THE ROLE OF BODY MOVEMENT IN CO-PERFORMERS' TEMPORAL COORDINATION

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ABSTRACT

Expressive performance requires strict temporal coordination. Especially in ensembles, temporal coordination between performers is crucial. Revealing co-performers' temporal coordination can provide useful suggestions not only for performers to generate musical expressiveness, but also for the further understanding of interactional processes in ensemble performance.

This issue has been investigated in terms of musical tones only. However, it has been pointed out recently that performers use various nonverbal behaviours to coordinate with other performers. Body movement seems to be particularly important due to its ongoing occurrence.

This study tried to examine the role of body movement in co-performers' temporal coordination. To this end, synchronization tasks on electronic drums by two participants were completed in face-to-face and non-face-to-face condition. Synchronization scores and the relationship between two participants' body movements were compared between the two conditions.

Higher synchronization scores were found in the face-to-face condition. Also it was found for this condition that participants' body movement showed similarities occurring due to the necessity of achieving temporal coordination.

This study clarified two significant aspects: first, the presence of visual information contributes to temporal coordination between performers, and second, performers' body movements interact in response to the necessity of temporal coordination when visual information is available. These results strongly suggest a significant contribution of body movement to temporal coordination between performers.

1. INTRODUCTION

Musical behaviour is one of the most time dependent activities of humans, and musical performances are produced and appreciated as they gradually develop over time. This characteristic of music requires performers to strictly control temporal aspects of their performance such as timing when they try to effectively generate musical expressiveness. Especially in ensembles, coordination between performers is crucial.

Revealing how co-performers achieve coordination has several important implications. First, it can provide useful suggestions for performers as to how to generate expressive performances. Expressive performances often include deviations from the timing indicated in the musical score, and therefore temporal coordination between co-performers becomes particularly important. Second, it can enable the improvement of performance support systems for more expressive human-computer interaction. Third, it can lead to a further understanding of interactional processes in ensemble performance. This can provide a theoretical foundation for a certain type of music therapy in which a therapist and a client perform together. Hargreaves, MacDonald & Miell (2005) referred to the potential of music to provide an opportunity to interact with others for people who have difficulties in communicating in ordinary ways. To understand such function of music, more knowledge about moment-by-moment interaction developed in ensemble performances is required.

This issue has inspired several researches (Rasch, 1988; Horiuchi, 2002). These studies investigated co-performer's temporal coordination only in terms of musical tones they produced. However, it has been argued that in actual ensemble situations, performers use various nonverbal behaviours, including body movement, breathing, gaze, to coordinate their performance (Williamon & Davidson, 2002). In focusing on body movement and describing its role in musical behaviour, Davidson & Correia (2002) pointed out that performers use the pattern of their body movement to coordinate with each other. Indubitably, body movement could be regarded as being a more prominent cue than other nonverbal behaviours because of its ongoing occurrence. Given this perspective, it seems that investigations in terms of musical tones only are not sufficient to explain co-performers' temporal coordination, and therefore the role of nonverbal behaviour, particularly body movement, needs to be examined. In addition, it is necessary to clarify the relationship between coordination and these cues in actual ensemble situations. However, little quantitative research in this respect has been carried out.

This study examined whether body movement contributes to temporal coordination between co-performers in a basic ensemble situation. For this purpose, a synchronization task on electronic drums in which two participants synchronized their equal interval tapping was completed. Two experimental conditions were applied: face-to-face condition and non-face-to-face condition. Synchronization scores and body movement were measured quantitatively and compared between the two conditions. We hypothesized that synchronization scores would be higher in the face-to-face condition than in the non-face-to-face condition because availability of visual cues in the face-to-face condition may facilitate temporal coordination between co-performers, and that in face-to-face condition, an interaction of body movement between the two participants would be found.

