Creation of a Sound-Image Scale

- Quantification of the Images of Chord Progressions with Impression Evaluation Used -

Tomomi Sangenya Takashi X. Fujisawa Noriko Nagata
Department of Informatics, Graduate School of Science and Technology
Kwansei Gakuin University
Sanda 669-1337, Japan
tomomi-s@kwansei.ac.jp

***Abstract*— Sound and music make impressions on listeners and can change their moods. In this paper, a sound-image scale that scales the relationship between chord progressions and their images is created. First, with the MDS method, the impression-based distance between chord progressions is calculated and, at the same time, main chord progressions used for an evaluation experiment are selected. Second, with the SD method, an evaluation experiment is conducted on the main chord progressions. As an image scale, the dimensions of activity and exaltation were adopted, and the axes were handled as "cool-warm" and "active-passive." In addition, based on factor loadings, scales are arranged on the image scale, and, based on factor points, the main chord progressions were represented on the same scale. Furthermore, the remaining chord progressions that had not been directly evaluated were mapped on the scale with the impression-based distance used. As a result, a sound-image scale concerning chord progressions was created.**

***Keywords*— image, sound, estimation, SD, MDS**

I. INTRODUCTION

Our daily lives are full of music. Various pieces of music, such as BGM played in stores and station precincts and alarm sounds emitted from industrial products, are used in various situations and environments.

Sound and music make impressions on listeners and can change their moods. With this expected effect, various researches based on the idea of so-called soundscape, as seen in providing music suitable to specific scenes and designing sounds that match the images of various environments, have been conducted thus far. Some examples of the researches are the evaluation of the impressions that alarm sounds give, the relationship between the physical characteristics of sound, such as frequencies, and images, and the relationship between environments and musical genres.

In this research, a chord progression, one of the important constituents that compose a mood that music has, is paid attention to, and a sound-image scale, which shows the relationship between a chord progression and an adjective that represents the image of the chord progression, is created. A chord progression is a time-series expression that consists of two to eight chords, and diversified chord progression data are created according to various combinations of chords. The number of frequently used types of chord progressions exceeds 100. On the other hand, when the number of adjectives that represent images does not exceed a certain level, they cannot represent various images. Therefore, it has been considered that the mapping of many stimuli (chord progression data) and many adjectives is difficult.

In this research, an evaluation experiment is conducted in two stages to solve this problem. First, an experiment with the multidimensional scaling method (hereafter referred to as MDS) is conducted on chord progressions, and some of the main chord progressions, each of which gives a different impression, are selected. Second, these selected chord progressions are evaluated with the semantic differential (SD) method, and the impression space of the chord progressions is sought. The impression space is mapped with the remaining unselected chord progressions with the relative distance between the unselected chord progressions and the selected main chord progressions. With this procedure followed, a sound-image scale that shows the relationship between many chord progressions and impressions is created.

In prior researches, the impressions of several types of chord progressions have been evaluated, but there are no other researches than this one concerning a large-size sound-image scale where common impressions are extracted from many chord progressions and chord progressions and adjectives are arranged on the same axis. This research got a hint from a color-image scale [1], but what is different from the color-im se scale is that, with adjectives unique to sounds used and with sounds specialized in, a newly created im se scale is used. A sound-image scale is not only useful in designing environmental sounds but it is also expected to be applied to various fields, such as music information processing, including automatic musical composition and arrangement and entertainment.

II. STEP1: SELECTION OF MAIN CHORD PROGRESSIONS

A. Objective

The first step in the creation of a sound image scale is the selection of the main chord progressions. Then, using the MDS method, the distances between the chord progressions are calculated on the basis of the impressions they generate, and the chord progressions are mapped depending on the distance. Chord

progressions with distinctive impressions are selected as the main chords.

The MDS method is a technique used to determine similarities in data. This algorithm rates items on the basis of their similarities or dissimilarities to a particular factor. It then determines the number of dimensions in a multidimensional space and the Euclidean distance between items and assigns a location to each item in a low-dimensional space. In this study, we use the rating scale method to obtain the distance between items, that is, we use the rating scale to determine similarities between pairs of items [2].

