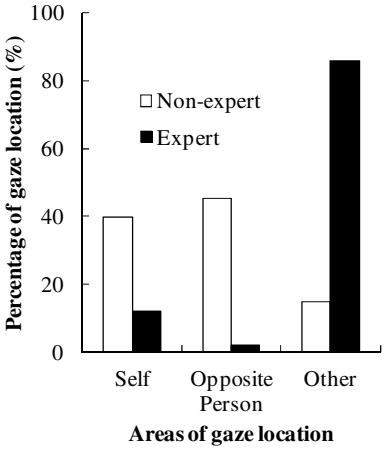


Fig. 6. Comparisons of percentages of gaze location

Table 1. Percentages of gaze location by area (%)

	Non-expert	Expert
Right Upper Extremity	4.2	0.4
Left Upper Extremity	1.6	0.0
Drum Surface	33.9	11.7
Self	**39.7**	**12.0**
Face	2.3	0.0
Right Upper Extremity	6.0	0.0
Left Upper Extremity	4.1	0.0
Trunk	3.5	0.2
Drum Surface	29.6	2.0
Opposite Person	**45.5**	**2.1**
Between Players	8.8	0.0
Outside of Players	6.1	0.0
Between Drums	0.0	85.8
Other	**14.9**	**85.8**

3.3 Time-Series of Gaze Location

Figure 7 shows the percentages of gaze location areas for all 64 beats per frame around the beat time. In comparison to the expert, the non-expert was more likely to turn his gaze on the self between 1.0 seconds and 0.7 seconds before the beat. Then the percentage of his gaze on the opposite person increased once, but the percentage gaze on the self again rose immediately before the beat. His gaze on the self gradually decreased after the beat, while that on the opposite person increased, and these proportions were reversed 0.8 second after the beat.

On the other hand, the expert's gaze was on the self approximately 20% of the 64 beats 1 second before the beat. However, its percentage decreased when approaching the beat time and was reduced to about 10% at the beat time. Moreover, the percentage of his gaze on the self was at the lowest point, 0.3 seconds after the beat. Furthermore, gaze location on the opposite person was not observed after 0.5 seconds before the beat.

Figure 8 compares the percentages of gaze location areas for the right-and-left-hand beats between the expert and the non-expert. When the drum was beaten with the right hand, gaze location on the self was more common than was the case when the drum was beaten with the left hand. This was true for both the expert and the non-expert, and this tendency was particularly notable for the non-expert.

In the case of the non-expert beating the drum with his left hand, his gaze location on the self increased from 1 second before the beat, whereas the percentage of his gaze on the self tended to decrease when beating the drum with his right hand. Additionally, gaze location on the self was not observed between 0.1 second before- and 0.6 second after a left hand beat in the case of the expert.

