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Development of a Quantitative Methodology to Analyze the Growth of Recognition of Musical Elements in Early Childhood from a Viewpoint of Change of Body Movement

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Abstract

It is widely viewed that music induced body movement of early childhood children changes reflecting progress of development stage of recognition of musical elements. The author had devised four-phased Music Expression Bringing-up (MEB) program to enhance music recognition of children and devised associated Music Test to evaluate recognition achievements based on respective development phase. As such framework successfully showed development of recognition, the author tried to introduce additional quantitative measure which observes body movements on each development phase utilizing 3D motion capture. In motion capture study, 3-year-old (n=28), 4-year-old (n=25), and 5-year-old (n=31) children participated in the every phase's activity of MEB program. Applying such movement results of 4 and 5-year-old children at multiple development phases with MEB program results of relevant phases, statistically significant relationship was attained in ANOVA and relationship was depicted in Circular Affect. Results indicated that usage of 3D motion capture has consistent outcome with MEB program and body parts movements had the characteristic change of element in musical expression, especially, in the right hand. Combining 3D motion capture can identify development signals in movement of body parts and support to understand development achievements of children.

Keywords: Music expression, Recognition of music elements, MEB program, 3D motion capture, Music Test, ANOVA

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Introduction

Children in early childhood frequently move while singing. They voluntarily indicate that they are feeling the beat and rhythm of the music by moving the ankles up and down or clapping their hands according to the music. Specifically, body movement is included in musical expression during early childhood. Children also express their feelings through "make-believe play" and "dramatization" according to music.

Based on these early childhood developmental characteristics, several studies presented the importance of movement activities in musical expression from early childhood (Jalongo & Isenberg, 2001). In parallel, the importance of story creation (Hendy & Toon, 2001) and activities of dramatization (Bolton, 1984; Hendy & Toon, 2001; Winston & Tandy, 2005) described. Some of studies examined the activity contents of movement with music (Burton & Kudo, 2000; Jalongo & Isenberg, 2001; Schirrmacher, 2005; Winters, 1997). Musical expression including dramatic play (Ballema, 2005; Isle, 2007) pointed out the process as integrated music with dramatization (Rubin & Merrion, 1996). In the research on the relationship between recognition of musical elements and movement in early childhood, as a qualitative research, there were a study which presented to deepen the recognition of musical elements at early childhood during activities (Kemple, Batey, & Hartle, 2004) and studies that point out the importance of creative movement (Marigliano & Russo, 2011) in music activities. However, it was mainly in experimental research that attempts were made to elucidate the cognitive strategies regarding the sounds, beats, and rhythm patterns in early childhood (Hannon & Johnson, 2005; Zatore, Chen, & Penhune, 2007).

Thanks to recent motion capture technology, researchers can now implement methodology to observe the developmental characteristics of early childhood and singing and moving are integrated in musical expressions.

In order to encourage music recognition of children, the author had devised the Musical Expression Bringing-up (MEB) program which stimulates in multi- phase. The MEB program consists of four phases' activities such as (1) "beginning activity," (2) "from beginning activity to pantomime," (3) "from improvisation to story creation," and (4) "story dramatization". MEB program begins with awareness of the sound regarding everyday life. Children also establish the image of phenomenon through the experience such as a

name-game and song-play that relate the image of sound with the visual image. Children gradually advance from musical expression including body movement to the formation of a rhythmic pattern and reply song, creative movement, story creation, and integration with dramatization and music. As a result, children would be able to naturally cultivate rich musical expressions by themselves in early childhood.

In order to capture such recognition development in phase by phase, firstly, the author carried out practical process of MEB program for 3, 4, and 5-year-old children. The Music Test was applied on children at beginning phase and at final phase to evaluate developments of children. The Music Test consists of six domains such as “Strength of sound,” “Duration of sound,” “Rhythm,” “Pitch of sound,” “Harmony of sound”, and “Expression and appreciation” and every domain includes 10 contents (Sano, 2014). In the past study, the result of Music Test showed the effectiveness of practice of MEB program based on the multivariate analysis of principal component and clustering (Sano, 2013).

