KANSEI Information Processing of Human Body Movement

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Abstract. To quantitatively clarify the cognitive mechanism of KANSEI information conveyed by body movement, we conducted evaluation experiments and movement analysis by optical motion capture. We attempted to develop multiple regression models to investigate the effect of physical movement on subjective evaluation. The results show the relation between subjective feature of movements and the physical measurement. Thus, we expect that our research is effective to the guidance of dancing and acting, because it is possible to paraphrase sensitive image (KANSEI information) in another word (movement feature) which has strong relation with physical movement. Furthermore, this relational model which can replace human sensibility by digital data is useful for human-computer interaction.

Keywords: Body movement, KANSEI information, Motion capture.

1 Introduction

In the field of non-verbal communication research, the facial expression has been focused on, because it was considered that the body movement played only a secondary role (Ekman & Friesen, 1975). However, in the research by authors, people can perceive KANSEI information (emotion, impression and image etc.) from body movement, even without facial expressions, and the body does not only have additional or secondary function, but also plays an important role as independent media in human communications (Sakata et al., 2004). Recently, there are some researches aiming to find the relation between KANSEI information and body movement, we don't very often find the researches with a quantitative underpinning. In effective communications among humans, and also between human and robots, to quantitatively examine KANSEI information conveyed by body movement is very important.

So far, it was tried to demonstrate the relationship between body motion and the impression arising from the motion. When doing this they extracted the physical values of movement through analysis of silhouette images from video image taken

from directly in front of the performer (Camurri et al., 1999, 2002, Inoue et al., 2005). However, this method discards the three dimensional information.

Therefore, we use optical motion capture system to extract the characteristics of body movement, because a time series 3-D coordinates value are obtained.

In this paper, we aim to analyse the relation between the subjective evaluation of body movement and the physical measurement, and to quantitatively clarify the cognitive mechanism of KANSEI information conveyed by body movement.

2 Target Movements

In this research, Matsumoto's 7 Motives (Matsumoto, 1985) was subjected to study. It empirically verified the connection between images and movements. The 7 Motives are the seven dance movements that Matsumoto set up to be the minimum unit of expressions, in which each Motive contains clearly distinguishable emotional value. Matsumoto added the arms raising/lowering and closing/opening movements to the ordinary walking movement, and then set up the movements that involve the entire body, including exhalation and inhalation, as the "basic pattern" and called it the Natural Mv. Based on the Natural Mv., she varied the time, energy and design factors of movements, while retaining the characteristics of the Natural Mv. to the extent possible, and created three movements at both extremes. She named them as Happy Mv., Lonely Mv., Sharp Mv., Solemn Mv., Dynamic Mv., and Flowing Mv. Mv. is the abbreviation of "Motive" used by Matsumoto (see Table 1).

In the two experiments (evaluation experiment and motion capture), a skilled female dancer who is a 26-year-old majoring in dance with 15 years of training in modern dance, classical ballet, and contemporary dance performed 7 Motives. Before starting the experiments, she was briefed on the experiment, which was followed by

Table 1. Target Movement; Matsumoto's 7 Motives

	Time	Energy	Design	Movement
Happy Mv.	M.M. ♩=120	High	Skip Turn
Sharp Mv.	M.M. ♩=100	High	Straight
Lonely Mv.	M.M. ♩=36 o o	Low	Up & Down, Asymmetrical
Natural Mv.	M.M. ♩=96	Normal	Symmetrical, Balance
Flowing Mv.	M.M. ♩=92	Normal	Smooth -faced turn
Dynamic Mv.	M.M. ♩=192	High	Jump
Solemn Mv.	M.M. ♩=15	Low	Symmetrical, Balance

several weeks rehearsal. During the rehearsal, the authors familiar with the 7 Motives were present and the performer rehearsed until she was able to represent the 7 Motives in a loyal manner.

3 Extraction of KANSEI Information from Body Movement

In this chapter, to extract KANSEI information from the body movement, we conducted an evaluation experiment using 7 Motives as the stimulus. We researched what the kinds of KANSEI information perceived from body movements and how the raters catch the feature of movement, and developed relation models to investigate the effect of movement feature on KANSEI information conveyed through the body movement.

Forty-eight raters (39 men, 9women, with average age of 22.4, SD=2.05) participated in this experiment. To allow the raters to sufficiently observe the stimuli, movement image were projected on a large display.

Matsumoto’s 7 Motives were newly acted out by the foregoing dancer and was recorded on a video-tape, which was used as the displayed stimulus. The face of the dancer in the image was obscured by mosaic to exclude the influence of the expression (see Figure 1). The name of each motive was not taught the raters.

