Quantifying "*Waza*" in *Nihon-Buyo* Dance Movements

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Abstract: Dance is an intangible cultural asset. It is passed on from one person to another through oral instruction, and so are the *waza*, the skills and techniques, involved in dance. Many traditional dances in Japan, however, are 'endangered species' due to the shortage of practitioners. We are attempting to create digital archives to record and store the body motions of *buyo* using digital technologies, such as motion capture. We are endeavoring to solve this serious issue of losing an important tradition. In this paper, I would like to present part of our scientific analysis of the *waza* in *Nihon-buyo*, which have been passed down, sometimes in silent, tacit manners.

Keywords: Japanese traditional dance, *Nihon- buyo*, Motion Capture

I. INTRODUCTION

Dance is an intangible cultural asset. It is passed on from one person to another through oral instruction, and so are the *waza*, the skills and techniques. involved in dance. Many traditional dances in Japan, however, are 'endangered species' due to the shortage of practitioners. We are attempting to create digital archives to record and store the body motions of *buyo* using digital technologies, such as motion capture. We are endeavoring to solve this serious issue of losing an important tradition. In this paper, I would like to present part of our scientific analysis of the *waza* in *Nihon-buyo*, which have been passed down, sometimes in silent, tacit manners.

The purpose of this research is to examine how the performers of *Nihon-buyo* differentiate the basic motions when performing different dance roles and how their proficiency levels affect the differentiation. We plan to achieve our goal by analyzing their motions and evaluating the impressions generated.

II. THE DESCRIPTION OF THE WORK

This research examines "*Musume-Dojoji*" and "*Tenaraiko,*" both key titles in *Nihon-buyo*. "*Musume-Dojoji,*" which premiered in 1753, portrays an adolescent girl who is in love with a mountain priest. "*Tenaraiko,*" which premiered in 1792, portrays a precocious downtown girl who is on her way back home from a temple school called *Terakoya*. "*Tenaraiko*" is a play that was made about forty years after "*Musume-Dojoji,*" and a passage from this earlier play is used in "*Tenaraiko.*" The girl in "*Musume-Dojoji*" dances with her heart filled with love, and this same passage is used in "*Tenaraiko*" when the young town girl dances in a precocious manner. The lyrics and the dance motions are the same in both plays. However, while the amorous attention of an adolescent girl has to be portrayed in the former, almost a childlike innocence of a precious girl has to be portrayed in the latter.

III. ABSTRACTION IN MOTIONS

This research examines the aforementioned common portions of the dances from "*Musume-Dojoji*" and "*Tenaraiko,*" namely, the three basic motions of *Nihon-buyo*: *Okuri*, *Osuberi* and *Mitsukubi*.

Okuri is about the motion of walking. Although it is a simple walking motion, the performer in "*Musume-Dojoji*" is required to walk with her toes turned inward and slide on the floor, while her knees and pelvic region are relaxed *Musume-Dojoji*. On the other hand, in "*Tenaraiko*," the performer is required to walk lightly with short steps while pressing the legs and knees together.

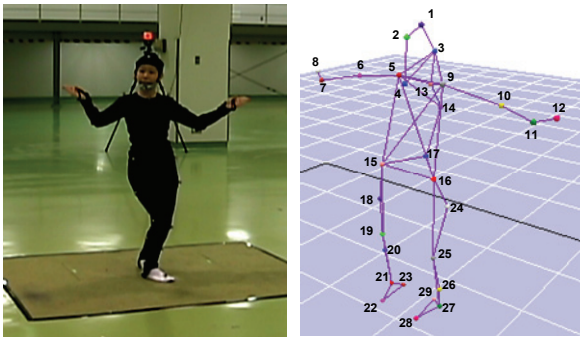

Fig.1. Positions of markers

IV. MOCAP AND THE METHOD

We used an optical motion capture system to measure the body motions from the aforementioned dance. In our research, we placed 29 markers on the dancer's body, and her movements were measured with 10 cameras(See Fig.1.). The acquired data can be observed as a time series of 3 dimensional coordinate values (x, y, z) of each marker in a frame (60 fps).