Secondly, the author utilized 3D motion capture system to the relevant phase of MEB program to quantitatively analyze the evolution of children’s body movement of musical expression. Previous studies regarding the movement analysis as a reaction to music in adulthood were limited in their experimental environment (Burger, 2013; Burger, Thompson, Saarikallio, Luck, & Toiviainen, 2013) or previous studies did not apply motion capture technology to track the change of musical expression including body movement in early childhood but the movement such as a dance or sawing posture for only adulthood participants in Japan (Ando & Sumikawa, 2012; Sato, Kaiga, & Watabe, 2010). On the other hand, previous studies of music behavior focusing on the body movement of the music performer showed an experiment that the motion conveys emotion to expression and carried out video analysis of motion capture image regarding a relationship between specific parts of the body movement and expression such as performance of instruments (Dahl & Friberg, 2007; Kawase, 2015). In such video analysis, the importance of head movement was indicated. However, there are no research reports on quantitative analysis of the transformation of musical expression in early childhood, especially, from the viewpoint of body movement during practical process of musical experience.

In this article, the change of body movement in every phase of MEB program was observed with 3D motion capture and statistically strong difference of movement of body

parts was figured out along with advancement of phase of MEB program.

Purpose of the Study

This study aims to present methodology to introduce 3D motion capture technology to enhance analysis of development of music recognition of children from the viewpoint of body movement in musical expression in association with the practice of MEB program. By extracting a relationship between body movement and the recognition of musical elements in developmental phase, it would support educators to focus on encouraging specific children to improve recognition at relevant developmental phase of MEB program focusing on specific movement of body parts.

Previous studies established relationship between music recognition and body movement, but did not show quantitatively any specific verification regarding a relationship between music and movement although it was explained in music education such as Jaques-Dalcroze (1921)'s theory with practice. It should be helpful to develop a quantitative methodology by employing 3D motion capture regarding movement analysis based on full body musical expression to devise appropriate musical experience according to early childhood development.

Method

Children will apply four-phased MEB program which was derived from theory of Rubin and Merrion (1996) to encourage development of music expression. Achievements of children by MEB program will be evaluated by associated Music Test. Question of Music Test has been designed to verify the recognition of the musical expression of children by answering of children responding to teacher's playing of pianos and percussions, etc. The Music Test consists of 6 domains with 60 question items (10 items per domain) to enable quantitative analysis of musical elements (Sano, 2014). 6 domains are: "I. Strength of the sound" (to distinguish between a weak sound and a loud sound); "II. Number, duration of

the sound" (to compare the duration of two sounds); "III. Rhythm" (to distinguish between a certain melody and different melody and rhythm pattern); "IV. Pitch of the sound" (to distinguish between high-and low-pitched tones); "V. Harmony of the sound" (to spot a dissonance in the chord of beautiful sound); and "VI. Expression and appreciation" (to choose music in accordance with a scene). The resource of the Music Test is shown in the References (Sano, 2014). "I. Strength of sound" consists of five items to select weak and loud by listening to the sound of rhythm instruments such as a tambourine and pianos and to select the strength of melody to be played on the piano. Concerning "II. Number, duration of the sound", children have 3 items to answer the number of times a sound of a rhythmic instrument such as piano or tambourine was played and the duration of sound. For 2 items, children answer whether the tempo feeling changes or not according to the duration of sound. "III. Rhythm" is a list of 2 items to select different ones of the rhythm by listening to the piano sound, 4 items to select things of the same rhythm, 1 item to sense expressing the image of movement, and 3 items to count the number of same short rhythm pattern. "IV. Pitch of the sound" includes 7 items for selecting the high/low of the piano sound, 1 item for selecting the gradually rising melody, and 2 items for selecting the jumping of the sounds. "V. Harmony" includes 10 items to choose beautiful sound overlap listening to the piano. "VI. Expression & appreciation" include 9 items to sense of the image of the melody and 1 item to relate the image sensed from the picture to the music.