After the raters were asked to glance over the two lists of rating terms, they were shown the display stimulus showing the motives one by one. After the same motive was shown, the vision changed to an interval. During the interval, the raters were asked to fill in the answer sheets with the following questions.

- i. How much of the seven KANSEI information (happy, sharp, lonely, natural, flowing, dynamic and solemn) were expressed in each Motive: (Rated in the 5-level scales ranging from 1. ‘not expressed’ through 5. ‘very clearly expressed’)

ii. What kind of motion each motive showed: (Rated in the 5-level extreme scales by semantic differential method, see Table 2) This rating terms are selected in terms of time, energy and design; the elements that composes movement (Matsumoto, 1968).

Fig. 1. Mosaic

Table 2. The Rating Terms for Movement Feature

Time	T1: Speedy—Slow T2: Accentual—Smooth T3:Irregular—Regular
Energy	E1: Strong—Weak E2: Heavy—Light E3: Variable—Constant
Design	D1: Linear—Curved D2: Expansive—Shrinking D3: Balanced—Imbalance

3.1 The Subjective Features of Body Movement

Rating on KANSEI Information of the 7 Motives

The rating results using the 5-level scales for the seven KANSEI information (happy, sharp, lonely, natural, flowing, dynamic and solemn) were converted into numerical values (from 1 to 5 points). The mean value were obtained and tabulated in Table 3.

Table 3. Mean Value of KANSEI Information

		<i>7 Motives</i>						
		<i>Happy Mv.</i>	<i>Sharp Mv.</i>	<i>Lonely Mv.</i>	<i>Natural Mv.</i>	<i>Flowing Mv.</i>	<i>Dynamic Mv.</i>	<i>Solemn Mv.</i>
KANSEI	Happy	4.56	1.98	1.79	2.19	4.08	4.33	1.58
	Sharp	2.04	4.67	1.40	1.60	1.81	2.92	1.54
	Lonely	1.29	2.25	3.81	2.54	1.73	1.40	3.67
	Natural	1.94	1.56	2.75	3.27	2.42	1.71	2.54
	Flowing	4.06	1.75	3.35	4.02	4.56	3.54	3.23
	Dynamic	4.33	3.06	1.81	1.96	3.77	4.83	1.85
	Solemn	1.43	3.63	2.96	2.25	1.85	1.65	3.90

Rating on Movement Features of the 7 Motives

Table 4 shows the results of rating on movement features of the 7 Motives. “It applies” was made a score as one point to the left term of Table 2, and “It applies” was made a score as five points to the right term, and “There is not both” was made a score as three points.

Table 4. Mean Value of Movement Features

	<i>Happy Mv.</i>	<i>Sharp Mv.</i>	<i>Lonely Mv.</i>	<i>Natural Mv.</i>	<i>Flowing Mv.</i>	<i>Dynamic Mv.</i>	<i>Solemn Mv.</i>
T1	1.77	2.19	4.85	3.88	3.17	1.25	4.81
T2	2.88	1.25	4.63	4.08	3.79	1.81	4.42
T3	3.75	4.50	3.06	4.54	3.63	3.40	3.98
E1	2.58	1.42	3.69	3.33	2.75	2.08	2.96
E2	4.33	2.42	2.52	3.27	3.98	4.13	1.88
E3	3.50	2.15	3.98	4.25	3.52	2.31	4.25
D1	3.85	1.38	4.60	3.15	4.52	2.21	3.85
D2	2.58	2.75	2.79	2.79	2.04	1.69	2.69
D3	2.58	2.17	3.00	1.77	2.48	2.67	2.17

3.2 The Relation Between KANSEI Information and Movement Feature

In order to examine the relation between the perceived KANSEI Information and movement feature, we conducted multiple regression analyses using the nine evaluated scores of each movement feature (mean value of Table 4) as explanation variables, and the evaluated scores of the seven KANSEI Information (mean value of Table 3) as destination variables (by stepwise way). Table 5 shows the standardized coefficients ($p < 0.05$) and the scores of adjusted R^2 .

As shown by Table 5, a regression model with high significance was obtained for all of the KANSEI information, except for “flowing” (significance level $p<0.05$). In the author's earlier study, a multiple regression model for the flowing impression could not be obtained, too. From the values of the coefficient concerned with each model, we can find that “light” motion contribute to happy impression, while it is “strong” motion for sharp, “heavy” and “slow” for lonely, “balanced” and “weak” motion for natural, “speedy”, “curved”, “Expanding” and “heavy” motion for dynamic, and “heavy”, “strong” motion for solemn. It seems that KANSEI information perceived from each motive are greatly affected by the energy factor of movement.

