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Expression of music by colors

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Abstract: Music comprises numerous components and is thus difficult to express. If an image of music could be visually articulated, smoother communication could be achieved. Previous research has demonstrated that color is able to express impressions, and this study aims to express music through colors. Two experiments were conducted. Experiment 1 evaluated the impression of music and 40 compositions of varied genre were used as stimuli. Color stimuli were selected from the Practical Color Co-ordinate System (PCCS). 12 tones, 12 hues, and achromatic colors (in total 25 color stimuli) were used. Impressions were assessed using the 7 step Semantic Differential (SD) method that utilized 20 adjective pairs. Subjects first evaluated the impressions they received from the music, then selected colors that matched or mismatched those impressions. The music stimuli used in experiment1 were also employed for Experiment 2, which pertained to the expression of music through colors and an application was used for this purpose. The expression of the music was accomplished in two parts: by tone, and by hue through achromatic color. Subjects changed the size of the color patches displayed on the screen of the application to express the music they heard using colors. Results were recorded for each stimulus with each color designated a numerical value between 0 and 100. The results of the factor analysis for impression data revealed four factors. The regression analysis demonstrated that color expressions using tones in Experiment 2 corresponded to these factors.

Keywords: *color, music, PCCS tone*

1. INTRODUCTION

It is difficult to express music because it consists of numerous components. Smoother communication could be achieved if music could be visually expressed. Some studies have previously demonstrated a relationship between color and sound, and between color and music. Marks (1975) proved that the robust correspondence between the lightness of color and the pitch of sound [1]. Palmer et al. (2016) showed that color is useful for expression of music by asking subjects to select the color to be imaged against a melody they heard on the piano and to evaluate their impressions through four emotional terms [2]. Katayama et. al. (2006), used the Practical Color Co-ordinate System (PCCS) tone to select tones to associate with the sound that was heard [3]. The results of this experiment suggested that higher pitched sounds evoked the tendency of selecting vivid colors, and that the correspondence of colors was not limited merely to lightness. The PCCS tone is a mixed concept that includes both lightness and brightness, and comprises12 tones. A previous study on the image of PCCS tone illustrated that the PCCS tone can capture a wider range of impressions than hue (Wakata & Saito; 2012, Wakata & Saito; 2015) [4,5]. Yamawaki & Shizuka (2005) suggested that the visualization of sound and color do not inhabit totally different image spaces [6].

In this study, it was assumed that color can express impression, and the investigation aimed at expressing music through color.

2. Method

2.1. EXPRRIMENT 1_Stimuli

Music: 40 musical compositions selected from Goto et.al. (2002) were used as stimuli. In this previous study, 100 music pieces were classified into 10 genres and 40 sub genres [7]. Each sub genre contained 1 to 3 songs. The 40 pieces of music were randomly selected from each sub genre (Table1) and were edited to durations between 1 and 2 minutes. White noise was used as the blank stimulus. The stimuli were presented using a tablet (iPadAir2: Apple) and headphones (Quiet Comfort 35 wireless headphones :BOSE).

Color: The colors were selected from PCCS. The tone stimuli used 12 tones [vivid: v, bright: b, strong: s, deep: dp, light: lt, soft: sf, dull: d, dark: dk, pale: p, light-grayish: ltg, grayish: g, and dark-grayish: dkg]. A color wheel with 12 patches of hues (1.5cm × 1.5cm) was pasted onto a piece of cardboard (10cm×10cm) next to each of these tones. The