3-year-old (n=40), 4-year-old (n=40), and 5-year-old (n=40) children in two nursery schools participated in the practice of MEB program in Japan. The author extracted measurement contents of every phase from MEB program to analyze the change of body movement in musical expression of participant children. At the same phase of each MEB program, participant children without 3-year-old children took the first time (pre-test) of music test devised by the author. 3-year-old children were too immature to take the Music Test. The Test took 60 minutes for 4-year-old and 5-year-old children to choose the option of the sheet prepared by the author and mark. The Test result data of the first phase, which should be the closest state before MEB program practice, and the Test result data of the fourth phase, which should be the closest state completing MEB program practice, were statistically processed. Achievements by way of practice of MEB program will be evaluated by the Music Test and results will be processed by multivariate statistics.

Thirdly, the author used MVN system developed by Xsens Technologies B.V. as 3D motion capture to collect data at a frame rate of 60 Hz regarding body movement in musical expression of every phase during the practice of MEB program (n=84). The latest development model of MVN system is a light weight and compact device which provides less constrained environment for even small sized children. The MVN system utilizes seventeen motion trackers to monitor full human body activity and posture such as head, arm, hands, and feet. Calibrated with body lengths such as arm-span, leg length, and waist position, 3, 4 and 5-year-old children were surveyed on by one in each nursery school. MVN motion capture data include seventeen measurement points of body parts such as the pelvis, head, right shoulder, right hand, and right foot. The children were measured one by one during approximately 30 seconds of piano play as music stimuli. Data recording of each child needed 5-10 minutes including attaching and detaching MVN system devices to body parts (see Figure 1). Later, motion capture data were processed in kinetic manner such as distance, velocity, or acceleration in spread sheet and subsequently Analysis Of Variance (ANOVA) was applied with SPSS 21. Table 1 shows activity contents and the measurement dates when they were extracted from each phase of MEB program for the MVN measurement.

Figure 1. A 4-year-old Boy wearing MVN's 17 Motion Trackers

Table 1. *Activity Contents and the Measurement Dates*

	Activity Contents at the Time of the Measurement according to the Phase	U Nursery School	K Nursery School
First Phase	・Music play and self-introduction with the song, "What is your name?"	May 20 in 2016 June24 in 2016	May 23 in 2016 June 20 in 2016
Second Phase	・Song play of "Shopping at a Bakery."	July 15 in 2016 August 19 in 2016	July 11 in 2016 August 15 2016
Third Phase	・The movement of the lion during "The Grand March of the Lion".	September23 in 2016	September 5 in 2016 October 30 in 2016
Fourth Phase	・Movement to play a musical instrument while singing a song including a story ・Question and reply song	December16 in 2016	December 26 in 2016 January 25 in 2017

Furthermore, using Circular Affect referred to Burger (2013)'s study, the author illustrated a relationship between the result of the first time Music Test and the measurement data of body movement in musical expression during the first phase of MEB program in two dimensional space resulting in a spherical design. The author also analyzed the relationship between a result of the second time music test and the measurement data of body movement in musical expression during the fourth phase of MEB program as well.

Results

The Result of the Music Test with the Measurement during the First Phase of MEB Program

The result of the music test concerning 4-year-old with 5-year-old children. U nursery schooler's data concerning the average total score of 5-year-old children were significantly higher than the score of 4-year-old children based on T-statistics ($t4(40) = 5.592$, $p<0.01$) (see Table 2).

K nursery schooler's data concerning the average total score of 5-year-old children were significantly higher than the score of 4-year-old children based on T-statistics ($t(36) = 10.467$, $p<0.01$) (see Table 3).

Table 2. *The Result of the First Time of Music Test concerning 4-year-old with 5-year-old Children in U Nursery School*

		Ⅰ Strength of Sound	Ⅱ Number Duration	Ⅲ Rhythm	Ⅳ Pitch	Ⅴ Harmony	Ⅵ Expression & Appreciation	Total Score
4-year -old	*M*	5.409	4.318	2.546	3.682	4.136	4.080	24.171
	SD	1.944	1.887	1.143	1.985	1.833	2.323	5.360
5-year -old	*M*	7.500	6.200	4.200	5.300	5.700	6.575	35.475
	SD	1.357	2.215	2.042	1.949	2.364	1.692	7.642