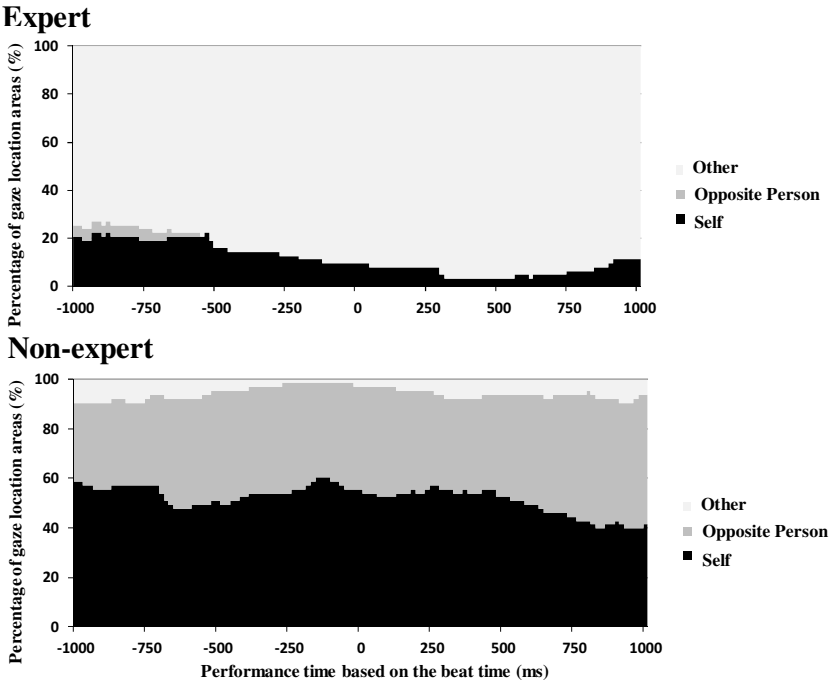


Fig. 7. Time series variation of percentage of gaze location areas

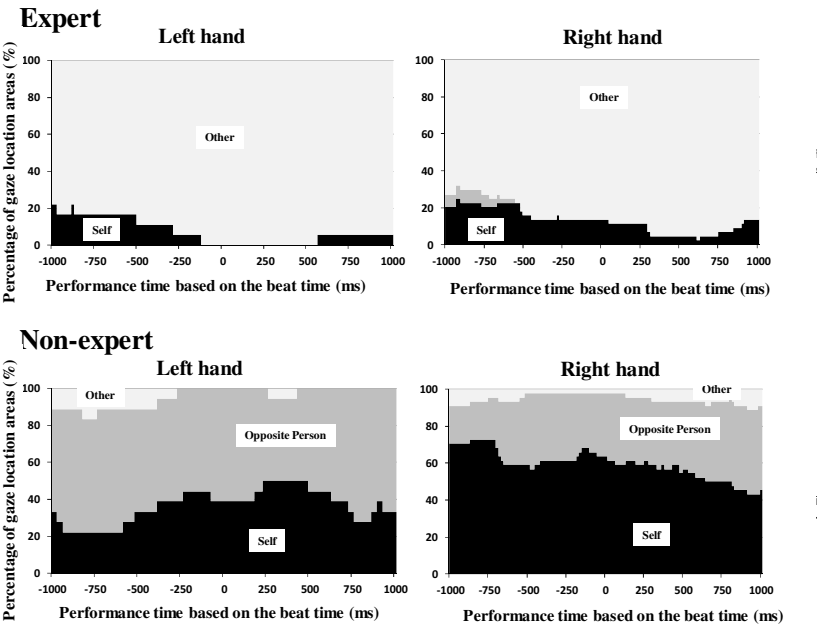


Fig. 8. Percentage of gaze location areas for the right-and-left hand beats

4 Discussion

The performance time of the non-expert was approximately 95% that of the expert, which was about 10 seconds shorter. This is probably because there is no conductor in *Gion* Festival Music, and the tempo of musical pieces is not prescribed, therefore the performance time varies depending on the player. In the actual *Yama-Hoko* parade, as a large number of *Yama-Hoko* floats parade in order, the speed of the advancing procession differs every year, depending on the condition of the floats in front and behind. Thus, it is thought that the tempo of musical pieces is loosely prescribed in order to adjust the length of each piece according to the time required for the parade. Therefore, although there was a difference in the length of time of the performance between the participants, by approximately 10 seconds, it was about a 5% difference and we were determined to analyze it, because it could be compared.

To summarize the results obtained in the present study, (1) the number of gaze shifts for the expert was less than that for the non-expert; (2) the expert's gaze shifts decreased significantly at the moment of a beat; (3) the expert did not turn his gaze on the drum surface, but turned his gaze between his drum and the opposite person's drum; and (4) the percentages of gaze location on the drum surface of the self and the drum surface of the opposite person were higher in the case of the non-expert.

As for the expert, the number of gaze shifts was low, which decreased considerably around the beat time. Moreover, the area of gaze location was on between rums. Therefore, the expert is assumed to have been playing the drum using visual information obtained by peripheral vision. On the other hand, the number of gaze shifts was very high for the non-expert, and the area of gaze location was often on the drum surface of the self; thus, he is assumed to have obtained visual information regarding the beat location mainly by central vision. It seems that the non-expert frequently turned his gaze on the self in order to confirm the position of drum surface so that the stick would hit the surface, as well as to confirm the movement of his raised stick.

In contrast, because the expert had acquired a highly refined performance technique for beating the drum, he did not need to confirm the beat location, or his motions by using his gaze, he was able to perform without looking at the self, or the drum surface. This is the automation of the beating technique, and it seems that when the player has room to turn his/her gaze on things other than the self, he/she can pay attention so as to match timing with other drum-*kata*, flute-*kata*, and gong-*kata*. However, in this experiment, neither the expert nor the non-expert turned his gaze on flute-*kata*, or gong-*kata*. One reasons for this might be that the experiment was conducted immediately after the *Gion* Festival, and there was a long time before next year's Festival. In other words, it was likely to be the time for them to practice basic drum beating techniques and coordination among drum-*kata* above all, rather than with flute-*kata* and gong-*kata.*

Furthermore, the non-expert frequently turned his gaze on the drum surface of the opposite person. In the drum performance of the *Gion* Festival Music, the tempo of a musical pieces is not prescribed, but the drum players need to beat by matching the timing with others. Therefore, it is inferred that the percentage of gaze location on the drum surface of opposite person was high, so as to measure the timing of the other players.

5 Conclusion

To summarize the results obtained in the present study, (1) the number of gaze shifts for the expert was less than that for the non-expert; (2) the expert's gaze shifts decreased significantly at the moment of a beat; (3) the expert did not turn his gaze on the drum surface, but turned his gaze between his drum and the opposite person's drum; and (4) the percentages of gaze location on the drum surface of the self and the drum surface of the opposite person were higher in the case of the non-expert. The present study focused on visual information processing, and examined the characteristics of coordinated performance of drum-*kata*, by comparing an expert and a non-expert, by using data from an Eye Mark Recorder. Thus, it was not possible to investigate the relationship between expertise and performance, such as the gap in the timing of a beat and the strength of a beat. By evaluating the relationship between performance and body motions and sounds, in addition to visual information, it would be possible to further clarify coordination of drum performances that are conducted without using musical scores.

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