B. Methods

Forty two university students with four years or more experience in music participated in our study. We selected 19 chord progressions as stimuli from a total of 150 progressions in a stylebook of chord progressions [3].

The chord progression data was generated as a wav file using music notation software and was then shown to the participants. The participants were asked to rate the similarity of the chord progressions on a 7-point scale ranging from ratings for very similar to extremely dissimilar. In this study, we used the rating scale method to obtain the distance between items, that is, we used the rating scale to determine similarities between pairs of items. A total of 171 pairs generated by the combination of 19 items were divided into four groups, each of which was rated by the participants, who were also divided into four groups (two groups of 10 people each and two groups of 11 people each).

In order to avoid the effect of voicing (the invention of a chord), the participants were trained to form impressions based on the whole stimulus and not on the pitch of a sound or a change in the pitch of the highest tone, which is the most clearly audible. In addition, in order to help the participants to be able to easily assign ratings, the participants were given a few preselected examples before the rating experiments. These examples were of chord progressions with similar impressions as well as dissimilar impressions and which were prepared based on the opinions of experts in music. After this, the data was collected.

C. Results

The data from the responses of the participants were analyzed by ALSCAL. From the results, seven main chord progressions that were positioned at a considerable distance from each other were selected, as shown in Table I.

TABLE I. SEVEN SELECTED CHORD PROGRESSIONS

C Dm7 G7 C
C Em/B Em7(b5)/Bb A7
C Am Dm E7
C Gm C7 F
C G Am Em
C Caug C6 Caug
C C△7/B C7/Bb A7

III. STEP 2: EVALUATION OF MAIN CHORD PROGRESSIONS WITH THE SD METHOD

A. Objective

As the second step in creation of a sound-image scale, the factor structure of the impression concerning the chord progressions is determined by the SD method. As rating many chord progressions with many adjectives put a strain on participants, this experiment is conducted with only seven chord progressions chosen in the previous experiment. Since the chord progressions chosen have quite different impression each other, it should be relatively easy to find the impression dimensions.

B. Methods

A total of 25 pairs of adjectives were selected from the adjectives concerning chord progressions and impressions on music. The seven chord progressions were rated on a seven-point scale by using the adjectives with the SD method. The participants rated the chords while listening to the stimuli on a headset.

C. Results

Factor analysis (main factor method, the varimax method) was applied to the SD data obtained, which was referred to as two-mode by putting the mode "participants" and "objects (stimuli)" together. As a result, five factors whose eigenvalue was greater than one were extracted. From this, the number of factors is determined. In this experiment, three factors structure can be assumed for the following reasons.

- 56.6% of the variance can be accounted for by the three factors.
- The gap between eigenvalues of the third and fourth factor is rather large.
- It is easier to interpret and more practical that the fewer the number of factors is the better as an image scale.

Next, factor analysis was applied again with the number of factors fixed at three. Since there is no scale whose communality is less than 0.4, no items were omitted. Table 2 shows the factor loadings as a result.

The factors are interpreted on the basis of these results. The first factor, which is thought to be involved in the evaluation of the chord progressions such as "uncomfortable-comfortable," "inelegant-elegant," "dislike-like," and "clear-dirty," can be interpreted as an "evaluating" factor. The second factor is explained as a "warming" factor according to the adjectives such as "cheerful-depressed," "sad-joyful," and "bright-dark." The third factor, which has high loadings from the variables of "gorgeous-modest," "dispassionate-passionate," and "fearless-fearful," is interpreted as an "activating" factor.

An interpretable three-factor solution consisting of an evaluating factor; a warming factor and an activating factor was indicated from these results. However, as this study aims to construct a clinical image scale for sound design and music creation, the two scales of the warming factor and the activating

factor are adopted, except for the evaluating factor which is more subjective.