Table 3. *The Result of the First Time of Music Test concerning 4-year-old with 5-year-old Children in K Nursery School*

		Ⅰ Strength of Sound	Ⅱ Number Duration	Ⅲ Rhythm	Ⅳ Pitch	Ⅴ Harmony	Ⅵ Expression & Appreciation	Total Score
4-year -old	*M*	6.8333	4.7222	4.1111	4.7222	5.1667	5.958	31.514
	SD	1.7573	1.7758	1.3672	1.3198	1.0981	1.799	4.517
5-year -old	*M*	9.350	8.300	6.700	6.750	5.350	8.138	44.588
	SD	.875	.733	1.418	1.682	1.040	1.047	3.123

Concerning the total score of 4-year-old children, K nursery schooler's score was significantly higher than U nursery schooler's score ($t(38) = 4.621$, $p<0.01$) based on T-statistics. Concerning the total score of 5-year-old children, K nursery schooler's score was significantly higher than U nursery schooler's score ($t(38) = 4.937$, $p<0.01$) based on T-statistics. Through the multiple comparisons by Tukey's HSD (Honest Significant Difference) test, a statistically significant difference was recognized between U nursery school and K nursery school and between 4-year-old children and 5-year-old children ($p<0.05$).

In other words, the average score of 5-year-old children in the K nursery school concerning 5 domains without "harmony" was significantly higher than other three group's score. The average score of 4-year-old children in the U nursery school was significantly lower than others. The average score of the domain "Number, duration" of 4-year-old children in both U and K nursery schools was significantly lower than the score of

5-year-old children in both U and K nursery schools (p<0.05).

The Element of Movement by Activity Phase of MEB Program with Motion Capture Data

The result of a three-way non-repeated ANOVA regarding the measurement data. Motion capture data were based on five body points: the pelvis, head, right shoulder, right hand, and right foot. Concerning those data, a three-way non-repeated ANOVA was applied on MEB program phase factor (4 standards), different childcare form factor (2 standards), and children's factor (3 standards). Table 4 shows the result of measurement data of the moving distance of the pelvis by the activity phase/nursery school/age. The pelvic movement of the trunk that supports the limbs captures the whole picture of the transformation of elements of movement in musical expression because the pelvic movement changes relating to the moving distance that depended on the movement of limbs to sense music while beating and the movement of legs unexpectedly trying to express the image of music. The main effect/interaction of the test of the effect between-subjects is shown in the Table 5. The test regarding simple main effect with multiple comparisons was carried out by Bonferroni method. A main effect/interaction of the test showed the significant difference of the 0.5% standard without age factor and phase factor * age factor. Concerning the result of multiple comparisons, a significant difference of the 5% standard was observed. The moving average of the distance regarding 3-year-old (10.562m) with 4-year-old (10.848m) during the third phase of MEB program was significantly higher than the average data of 5-year-old children (5.749m). In other words, the moving distance of pelvis was long during the third phase of MEB program. Concerning 3-year-old with 4-year-old, the moving distance of K nursery schoolers was significantly longer than the data of U nursery schoolers. The children expressed the symbolic movement of the children's own image of lion by the body sound with pretend when they sensed the music of "Lion's great march" during the third phase of MEB program. Children tried to create a process to express the recognition of the musical elements even if they were immature in expressive ways.

Table 4. *A Three-Way Non-repeated ANOVA regarding the Change of the Moving Distance of Pelvis by the Activity Phase/Nursery School/Age*