2. METHOD

2.1 Participants

16 graduate and undergraduate students (male=8, female=8) of Osaka University participated. Their age ranged from 18 to 46 years old(mean= 23.6 years). The participants were tested in pairs of the same sex, and they had not met prior to the experiment. None of them had any previous musical experience as a drummer. 10 participants were assigned to the face-to-face condition, and the rest to the non-face-to-face condition.

2.2 Apparatus

The experiment was conducted in two adjacent sound proof rooms separated by a window. The two rooms were acoustically independent from each other, and shared visual information through the window. In the non-face-to-face condition, visual information was eliminated by drawing a curtain over the window. An electronic drum pad (Roland, PD-6) was placed in front of the window in each room. A percussion sound module (Roland, TD-10) was used to generate drum tones and MIDI data based on the participants' tapping on the drum pads. A work station (TASCAM, SX-1) recorded the MIDI data transmitted through the sound module. The drum tones were presented through loud speakers (DENON, SC-T777SA) in each room through an amplifier (SONY, TA-V88ES). To record the participants' body movement, a CCD camera (DAIWA, SE-72F) and HD-equipped DVD recorder (TOSHIBA, RD-X5) were used.

2.3 Task

Participants were asked to synchronize as much as possible their equal interval tapping on electronic drum pads with their dominant hand. They didn't receive any instruction about tempo. They were seated on chairs placed to face each other across the window which separated sound proof rooms. They started and stopped their tapping following audio cue presented at the start and end of a trial. Each experiment consisted of five trials, the duration of each being one minute.

2.4 Procedure

After receiving instructions regarding the experimental procedure together, participants were introduced into each sound proof room separately. First, they were prepared for the measurement of body movement by covering the area around their wrists with black cloth, with a white mark at the wrist position. Next, they were instructed to practice tapping on the electronic drums. During the practice session, participants could hear only drum tones produced by themselves, and could not see each other, the curtain being drawn over the window. Participants continued their practice until they considered they were familiar enough with the electronic drum pad tapping. After both participants finished their practice, they proceeded with the synchronization task.

2.5 Measurement

Participants' tapping on the electronic drum pads was recorded as MIDI data by the work station. Their tapping time was obtained by analyzing the MIDI data. Participants' body movements recorded during the practice session and the synchronization task were analyzed using a time-serial body movement analysis software (DKH, FrameDIAS II).

Synchronization scores. Synchronization scores were calculated for each pair as the absolute value of time difference between the two participants' tapping. Only the last 30 taps of each trial became subject of analysis.

Indicators of body movement. The two indicators of body movement considered in this study were size and temporal patterns of the rise and fall movement of the wrist. They were obtained based on time-serial body movement data for the last 30 taps of each trial and the practice session. Size of wrist movement represents the distance between the lowest position of a tap and the highest position prior to the next tap. Temporal pattern indicates the duration from the moment of tapping to the next highest position calculated in proportion to the duration from the moment of tapping to the next tap.

3. RESULTS

3.1 Synchronization scores

Synchronization scores were compared between face-to-face condition and non-face-to-face condition in order to examine whether participants' temporal coordination differed between the two conditions. Figure.1 shows means of synchronization scores in the two conditions for each of the 5 trials. In all trials, synchronization scores were higher in the face-to-face (FTF) condition than in the non-face-to-face (nonFTF) condition.

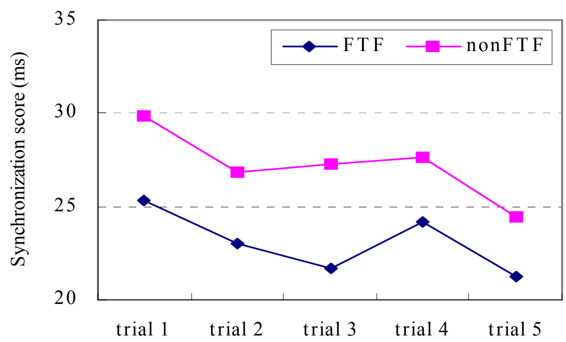

Figure 1: Synchronization scores in the two conditions. All pairs' synchronization scores in each condition were averaged for each trial.