1. The Experiment: Performers

The performers selected for our motion analysis were three women who have studied *Nihon-buyo*. Their experience varies. Performer A with *Nihon-buyo* training and experience of less than a year, Performer B, 17 years, and Performer C, 15 years. We asked them to dance each play five times. After taking the measurements, we asked the performers what dance strategies they used in their renditions.

2. Feature Values for Body Motion

In order to understand the intensity of the features of each dance motion, its physical features were extracted from the perspective of time, space and dynamics, which are the components of a movement.

Result of *Okuri* movement analysis

From the simple walking motion of *Okuri*, 16 physical features were obtained: the velocity and the acceleration of the vertex of the head, right shoulder, right elbow, right fist, lower back, right knee and right toes, the angle of the knee and the height of the lower back. We then conducted a principal component analysis using a total of 32 variable quantities, which were the mean values and the standard variations. We extracted 5 principal components with the eigenvalues of 1 or greater, with an accumulated contribution rate of 84.5%. We interpreted PC1 to be the variable quantity showing "the speed of motion," PC2 "the motion of hand," PC3 "the strength of the lower body," PC4 "the strength of the elbow" and PC5 as the "the strength of the feet."

The PC1 and PC2 scores were plotted on the x-axis and the y-axis respectively, and all trials were plotted on the x-y graph ,as in Fig. 2. PC1 is the axis showing the speed of motion. In this Fig., the speed increases as the score shifts toward the right side of the graph and decreases as it shifts toward the left. PC2 is the axis showing the motion of the hand. In the same Figure, the hand is moving more quickly as the score nears the top of the graph, while the movement is slower when the score approaches the bottom.

Fig. 2 shows that these measurable variables were largely divided into three groups according to each performer. Comparing the performers, it was found that performers B and C, with higher proficiency levels, moved more quickly than performer A, a dance beginner. All performers danced "*Musume-Dojoji*" and

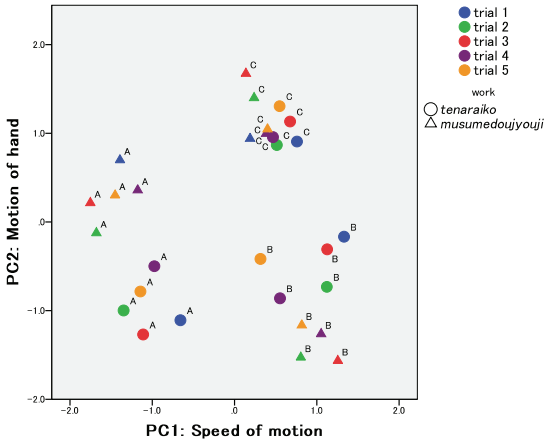

Fig.2. Plot of PCA score of *Okuri*

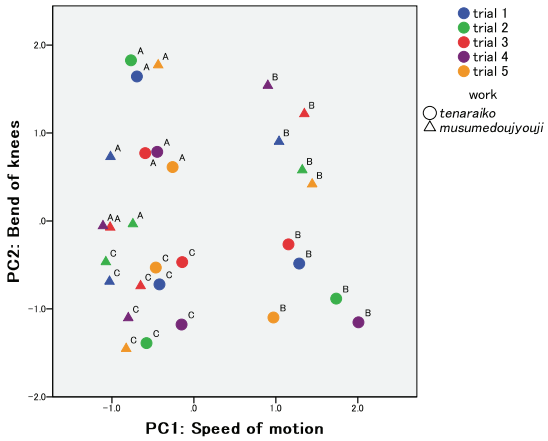

Fig.3. Plot of PCA score of *Osuberi*

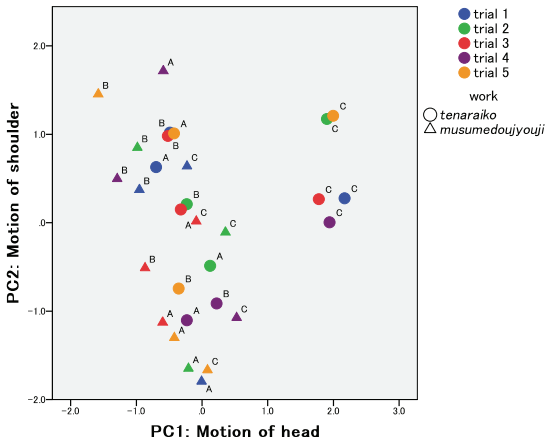

Fig.4. Plot of PCA score of *Mitsukubi*

"*Tenaraiko*" differently; however, the ways they differentiated their dances varied considerably from performer to performer.