TABLE II. RESULTS OF FATOR ANALYSIS (FACTOR LOADINGS) ▪

	Factors		
	1	2	3
uncomfortable–comfortable	**0.85**	-0.197	-0.207
inelegant–elegant	**0.755**	-0.065	0.094
dislike–like	**0.748**	-0.114	-0.242
clear–dirty	**-0.698**	0.284	-0.008
unstable–stable	**0.693**	-0.185	0.171
profane–sacred	**0.599**	0.016	0.216
verbose–frank	**0.539**	-0.345	0.283
simple–complex	**-0.518**	0.282	-0.346
modern–classic	**0.482**	0.003	0.461
fashionable–dowdy	**-0.477**	0.17	0.45
cheerful–depressed	-0.206	**0.839**	0.26
sad–joyful	0.396	**-0.768**	-0.239
bright–dark	-0.337	**0.752**	0.261
heavy–light	0.033	**-0.625**	-0.045
warm–cool	-0.256	**0.606**	0.124
hard–soft	0.286	**-0.574**	-0.006
tense–relaxed	0.038	**-0.564**	0.355
childlike–adult	0.124	**0.52**	-0.216
gorgeous–modest	0.122	-0.078	**0.68**
dispassionate–passionate	-0.134	-0.163	**-0.603**
fearless–fearful	-0.055	0.179	**0.594**
showy–plain	0.109	0.126	**0.591**
naive–sophisticated	-0.021	0.235	**-0.586**
passionate–calm	0.411	-0.189	**0.581**
weak–strong	0.243	-0.108	**-0.526**

IV. STEP 3: ESTABLISHING THE IMAGE SCALE

In order to develop an image space based on two components, namely the "warming" factor and the "activating" factor, we developed a coordinate system defined by two axes termed as the "warm-cool" and "active-passive" axes. The adjectives and their corresponding chord progressions were mapped onto this image space.

First, the adjectives were laid out in the image space on the basis of factor loadings.

Then, the chord progressions were laid out in two steps, as described below. First, the main chord progressions characterized as stated in the previous section, were laid out. This was followed by the plotting of the remaining uncharacterized chord progressions.

A. Mapping adjectives

The adjectives were laid out in the image space on the basis of factor loadings.

B. First step for mapping chord progressions (main chord progressions)

The factor score of the main chord progressions, which were characterized as mentioned in the previous section, was calculated using the factor loadings obtained in experiment 2. The factor score is the compound score obtained by conversion of the factor loadings. The chord progressions were then laid out in the image space on the basis of the calculated factor scores.

C. Second step for mapping chord progressions (remaining chord progressions)

The relative distances between the different types of impressions were determined from the results of experiment 1. The remaining chord progressions that were not characterized by the SD method were then mapped on the basis of these distances in the same figure where the main chord progressions were mapped.

Let us consider the chord progression C-E7-Am-C7 as an example. The method of mapping is as follows: First, using the locations of the chord progressions plotted on the basis of their impressions according to the MDS method, the distances dm[1], dm[2], … dm[7] between the chord progression C-E7-Am-C7 and the seven main chord progressions are determined. Figure 1 shows the mapping of the chord progressions according to their impressions.

Next, the x and y axes are graded from –1.5 to +1.5 with an increment of 0.05 to define a grid of "i" points. The factor scores are obtained by determining the distances di[1], di[2], … di[7] from each grid point to the seven main chord progressions. Figure 2 shows the mapping of the chord progressions on the basis of the factor scores.

The total sum of the square of the differences between these obtained distances is defined as error "e_i."

$$e = \sum_{k=1}^{7} (dm[k]-di[k])^2$$

Then, "e_i" is calculated for each grid point. The grid point with the smallest error is taken up as the final position of the chord progression.

This process is then repeated for all the other chord progressions.