Since participants were faced for the first time with the necessity of coordinating their tapping during the first trial, it is expected that their behaviours would be heavily influenced by that necessity in the first trial, and therefore we may assume that characteristics of body movement for participants' temporal coordination can be already identified from the first trials. Herein we shall take into consideration for analysis only the results obtained in the first trials.

3.2 Body movement

To examine whether an interaction existed between participants' body movement in the face-to-face condition, similarity of body movement was inspected in regards to size and temporal pattern. Participants had individual characteristics of body movement, and therefore the relationship between their body movements was peculiar to each pair. Given this, the similarity of body movement was examined based on comparisons of the relationship of body movements in the first trials with that in the practice sessions.

Similarity of body movement size was calculated as a ratio of the two participants' body movement sizes for each tap, smaller ratio indicating more similarity. Figure.2 and Figure.3 show the mean ratios of body movement size for the practice session and the first trial. In the face-to-face condition, participants' body movement sizes were more similar in the first trial for all pairs; however, consistent results were not found in the non-face-to-face condition.

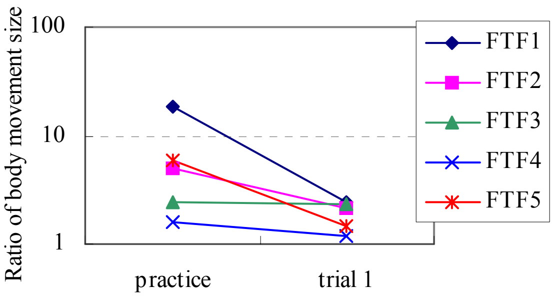

Figure 2: Ratio of the two participants' body movement size in the face-to-face condition. Ratios of the practice session and the first trial are shown for each pair in logarithmic scale.

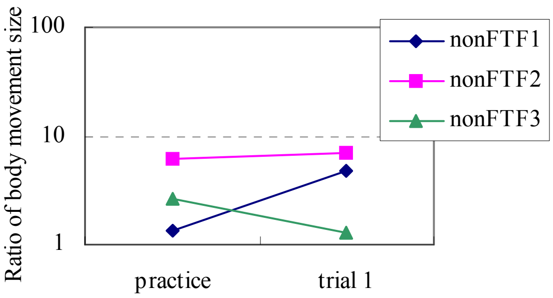

Figure 3: Ratio of the two participants' body movement size in the non-face-to-face condition. Ratios of the practice session and the first trial are shown for each pair in logarithmic scale.

Similarity of temporal pattern of body movement was calculated as the difference of the two participants' temporal patterns of body movement. Smaller difference signifies more similarity. Figure.4 and Figure.5 show the mean differences of temporal patterns of body movement for the practice session and the first trial. In the face-to-face condition, temporal pattern of participants' body movements were more similar in the first trial, except for one pair; Again, the non-face-to-face condition did not show consistent results.

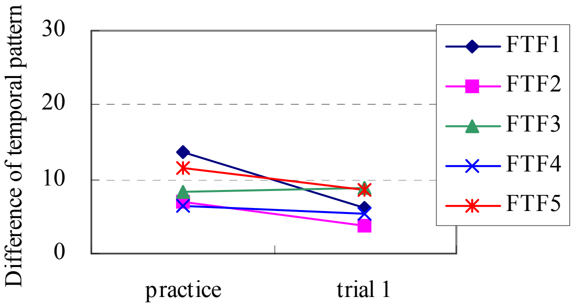

Figure 4: Difference of the two participants' temporal patterns of body movement in the face-to-face condition. Practice session and first trial results are shown for each pair.