Phase of "MEB" Program	Nursery School: KU	Age	*M*	*SD*	N
The First Phase	K nursery school	3-year-old	0.814	0.385	17
		4-year-old	0.739	0.390	17
		5-year-old	0.817	0.445	20
	U nursery school	3-year-old	0.649	0.269	11
		4-year-old	0.632	0.136	8
		5-year-old	0.978	1.136	10
The Second Phase	K nursery school	3-year-old	0.538	0.301	8
		4-year-old	0.584	0.530	14
		5-year-old	0.557	0.202	17
	U nursery school	3-year-old	0.633	0.341	10
		4-year-old	0.590	0.347	9
		5-year-old	0.749	0.295	11
The Third Phase	K nursery school	3-year-old	10.562	4.850	18
		4-year-old	10.849	5.239	17
		5-year-old	5.749	3.789	18
	U nursery school	3-year-old	3.114	2.170	11
		4-year-old	2.017	0.792	8
		5-year-old	3.981	2.137	9
The Fourth Phase	K nursery school	3-year-old	1.202	0.597	16
		4-year-old	1.781	0.722	12
		5-year-old	1.520	0.672	21
	U nursery school	3-year-old	1.683	1.004	9
		4-year-old	0.634	0.169	9
		5-year-old	0.889	0.319	10

Table 5. *The Main Effect/Interaction of the Test of the Effect Between-Subjects*

Factor	*df*	*F*	Significance Probability
phase	3	112.081	$p<0.005$
Nursery school	1	41.595	$p<0.005$
age	2	1.449	*ns*
phase * nursery school	3	36.36	$p<0.005$
phase * age	6	1.657	*ns*
Nursery school * age	2	5.733	$p<0.005$
phase * nursery school * age	6	4.958	$p<0.005$

The change of movement in musical expression of every phase of MEB program in U nursery school. A two-way non-repeated ANOVA was applied on MEB program phase factor (4 standards) and children's age factor (3 standards) was done to examine the difference of the average data regarding the moving distance, the moving acceleration, and the moving velocity. The average data of 5-year-old children were remarkably big in the third phase of MEB program. The characteristic was observed as the result of analysis regarding the moving distance of pelvis and right hand.

As a result of analysis concerning the moving distance of pelvis, the author observed a statistically significant difference in the average of moving distance of pelvis in the third phase of MEB program between phase and different ages (phase: $F(3, 103) = 32.044$, $p<0.005$, $F(2, 103) = 4.285$, $p<0.005$). 5-year-old children showed a higher mean than 4-year-old children with the significant difference of the 5% standard at the age. The data in the third phase showed a higher mean with the significant difference of the 5% than other phases at the activity phase. As a result of the multiple comparisons, 5-year-old children's mean was higher than 4-year-old children with the significant difference of 5% standard in the third phase. The data regarding the right shoulder and the right foot also showed the similar change. The moving distance of the head was longer than pelvic data in the third phase.

Furthermore, the change of the moving distance and the moving average acceleration of right hand were remarkable. Specifically, the moving average acceleration of 3-year-old children significantly increased from the second to the fourth phase. The increase of the moving average acceleration of 3-year-old children was significantly larger than the change of 4-year-old and 5–year-old children as the author showed in Figure 2 ($F(2, 103) = 6.912$, $p<0.005$). The result shows a statistically significant difference in the average of moving distance of the right hand in the third phase of the MEB program between phase and different ages (phase: $F(3, 103) = 5.719$, $p<0.005$, age: $F(2, 103) = 8.396$, $p<0.005$). Because 3-year-old children became to react sensitively to the beat and rhythm, they increased to beat by naturally using their hands and singing during the fourth phase of activity. Changes of velocity also showed the tendency to be the maximum value during the third phase regarding the movement of head, pelvis, and right shoulder.

Concerning the change of the moving distance of the interval between the both hands,

3-year-old children's data were significantly higher than 4-year-old with 5-year-old children's data as the author showed in Figure 3 (phase: $F(3, 103) = 4.182$, $p<0.005$, age: $F(2, 103) = 5.144$, $p<0.005$). The average of the moving distance of the interval between the both hands showed 3.82m as the maximum value during the third phase. As a result of the analysis of moving distance of the interval between the both hands, a significant main effect was observed in both factors of activity phase * age (activity phase * age: $F(6, 103) = 6.918$, $p < 0.005$). Specifically, 5-year-old children's data were significantly larger than data of 3-year-old with 4-year-old children in the third phase of MEB program. As a result of the multiple comparisons, the average data of 5-year-old children and the average data of 3-year-old children in the fourth phase were high with the significant difference of 5% standard.