The relation between KANSEI information and movement feature is shown in the Figure 2.

Table 5. Relation between KANSEI Information and Movement Feature

	T1	T2	T3	D3	E1	E2	adjusted R ²
Happy**	—	—	—	—	—	0.952**	0.887
Sharp**	—	—	—	—	-0.927**	—	0.831
Lonely**	0.590 *	—	—	—	—	-0.466*	0.924
Natural**	—	—	—	-0.427***	0.946***	—	0.952
Flowing	—	—	—	—	—	—	—
Dynamic**	-1.178**	0.468**	-0.287**	—	—	-0.213*	0.998
Solemn***	—	—	—	—	-0.180*	-1.006***	0.991

*... $p<0.05$, **... $p<0.01$, ***... $p<0.001$.

Fig. 2. Relation between the KANSEI Information and the Movement Feature

4 Measurement of Body Movements

In the preceding chapter, we examined the relation between KANSEI information perceived from body and the movement feature. It was clarified that KANSEI

information perceived from each motive were greatly affected by the energy factor of movement. However, the feature of movement is only a subjective factor. It is necessary to examine the relation to the above-mentioned movement feature by the rater and a physical actual one. Therefore, we measured the dancer's movements of 7 Motives by using the optical motion capture.

4.1 Optical Motion Capture

The optical motion capture system employs video camera to track the motion of reflective markers attached to joints of the actor's body. The system uses LED's mounted around the camera lens. In this system, the centre of the marker images are matched from the various camera views using triangulation to compute their frame-to-frame positions in 3D space. Several problems often occur during the tracking process, including of markers, noisy or missing data and false reflections.

In this experiment, 44 markers were put on the same dancer's body to the way of Figure 3, and the movement was measured with ten LED's cameras. The acquired data is obtained as a time series coordinates value(x, y, z) of each marker position by each frame (frame rate 1/60sec.).

Fig. 3. Positions of Markers

4.2 Physical Measurement

When the motion capture is used, the enormous quantity of data by each part is obtained. Then, it becomes important to discover a significant parameter which influences KANSEI information.

In this paper, the following 16 measurements are calculated as the physical parameters that seem to influence KANSEI information; mean velocity of hand, SD velocity of hand, mean acceleration of hand, SD acceleration of hand, Mean velocity

<Physical Measurements>

- P1: Mean velocity of hand
- P2: SD velocity of hand
- P3: Mean acceleration of hand
- P4: SD acceleration of hand
- P5: Mean velocity of foot
- P6: SD velocity of foot
- P7: Mean acceleration of foot
- P8: SD acceleration of foot
- P9: Mean velocity of root
- P10: SD velocity of root
- P11: Mean acceleration of root
- P12: SD acceleration of root
- P13: Mean dimensions of opened body
- P14: SD dimensions of opened body
- P15: Mean height of root
- P16: SD height of root

Fig. 4. Dimensions of Opened Body

of foot, SD velocity of foot, Mean acceleration of foot, SD acceleration of foot, Mean velocity of root, SD velocity of root, Mean acceleration of root, SD acceleration of root, Mean dimensions of opened body, SD dimensions of opened body, mean height of root, SD height of root. Because 7 Motives are basically symmetric movements, only the right were adopted as for measurements of both hands and feet. The dimensions of opened body are the sum total of the triangular area made when drawing a straight line from five end parts (head top, both hands, both ankles) to the root (Figure 4).The height of root was based on the absolute origin of the capturing area.

4.3 Result of Physical Measurements

Table 7 shows the mean value and standard deviation of physical measurement of each motive. In the next chapter, we examine the relation between this result and the subjective evaluation by the raters.

Table 7. Result of Physical Measurement.