Result of *Osuberi* movement analysis

From the soft curvilinear motion of *Osuberi*, we obtained 12 physical features: the velocity and acceleration of the vertex of the head, right shoulder, right elbow, right fist, lower back, right knee and the toes of the right foot, the angle of the right knee and the height of the lower back. Again, we conducted a principal component analysis using a total of 24 variable quantities, which were the mean values and the standard variations. As a result, 5 principal components with eigenvalues of 1 or greater were extracted (the accumulated contribution rate was 85.3%). We named PC1 as "the speed of motion," PC2 as "the bend of the knees," PC3 as "the strength of the body's center," PC4 as "the strength of the area below the neck" and PC5 as "the strength of the feet."

We plotted the PC1 and PC2 scores on the x-axis and y-axis respectively; all trials were plotted on the x-y graph. The result is shown in Fig. 3. PC1 is the axis showing the speed of motion. In Fig. 3, the speed increases toward the right side of the graph and it decreases toward the left. PC2 is the axis showing the bend of the knees. In the Fig., the knee is stretched more as it nears the top of the graph, but the knee is more bent towards the bottom, with the lower back in an increasingly lower position.

As Fig. 3 shows, quantitative measurements of the Osuberi motion showed similarity with *Okuri*, i.e., the results were divided into three groups according to the performer. It was also found that performers B and C, with higher proficiency levels, differentiated the dances for each play. Performer A, however, was not able to differentiate them quite as well.

Result of *Mitsukubi*

Mitsukubi mainly involves the motions of the head and the shoulders, so we only calculated 4 kinds of physical features, i.e., the speed and the acceleration of the vertex of the head and the shoulders. By conducting a principal component analysis using a total of 8 variable quantities, which were the mean values and the standard variations, 2 principal components with eigenvalues of 1 or greater were extracted, with an accumulated contribution rate of 80.2%. PC1 was named "the motion of the head" and PC2 "the motion of the neck."

We plotted the PC1 and PC2 scores on the x-axis and y-axis respectively, plotting 35 trials on the x-y graph. This is shown in Fig. 4, and the variables plotted by each performer are shown in Fig. 5. PC1 is the axis showing the motion of the head. In these figures, the head moves more quickly toward the right side of the graph and more slowly when plotted toward the left. PC2 is the axis showing the motion of the shoulders. The figures show that the shoulders move more quickly and strongly when plotted near the top of the graph and more slowly and weakly when plotted near the bottom.

Unlike *Okuri* and *Osuberi*, the quantified variables of *Mitsukubi* did not divide into groups according to the performer. Notably, only the motions of performer C in "*Tenaraiko*" were very different. Regardless of the proficiency level, PC2 (the motion of the shoulder) was not stable, suggesting that the performers paid less attention to their shoulders than to their heads.

V. PSCHOLOGICAL EXPERIMENTS

In order to examine the type of impression perceived from the body movement of the two plays, we conducted a psychological rating experiment using stick figure animation (see Fig. 1) of the motion capture data. Twenty-four observers (7 men and 17 women) participated in this experiment. The mean and the standard deviation of age among the 24 observers were 21.7 and 0.98 respectively. They had no experience in dance performances of any kind and no particular knowledge about dancing and traditional Japanese culture. The animation was projected on a 50-inch display with no sound. The stick figure animation and muted audio were used to force the viewers to focus on the impression expressed by the body movements alone, discarding other factors such as facial expressions, costumes, music, etc.