In other words, 5-year-old children were intentionally creating a movement indicating the recognition of musical elements as a musical expression such as matching the character appearing in lyrics to the rhythm of music while singing. On the other hand, 3-year-old children frequently moved while singing and pretending to be evoked by the image of the lyrics. As opportunities to notice the movements of both hands according to the beat and rhythm of the music increased, they began to recognize musical elements.

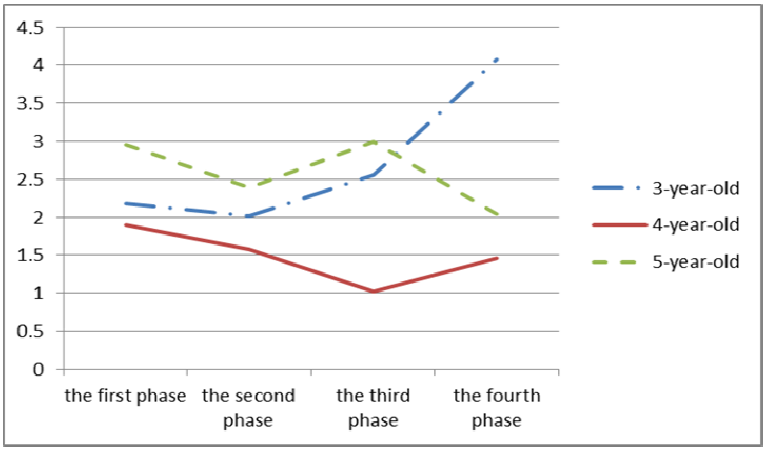

Figure 2. The Moving Average Acceleration of the Right Hand by Activity Phase (m/s^2)

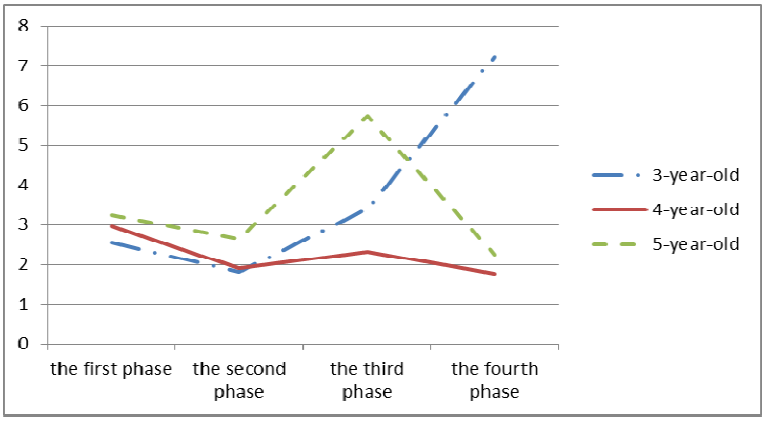

Figure 3. The Moving Distance of the Interval between the Both Hands by Activity Phase (m)

In this way, the significance of the activity contents of the every MEB program remarkably was observed in the change of the element of movement in musical expression regarding 5-year-old children in order to advance recognition of musical elements. For 3-year-old children, it was showed that the expression of musical elements by moving hands frequently increased as the activity phases advanced.

The result of analysis of the movement smoothness. The movement smoothness can be measured by the ratio of velocity/acceleration. A relationship between high velocity and low acceleration indicates the movement smoothness (Burger, 2013). The movement smoothness of the right hand showed a significant difference by activity phase although it did not show a significant difference by the ages. The movement of the pelvis of 4-year-old children showed smoothness although the smoothness of 5-year-old children was the lowest from the first phase to the third phase of MEB program. The movement of the right foot of 3-year-old children showed smoothness in the three phase's activity without the second phase although the movement of the right foot of 5-year-old showed the smoothest in the second phase. 3-year-old and 5-year-old children frequently moved their pelvis with the head and the movement of the head was smoother than the movement of the other measurement parts of their bodies.