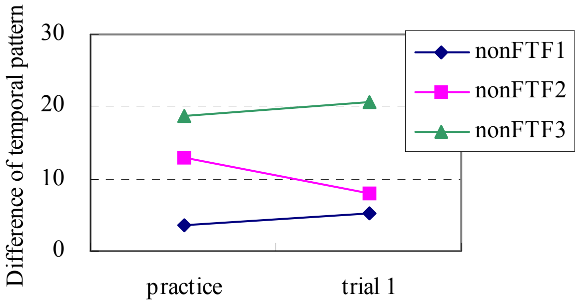

Figure 5: Difference of the two participants' temporal patterns of body movement in the non-face-to-face condition. Practice session and first trial results are shown for each pair.

4. DISCUSSION

Results obtained in this study confirmed our hypothesis that synchronization scores would be higher in the face-to-face condition. The scores were higher throughout all trials, indicating that visual information strongly contributed to the synchronization of tapping. This result provided quantitative evidence that the availability of visual information facilitates co-performers' temporal coordination, and supports previous research that suggested a contribution of various nonverbal behaviours to co-performers coordination in actual ensemble situations.

Comparisons of the relationship of participants' body movement in the first trial with that in the practice session showed that in the face-to-face condition, body movement became more similar in the first trial. This similarity in the first trial of the face-to-face condition was found both in size and temporal pattern of body movement. Absence of these similarities in the non-face-to-face condition indicates that they are specific to the face-to-face condition. In the practice session, since information about partners is not available, participants' body movements show more individual characteristics. Thus, the similarity of body movement in the face-to-face condition implies that participants changed their body movement to match that of their partners', based on available visual information. This means that interaction of body movement occurred. The similarity of body movement resulting from co-performer interaction was also pointed out in a case study on piano duo (Williamon & Davidson, 2002).

Another major difference between the practice session and the first trial relates interaction of body movement in the face-to-face condition to temporal coordination. Participants tapped individually during the practice session, without any information about their partners, and this situation did not require any coordination between participants. On the other hand, they were required to achieve temporal coordination in the first trial, thus the similarity of body movement in the face-to-face condition is thought to be caused by the necessity of reaching temporal coordination.

It is inferred that similarity of body movement includes characteristics that contribute to temporal coordination in several ways. As body movement provides ongoing information and is directly related to tapping, participants would be able to predict their partners' tapping from their body movement. If they display different temporal patterns of body movement, important information that can add to the coordination of their tapping would be provided too late for the partner to use. Similarity of temporal patterns appears to have an important role in the mutual utilization of the partner's body movements. In addition, similarity of movement size and temporal pattern may lead to the sharing of a common way of coordinating behaviour between participants, this enabling them to predict their partners' behaviour more easily.

As mentioned above, in the face-to-face condition higher synchronization scores and an interaction of the participants' body movement in response to the necessity of temporal coordination were found. These results strongly suggest the possibility that the interaction of body movement contributed to participants' temporal coordination.

This has several implications. For expressive performance, temporal coordination utilizing body movement may be useful in the cases in which produced musical tones deviate from the musical score, as it often happens in swing for instance, and therefore coordination based on musical tones would be difficult. For performance support systems, introducing coordination based on body movement may enable more expressive human-computer interaction. Recent development of sensing device of human movements may allow the designing of such system.

5. Conclusion

In conclusion, this study clarifies two significant aspects regarding co-performers' temporal coordination quantitatively. Firstly, co-performers' temporal coordination was facilitated by the presence of visual information. This contribution observed throughout all trials suggested that visual information continuously provides important cues in an ensemble situation. Secondly, when visual information was available, the interaction of performers' body movement occurred in response to the necessity of temporal coordination. These two aspects pointed out herein strongly suggest that body movement contributes to co-performers' temporal coordination. This study represents a first step in the exploration of a temporal coordination mechanism based on body movement. To generate such mechanism, further study on this issue is necessary, such as the examination of how performers coordinate through interaction of their body movement moment by moment, and the further clarification of the results obtained in this work by examining the situation in which only information about body movement is available.

6. REFERENCES

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