After each movement was shown, the viewers were asked to answer the questions on the response sheets. In this rating, we employed the Semantic Differential questionnaire. In the SD questionnaire, 10 image-word pairs were used for rating the movements. We selected 10 word pairs which were thought more suitable for the evaluation of human body motions, based on the list presented by Osgood [2]. The viewers rated the impression of the movement by placing checks in each word pair scale on a sheet.

The rating was done in 5 ranks from 1 to 5. Rank 1 was assigned to the left-side word of each word pair and

5 for the right side. Using this rating, we obtained a numerical value representing an impression for each of the body motions from each subject.

We then conducted a principal component analysis, PCA, based on a correlation matrix, to the mean value of the rating value and obtained the principal component matrix. Two significant principal components were extracted, which were PC1—PC2. We used the word pairs 'natural – unnatural,' 'experienced – inexperienced,' 'like – dislike,' etc., which are often used to represent refinement. Hence, it was interpreted that PC1 was a variable that related to the "refinement" of the motion. Similarly, PC2 was related to the "activity," as indicated by words such as 'large motion – small motion,' 'adult-like –childlike,' 'bright – dark' and 'happy – sad.'

We can conclude that the characteristics of the dance motions in "*Musume-Dojoji*" and *"Tenaraiko"* are based on two aspects - "refinement" and "activity."

Fig. 5 is a plot of the principal component scores of each motion datum. Since the x-axis (PC1) represents the degree of refinement, the performance is more refined toward the right side of the graph and less refined toward the left. The y-axis (PC2) represents activity. There is more activity toward the top of the graph and less activity as the plots near the bottom of the graph.

By looking at each motion, it was found that *Okuri* motions were more active for every performer in "*Tenaraiko*" but more refined in "*Musume-Dojoji.*" Considering that "*Tenaraiko*" is the dance of a child and "*Musume-Dojoji*" the dance of an adolescent girl, the psychological intentions of the performers seem to have been understood well by the audience. As for the *Osuberi* motion, the degrees of "refinement" and "activity" were higher for "*Musume-Dojoji.*" As for the

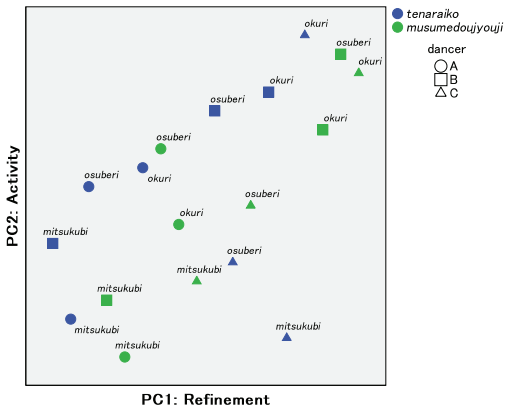

Fig.5. Plot of PCA score of the psychological ratin

Mitsukubi motion, the audience received different impressions from different performers.

As a result of the evaluation experiment, it was revealed that even the audience lacking any knowledge of *Nihon-buyo* understood, to some extent, the differences in the roles played in the stories. There was also a tendency for the audience to perceive the "different characters" of the performers rather than the "difference in choreography" of their dances. That is to say, it was revealed that the audience was seeing the motions of each performer, or the difference in personal characteristics, rather than the difference in the dance's choreography.

VI. FUTURE POSSIBILITIES

We can get information concerning the personality of the subject when we observe his or her body motion. We may get various impressions from body motions. This means that the human body motions convey emotion and personality of the person. Personality might be the involuntary and continuous expression of emotions, which are peculiar to the individual.

The results of this paper could be applied to producing a robot or CG character animation with personalities. Until now, many attempts have been made to add or enhance emotional expression of robots using linguistic communication, some simple body motions, e.g. nodding, and facial expressions. Also, changing the design or shape of robots might be a simple way of providing a robot with personalities. However, we could not find much research on giving robots personalities with body motions.

We think changing the personalities of a robot by changing its own body motions, and changing the expression of the affects of the robot through body motions are very promising areas for further investigation.

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