		<i>Happy</i> <i>Mv.</i>	<i>Sharp</i> <i>Mv.</i>	<i>Lonely</i> <i>Mv.</i>	<i>Natural</i> <i>Mv.</i>	<i>Flowin</i> <i>g Mv.</i>	<i>Dynami</i> <i>c Mv.</i>	<i>Solemn</i> <i>Mv.</i>
P1		40.82	26.04	5.13	7.27	34.49	51.16	3.34
P2	(cm/sec)	19.32	21.89	3.66	3.28	17.40	24.01	2.42
P3		6.94	5.00	1.56	1.70	4.66	9.97	1.26
P4	(cm/sec ²)	5.63	3.94	2.16	1.74	4.52	7.46	1.98
P5		24.61	22.57	2.76	15.57	17.05	47.96	2.47
P6	(cm/sec)	14.89	24.17	3.83	7.72	10.31	22.98	4.29
P7		7.52	4.86	1.07	2.11	3.00	10.50	0.55
P8	(cm/sec ²)	8.29	5.64	1.85	1.66	2.31	8.97	0.68
P9		19.35	11.29	1.84	13.41	10.46	44.54	1.89
P10	(cm/sec)	7.68	6.13	1.35	2.31	5.28	7.90	2.74
P11		3.58	1.11	0.40	0.66	1.00	3.69	0.29
P12	(cm/sec ²)	3.57	0.98	0.65	0.36	0.62	2.29	0.33
P13		7579.24	7146.98	6315.32	7641.95	8030.88	9277.37	8464.56
P14	(cm ²)	2867.52	3425.65	2061.86	2554.98	2442.39	2547.81	2799.85
P15		1.44	-0.92	-13.24	-2.04	-1.08	7.20	-10.88
P16	(cm)	6.19	5.64	13.40	0.77	8.93	13.98	9.31

5 Relation Between Subjective Evaluation and Physical Measurement

Section 3.5 above, we attempted to develop a multiple regression model of the seven KANSEI information using movement features. However, both of them are only subjective evaluation. In this chapter, we made sure the relation between the subjective evaluation by the rater and the physical movement by motion capture.

Table 8 shows the correlation matrix of subjective evaluation and physical measurements. Many of physical measurements correlated with “speed-slow”, because P1~P12 were velocity and acceleration. All of them correlated with at least one subjective term except for <mean dimensions of opened body>.

Next, we conducted multiple regression analysis using the nine evaluated scores of each movements features (Table 4) as explanation variables, and the physical

measurement (Table 7) as destination variables (by stepwise way). Table 9 shows standardized coefficients($p < 0.05$) and the scores of adjusted R².

As the result, we obtained a multiple regression model for all subjective features (significance level $p < 0.05$). When each feature was observed, the physical measurement that contributes to “Speedy-Slow” is <SD velocity of root>. Similarly, <mean and SD velocity of foot> contribute to “Accentual-Smooth”, whereas <SD height of root> is the factors of “Irregular-Regular”. <SD velocity of foot> contributes for “Strong-Weak”, whereas it was <mean velocity of hand> for “Heavy-Light” and “Variable-Constant”. <SD velocity of hand and foot> contribute for “Linear-Curved”, and <SD acceleration of hand and foot>, <mean velocity of root> are the factors of “Expanding-Shrinking”. <Mean dimensions of the opened body>

Table 8. Correlation Matrix of Subjective Evaluation and Physical Measurements

Movement Features										
	T1	T2	T3	E1	E2	E3	D1	D2	D3	
Physical Measurements	P1	-0.932**	-0.711	-0.229	-0.633	0.811*	-0.718	-0.325	-0.783*	0.318
	P2	-0.941**	-0.880**	-0.050	-0.839*	0.602	-0.889**	-0.532	-0.626	0.230
	P3	-0.945**	-0.773*	-0.233	-0.661	0.728	-0.775*	-0.450	-0.764*	0.326
	P4	-0.908**	-0.706	-0.323	-0.614	0.749	-0.729	-0.341	-0.807*	0.400
	P5	-0.920**	-0.787*	-0.053	-0.646	0.687	-0.767*	-0.605	-0.744	0.108
	P6	-0.909**	-0.994***	0.201	-0.927**	0.370	-0.961**	-0.832*	-0.449	0.003
	P7	-0.947**	-0.781*	-0.161	-0.630	0.708	-0.743	-0.514	-0.662	0.263
	P8	-0.939**	-0.807*	-0.140	-0.656	0.636	-0.749	-0.515	-0.493	0.309
	P9	-0.821*	-0.640	-0.161	-0.475	0.687	-0.626	-0.497	-0.769*	0.152
	P10	-0.963***	-0.816*	-0.025	-0.779*	0.675	-0.761*	-0.469	-0.619	0.166
	P11	-0.873*	-0.606	-0.251	-0.454	0.776*	-0.538	-0.291	-0.589	0.329
	P12	-0.764*	-0.497	-0.250	-0.356	0.690	-0.395	-0.142	-0.324	0.384
	P13	0.059	0.028	-0.273	-0.008	-0.066	-0.122	-0.114	-0.639	0.046
	P14	-0.454	-0.690	0.714	-0.810*	-0.174	-0.525	-0.717	0.201	-0.501
	P15	-0.932**	-0.750	0.154	-0.647	0.777*	-0.673	-0.555	-0.672	-0.101
	P16	-0.010	0.005	-0.878**	0.034	0.003	-0.231	0.206	-0.518	0.838*

