2pMU6. The examination of the performance motion and emotional valence by a pianist.

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We examined the performance motion of five emotion of Juslin and emotionless by the professional pianist using the motion capture system. We can examine correspondence of the emotion and the motion in detail by using a motion capture system. We analyzed the movement for the expressing emotion of the pianist using a motion capture. As a result, we found that movement was big under joy and tenderness of the positive emotions. Conversely, anger, sadness and fear of the negative emotions had a small movement. The perfumer changed the movement of the positive and negative. In addition, we suggested connection in movement of the head and emotion. We will clarify an association between emotion and motion by examining the arm and hand.
INTRODUCTION

Hitherto we measured motion of the performance using the motion capture system. And we considered to the association between emotion and motion of the musical performance [1] [2].

Mito [2] studied the impression evaluation for two different drummers of the carrier. As a result, we found that there was association between performance motion and the impression of the listener. We thought that the performer changed motion by emotion in detail. And we understood that the carrier did not influence in the communication of the performance expression. In addition, we understood that the speed of the both hands and the standard deviation (S.D.) of the both arms has an influence on difference of the image of active and calm.

Sato [3] investigated to correspondence relation between the performance motion and the emotion by the motion capture system in snare drum performance of intended expression. They examined correspondence during the performance motion and the emotion in snare drum performance for the five basic emotions and emotionless by the emotional space of Juslin [4].

Miura devised "Motion-Averaging-Method (MAM)" using motion data [5] [6]. They found the characteristic of the motion from the differences between average motion and each emotion (Fig.1).

![FIGURE 1. MOVEMENT FEATURES ON SNARE DRUM.](image)

In this way, there is the study on association between emotion and motion using the snare drum. Therefore in this study, we examine the performance of the piano using a motion capture system. Davidson [7] found that head movement is important for observers to discriminate between pianist's performances played with different expressive intentions. Castellano [8] examined emotion and motion by the pianists using the video. The results showed that both were sensitive to emotional expression, especially the velocity of head movements.

Then, we examined the performance motion of five emotion of Juslin and emotionless by the professional pianist using the motion capture system. We can examine correspondence of the emotion and the motion in detail by using a motion capture system.
EXPERIMENT

Subject

We measured a keyboard performance in the classroom of the university. The player was one professional pianist. The keyboard was CASIO CTK-810.

Experiment summary

The performance task used simple music for the beginners. We showed a performance task in Figure 2. The key is C major. He performed by expressing emotion of five emotion (happiness, tenderness, anger, sadness, fear) used Juslin[4] and emotionless for a task. After hearing four beats of sound, we requested to perform by the M.M. = 90. He performed the same melody on the both hands.

FIGURE 2. Performance task

Environment of the measurement

In motion capture, reflective markers are attached to a person’s upper body and multiple infrared cameras are used to detect the positions of these markers in three-dimensional space. These positions are output as a temporal series of absolute spatial coordinate values. The experimental apparatus was configured using a Motion Analysis MAC3D motion capture system with 6 Raptor-H cameras (frame rate 100 fps, shutter speed 1/2000 s). We used a total of 34 markers in the upper body and piano (Figure.3).

FIGURE 3. Marker adhesion position
Analytical approach

The analysis section was from the beginning of the first sound to the beginning of the last sound. To investigate how pianist moves the upper body, we calculated their center of gravity [9]. This was calculated by modeling the upper body as a collection of 8 parts (head, torso, upper arms, forearms, hands), using the center of gravity position of each part $P_{gi}(xg(i), yg(i), zg(i))$ ($i = 1, 2, ..., 8$), the mass center ratio $m(i)$ and the position data of each part of the body obtained from the motion capture data. The center of gravity position $P_{gi}(xg(i), yg(i), zg(i))$ of each body part is calculated using Eq. (1). Here, the positions $P_{si}(xs(i), ys(i), zs(i))$ are the start positions of each body part, and the positions $P_{ei}(xe(i), ye(i), ze(i))$ are the end positions of each body part.

$$\begin{bmatrix} x_s(i) \\ y_s(i) \\ z_s(i) \end{bmatrix} = (1-m(i)) \begin{bmatrix} x_i(i) \\ y_i(i) \\ z_i(i) \end{bmatrix} + m(i) \begin{bmatrix} x_e(i) \\ y_e(i) \\ z_e(i) \end{bmatrix}$$ (1)

Next, Eq. (2) is used to calculate the center of gravity $P_G(x_G, y_G, z_G)$ from the center of gravity position $P_{gi}$ and mass ratio $n(i)$ of each body part.

$$x_G = \frac{\sum_{i=1}^{8} n(i) x_g(i)}{\sum_{i=1}^{8} n(i)}$$

$$y_G = \frac{\sum_{i=1}^{8} n(i) y_g(i)}{\sum_{i=1}^{8} n(i)}$$ (2)

$$z_G = \frac{\sum_{i=1}^{8} n(i) z_g(i)}{\sum_{i=1}^{8} n(i)}$$

EXPERIMENTAL RESULTS

At first we calculated the movement distance of the upper body under the each emotion. We showed the result in Figure 4.
Next we calculated the movement of the head that corrected movement of the body. Thus, movement of the body does not influence the movement of the head. We showed the result in Figure 5.

From this result, we understood that the positive emotions had a long distance of the movement, and the negative emotions had a short distance of the movement. The emotionless was hardly moving. In addition, because the movement of the upper body and the head was the same result, we thought that the movement of the head influenced expressing emotion.
CONCLUSION

We analyzed the movement for the expressing emotion of the pianist using a motion capture. As a result, we found that movement was big under joy and tenderness of the positive emotions. Conversely, anger, sadness and fear of the negative emotions had a small movement. The perfumer changed the movement of the positive and negative. In addition, we suggested connection in movement of the head and emotion. We will clarify an association between emotion and motion by examining the arm and hand.

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