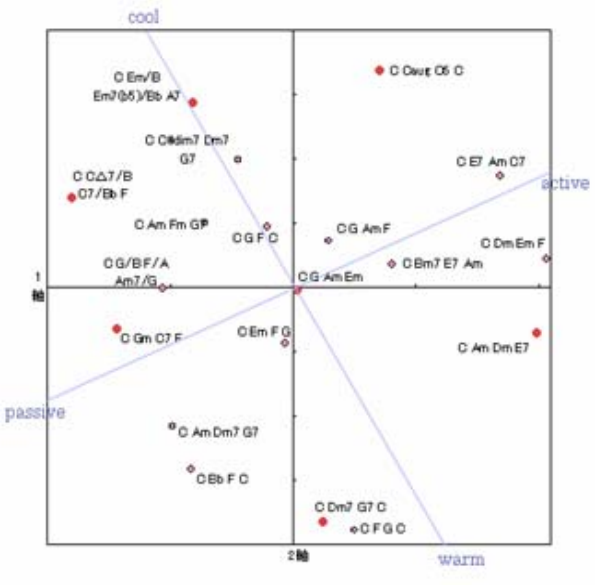

Figure 1. Distances mapped according to MDS method on the basis of their generated impressions

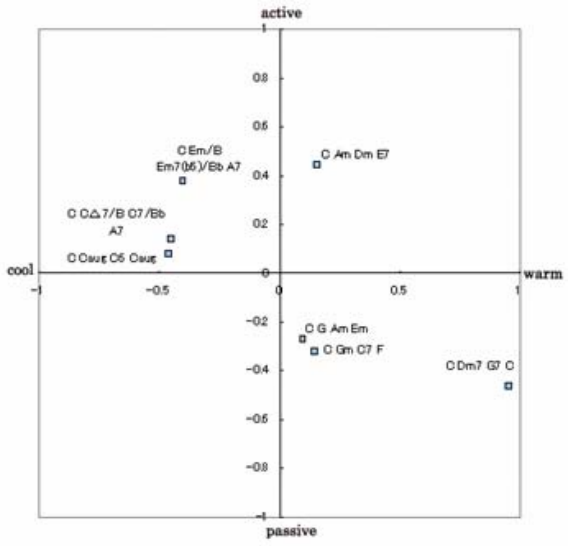

Figure 2. Chord progressions mapped on the basis of the factor scores

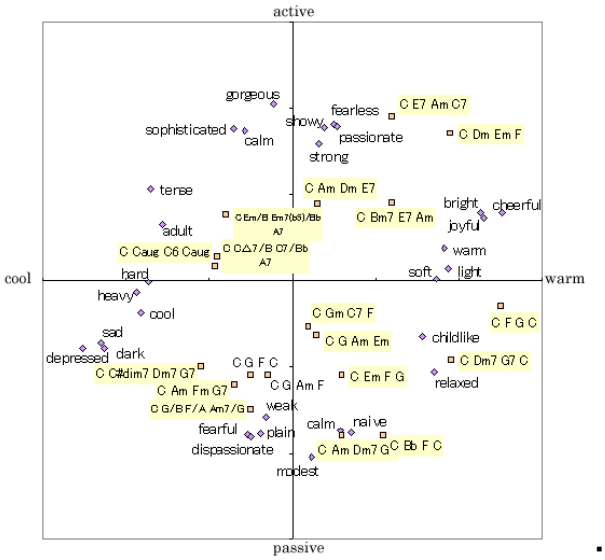

Figure 3. Sound image scale

D. Results of mapping and discussion

Figure 3 shows the sound image scale established by the above processes.

First, we clarify the scale used in the mapping. Adjectives such as "cheerful–depressed," "bright-dark," "light-heavy," "joyful-sad," "soft-hard," and "warm-cool" are laid out about the "warm-cool" axis. On the other hand, adjectives such as "gorgeous-modest," "passionate-calm," "fearless-fearful," "strong-weak," "sophisticated-naive," and "showy-plain" are laid out about the "active-passive" axis. The results demonstrate that the images associated with these adjectives can be expressed using a two-dimensional coordinate system. In addition, adjectives such as "relaxed-tense" and "childlike-adult" are plotted in the second and fourth quadrants; this indicates that another image can be expressed.