Table 9. Relationship between subjective evaluation and physical Measurements

	P1	P2	P4	P5	P6	P8	P9	P10	P13	P16	adjusted R ²
T1***	—	—	—	—	—	—	—	-0.963	—	—	0.913
T2***	—	—	—	0.173	-1.14	—	—	—	—	—	0.995
T3**	—	—	—	—	—	—	—	—	—	-0.878	0.724
E1**	—	—	—	—	-0.927	—	—	—	—	—	0.83
E2*	0.811	—	—	—	—	—	—	—	—	—	0.588
E3**	—	—	—	—	-0.961	—	—	—	—	—	0.908
D1***	—	1.285	—	—	-2	—	—	—	—	—	0.972
D2***	—	—	-1.575	—	—	1.328	-0.495	—	—	—	0.992
D3**	—	—	—	—	—	—	—	—	-0.572	1.146	0.901

*... $p < 0.05$, **... $p < 0.01$, ***... $p < 0.001$ ※The table shows only statistically-meaningful items of physical feature.

and <SD height of root> contribute for “Balanced-Imbalance”. From these results, it is assumed that the feature of movement that the raters subjectively felt can be replaced with the physical measurement.

6 Discussion

When the results of this research are brought together, it is schematised as shown in the following Figure 5.

The left lines show the relation between KANSEI information and movement feature in the raters cognition. On the right side, the relation between subjective value (movement feature) and physical value are connected. Put simply, the subjective and the objective feature of movement conveyed KANSEI information was revealed. For example, lonely motion is slow and heavy, and it is the actual movement that the hand is slowly moved and the difference of fast and slow of root (waist) is not applied. This result is effective to the guidance of dancing and acting, because it is possible to paraphrase sensitive image (KANSEI information) in another word (movement feature) which has strong relation with physical movement.

The reason of the failure to develop a multiple regression model on “flowing” image is attributed to the fact that it is difficult to replace “flowing” with another word representing motion. It seems that “flowing” is not KANSEI information, but movement feature.

Fig. 5. Relation among KANSEI Information and Movement Feature and Physical Measurement

7 Conclusion and Future Work

To quantitatively clarify the cognitive mechanism of KANSEI information conveyed by body movement, we conducted evaluation experiments and movement analysis by optical motion capture. We attempted to develop multiple regression models to

investigate the effect of physical movement on subjective evaluation. The results show the relation between subjective feature of movements and the physical measurement. Thus, we expect that our research is effective to the guidance of dancing and acting, because it is possible to paraphrase sensitive image (KANSEI information) in another word (movement feature) which has strong relation with physical movement. Furthermore, this relational model which can replace human sensibility by digital data is useful for human-computer interaction.

In the future, we will examine the all kinds of movement, not apply only to 7 Motives. Furthermore, we will verify the results of this paper and construct a more exquisite relational model that various movements are covered.

References

1. Camurri, A., Coletta, P., Mazzarino, B., Trocca, R., Volpe, G.: Improving the man-machine interface through the analysis of expressiveness in human movement. In: Proc. 2002 IEEE ROMAN conf., pp. 417–421 (2002)
2. Camurri, A., Hashimoto, S., Suzuki, K., Trocca, R.: KANSEI Analysis of Dance Performance. IEEE International Conference on System, Man and Cybernetics, vol. IV, pp. 327–332 (1999)
3. Ekman, P., Friesen, W.V.: Unmasking the face. Prentice-Hall, Inc., NJ (1975)
4. Inoue, M., Iwadate, Y., Shiba, M., Auzuki, M.: Kansei Feature Extraction Related to Human body-Movements. The Journal of The Virtual Reality Society of Japan 1(10), 31–40 (2005) (in Japanese)
5. Matsumoto, C.: Dance research: Problem situation and learning of problem solving II - Qualities of movements and feeling values. Lecture at the Tenth Congress of the international Association of Physical Education and Sport for Girls and Women. Lerwick (1985)
6. Matsumoto, C.: An introduction of kinesiology. Taishukan Inc., Tokyo (1968)
7. Sakata, M., Shiba, M., Maiya, K., Tadenuma, M.: Human Body as the Medium in Dance Movement. International Journal of Human- Computer Interaction 17(3), 427–444 (2004)