Analysis of the Relationship between the Element of Movement in Musical Expression and the Recognition of Musical Elements regarding Participant Children's Data

The author tried to quantitatively analyze a relationship between the result of the first time music test and the measurement data of body movement in musical expression during the first phase of MEB program. The author also examined a relationship between a result of the second time music test and the measurement data of body movement in musical expression during the fourth phase of MEB program as well. The method of Circular Affect was used to analyze a relationship between the motion capture data of MVN system and the music test score before and after the practice of MEB program. Circular Affect was devised by Russell (1980)'s study and revised by Burger (2013)'s study. Circular Affect aims to show the strength of the relationship and the tendency of dispersion by expressing the relationship of the data by a vector. The length of the vector indicates the strength of the correlation between the data and the deviation angle indicates the distance from the axis of the analysis. The author expressed the relation between calculated data of 13 measurement points captured by MVN system and 2 domains of the music test on 2 dimensions. The length of the arrow of the vector indicated the correlative strength and the angle of the arrow indicated the deviation of the vector. "III. Rhythm" and "VI. Expression & appreciation" as the music test domain were used as two axes of analysis because those combinations had the longest Euclidean distance based on the cluster analysis. From the above results, the author focused on the analysis of body movement such as pelvic distance, right hand distance, pelvic velocity, velocity of right foot, the acceleration of right hand, the movement smoothness of pelvis, and the movement smoothness of right foot.

Concerning a relationship between the result of the first time music test and the measurement data of body movement in musical expression during the first phase of MEB program for 4-year-old children (U & K nursery schools), a positive correlation was observed between "the right hand distance" and "I. Strength of sound (0.455)", "V. Harmony (0.427)," and between "the velocity of right hand" and "I. Strength of sound (0.439)", "V. Harmony (0.418)," and "VI. Expression & appreciation (0.364)". Active movement of the right hand had a strong correlation with "I. Strength of sound" including sound awareness in everyday life experience. Correlative strength and deviation angle were

calculated based on the relationship between motion capture data and the Music Test domain “III. Rhythm” with "VI. Expression and appreciation" as the author showed in Table 6.

Table 6. *Correlative Strength and Deviation Angle based on the Relationship between Motion Capture Data and the Music Test Domain “III. Rhythm” with “VI. Expression and appreciation”*

MVN Measurement Points	Correlative Strength	Deviation Angle
The moving distance of pelvis	0.299	-129.7°
The moving distance of the right hand	0.274	13.1°
The moving distance of the right foot	0.214	-131.6°
The moving average velocity of pelvis	0.248	54.2°
The moving average velocity of right hand	0.274	16.8°
The moving average velocity of right foot	0.262	-29.9°
The moving average acceleration of pelvis	0.342	125.5°
The moving average acceleration of right hand	0.427	190.2°
The moving average acceleration of right foot	0.141	-47.9°
Both-hand interval change	0.013	12°
The moving smoothness of pelvis	0.175	-62.3°
The moving smoothness of the right hand	0.343	26.6°
The moving smoothness of the right foot	0.372	43.6°

Table 6 showed that a correlative strength was high of the moving average acceleration of right hand (0.427) and the moving smoothness of the right foot (0.372). This result indicated the movement of the right hand and the right foot had a strong correlation with the music test score because the children whose Music Test score was high frequently waved their hands and moved smoothly their feet. Regarding the deviation angle, the distance was -131.6 ° to 13.1 ° and the acceleration was -47.9 ° to 190.2 °, which was distributed in a relatively wide area. On the other hand, it was found that the velocity was -29.9 ° to 54.2 ° and the smoothness was -62.3 ° to 43.6 ° in the relatively narrow region. Before the practice of MEB program in the first phase, “III. Rhythm” and “VI. Expression & appreciation” were not relatively related to the elements of movement.

The relationship between the elements of movement and the musical elements in the musical expression was represented in Figure 4 as a Circular Affect model based on the data of Table 6. Vector 8 in the Figure 4 showed that a strong correlation was observed between the moving average acceleration of right hand and the recognition of musical

elements. Vector 8 was near the axis “VI. Expression & appreciation” because 4-year-old children tended to express their image listening to the music using their right hand frequently. Vector 1 in the Figure 4 showed that a strong correlation was between the moving distance of pelvis and the recognition of musical elements. Vector 1 was near the axis “III. Rhythm” because 4-year-old children tended to take rhythm of music using the movement of pelvis.