We now discuss the results of the mapping of the chord progressions. Overall, since the results of the seven main chord progressions mapping by distances, shown in Figure 1, and the results of those mapping by factor scores, shown in Figure 2, are alike, it is considered that an appropriate image scale has been established.

From the results of the sound image scale, it can be observed the chord progression C-Dm7-G7-C, for example, is characterized as bright and mild and especially relaxed and childlike as it is in the fourth quadrant. The chord progression C-Am-Dm-E7 is interpreted as strong, bold, and showy as it is around the "active" axis. On the other hand, being in the second quadrant, the chord

progression C-Em/B-Em7(b5)/Bb-A7 is found to create an adult, tense image.

The remaining chord progressions, whose impressions have not been experimentally characterized by the SD method, are mapped on the basis of the distances determined by the MDS method that evaluates whether the impressions are alike or not. The results, however, include chord progressions that are plotted with a large error. A possible cause of such an error may be as follows: In the experiment that uses the MDS method, the participants were instructed to characterize an image based on the impressions created after listening to an entire chord progression. However, it is considered that as the participants listened to many chord progressions, they acquired a tendency to characterize the image based only on part of the stimulus. More particularly, their judgment might have depended on partial stimuli such as the fact that the pitch of the last note or the chord was alike or on high pitch notes that could be easily recalled. Hence, further studies are required to rectify this error. The results show that few chord progressions are present in the first and second quadrants. Hence, provisions should be made for handling a larger number of chord progressions including those belonging to these two quadrants. In addition, a more accurate image scale can be developed if the element of a chord progression that is dominant in creating an impression can be determined. We plan to investigate this issue in a future study.

V. CONCLUSION

In this research, a sound-image scale that scales the relationship between chord progressions and their images was created.

First, with the MDS method, the impression-based distance between chord progressions was calculated and, at the same time, main chord progressions used for an evaluation experiment were selected. Second, with the SD method, an evaluation experiment was conducted on the main chord progressions. As an image scale, the dimensions of activity and exaltation were adopted, and the axes were handled as "cool-warm" and "active-passive." In addition, based on factor loadings, scales (adjectives) are arranged on the image scale, and, based on factor points, the main chord progressions were represented on the same scale. Furthermore, the remaining chord progressions that had not been directly evaluated were mapped on the scale with the impression-based distance used. As a result, a sound-image scale concerning chord progressions was created.

In this way, multiple chord progressions and adjectives were associated with each other, and the relationship between chord progressions and images was clearly presented. In addition, it was suggested that there was a possibility that a large-size sound-image scale that represented the relationship between a larger number of chord progressions and adjectives could be created by combining the impression-based distance calculated with the MDS method and the factor points based on the SD method.
It is considered that the results obtained from this research can be used for various aspects, such as designing music suitable to some specific environments and automatic musical composition and arrangement. In addition, in the future, using a sound-image scale combined with a color-image scale [1], it is expected that a concept design that is suitable to a specific atmosphere or environment can be created from the images of both colors and music [2].

REFERENCES

[1] S. Kobayashi, "The Aim and Method of the Color Image Scale," In COLOR research and application, vol. 6, No.2, Summer 1981.

[2] N. Nagata, N. Takashima, A. Hasegawa, "Quality of Multimedia Contents-Ubteractuibs between Pictures and Music of TV Commercials-," in Prc. 7th international Conference on Quality Control by Artificial Vision, pp. 329–334. 2005.

[3] M. Naruse, "Stylebook of Chord Progressions," Rittor-Musis, 2001.

[4] T. Sugihara, , K. Morikomoto, T. Kurokawa, "Fundamental Characteristics of Kansei for Music through the SD Method," In ITE Technical Report, vo25. No.48(20010726), pp. 57–63, 2001.