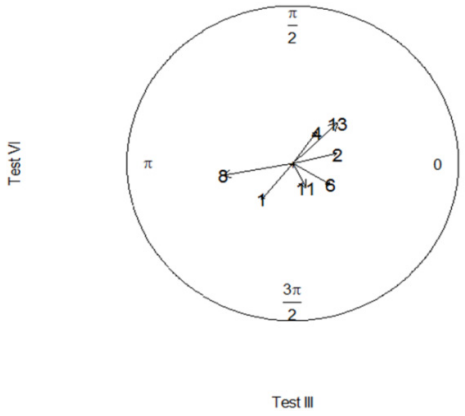

Figure Number	Measured and Calculated Data
1	The moving distance of pelvis
2	The moving distance of the right hand
4	The moving average velocity of pelvis
6	The moving average velocity of right hand
8	The moving average acceleration of right hand
11	The moving smoothness of pelvis
13	The moving smoothness of the right foot

Figure 4. Circular Affect and Movement Feature regarding 4-year-old Children’s Data (U & K Nursery Schools) in the First Phase of MEB Program

In other words, a strong relationship between the movement of the right foot and the music test score was observed in the closest first phase’s activity before the practice of MEB program, but the relationship between other motion capture data and the recognition of the musical elements was not strong during the first phase’s activity.

On the other hand, the correlative strength generally increased regarding the relationship between the motion capture result in the fourth phase closest after the practice of MEB program and the second music test (after practice) score. Measured and calculated data regarding the distance, the velocity, the acceleration, and the smoothness tended to distribute in narrower area. The correlative strength was particularly high between “the moving smoothness of the right hand (0.487)”, “the moving smoothness of pelvis (0.338)”, and “IV. Pitch of sound”.

As the result of the 5-year old children, vectors of the movement of the pelvis, right hand,

and right foot regarding the relationship between the first phase of the MEB program and the first time of the music test score were distributed in a narrow range. Specifically, the correlation between “smoothness” and “III. Rhythm” was strong. On the other hand, for the relationship between the measurement data in the fourth phase of MEB program and the second music test score, the correlative strength regarding “smoothness” was large between “pelvic smoothness (0.436)” and “V. Harmony” and between “the smoothness of the right hand (0.325)” and “III. Rhythm”. In addition, the distance, velocity, acceleration, and smoothness were distributed in a narrow area.

Concluding Discussion

In this study, body movement analysis was integrated into the investigation of recognition of musical elements of children. The change of recognition at relevant developmental phase was seamlessly examined. From captured data, statistically significant results extracted considering phase of MEB program, nursery school, and age of participant children and, thus far, compared with Music Test results applied at beginning and ending of practice of MEB program.

As a result, the characteristic change of element of movement in musical expression was represented, especially, in the moving distance of the right hand, the moving average acceleration of the right hand, and the smoothness of movement observed in both-hand interval change. Those changes were observed in the third phase including the main purpose of the recognition of musical elements in MEB program. The consistency between the body movement characteristics in the musical expression and the music test score was presented in Circular Affect based on the result of analysis regarding the relationship between the element of movement and the recognition of musical elements in musical expression. It was found to be expressed two-dimensionally.

It was considered that the importance of the movement as an element of the musical expression peculiar to early childhood was shown by quantifying the change of movement which was not so obvious at the time of observation. Therefore, early childhood teachers can learn about the progress of recognition of musical elements by early childhood children

from the measurement results of numerical values representing changes of elements of movement in the musical expression of early childhood children. As a result, early childhood teachers can predict how the body movement of children observed in musical expression and can think of a systematic music experience. In these respects, the method of 3D motion capture introduced in this paper is thought to be useful for early childhood music education for teachers to objectively and quickly find out to encourage specific children to have more process at which phase and how such achievements would be reflected in which domain of the Music Test.

In the future, the author will also add survey results at nursery schools with different childcare forms, classify the data, extract the developmental characteristics of the musical expression, and formulate an evaluation methodology of the development of the musical expression in early childhood.

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