Table1. Music stimuli

Stimuli No.	Genre	Sub Genre	Stimuli No.	Genre	Sub Genre
No. 01	pop	Pop	No. 21	march	Brassband
No. 02		Ballade	No. 22	classic	Baroque(instrumentalmusic
No. 03	Rock	Rock	No. 23		Classical(instrumentalmusic
No. 04		Heavymetal	No. 24		Classical(chambermusic
No. 05	dance	lap/hip-hop	No. 25		Romanticists(chambermusic
No. 06		House	No. 26		Romanticists(instrumentalmusic
No. 07		Techno	No. 27		Modernization(instrumentalmusic
No. 08		Funk	No. 28	world	Blues
No. 09		soul/R&B	No. 29		Fork
No. 10	jazz	Bigband	No. 30		Country
No. 11		Modernjazz	No. 31		Gospel
No. 12		Fusion	No. 32		African
No. 13	Latin	Bossanova	No. 33		India
No. 14		Samba	No. 34		Flamenco
No. 15		Reggae	No. 35	vocalmusic	Chanson
No. 16		Tango	No. 36		Canzone
No. 17	classic	Baroque(orchestralmusic	No. 37	Japanesemusic	Enka
No. 18		Classical(orchestralmusic	No. 38		Folksong
No. 19		Romanticists(orchestralmusic	No. 39		Court-music-of-Japan
No. 20		Modernization(orchestralmusic	No. 40	acappella	Acappella

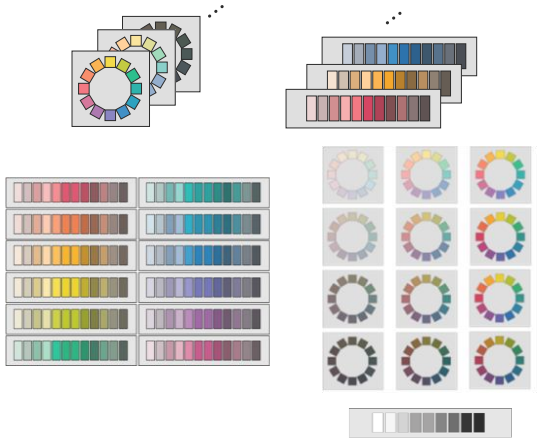

Figure1. Color stimuli

hue stimulus comprised the following 12 hues [2:R, 4:rO, 6:yO, 8:Y, 10:YG, 12:G, 14:BG, 16:gB, 18:B, 20:V, 22:P, 24:RP]. 12 tones (3cm × 1.5cm) were pasted in a belt-shape on a piece of cardboard (5cm × 21cm) for each hue. Items pasted onto an A3 sized cardboard (30cm x 42cm) were used for both tones and hues. Additionally, a gray scale of 9 neutral color shades [1.5Bk–9.5 W] was pasted in a belt-shape on a piece of cardboard (5cm × 21cm). There were thus a total of 25 color stimuli consisting of 12 tones, 12 hues, and 1 neutral color(Figure1).

2.2. EXPRRIMENT1_EvaluationItems

Impressions were assessed using the 7 step Semantic Differential (SD) method that utilized 20 adjective pairs selected by referencing previous studies. The color stimuli were evaluated using the Visual Analog Scale (VAS) that considers brightness/darkness and vividness/dullness. The subjects selected a total of 4 colors for the music stimuli: a color from both the tones/neutral colors and one from the hues that seemed to match the presented stimulus the most, and similarly, a color from each range that most mismatched the stimulus. Each of the assessments was accomplished using an application on an Apple iPad. *Data of VAS and selected colors were not used in this study.

2.3. EXPRRIMENT1_Environment and Subjects

The experiment was conducted on 65 subjects (average age of 21.5±1.2, 26 males, and 39 females) in a university classroom with normal fluorescent lighting (800-1,000lx).

2.4. EXPRRIMENT1_Procedure

The music stimuli were presented one at a time, followed by the evaluation of their impressions and the selection of matching and mismatching colors. White noise was provided for 10 seconds in the intervals between the presentation of the musical stimuli. The color stimuli were also presented one at a time, and the brightness and vividness of the color stimuli were evaluated using the VAS while the impression was evaluated using the SD method by presenting one color stimulus at a time. Several groups were set up for the presentation of the stimuli and for the order of the adjective pairs used for the SD method, and these groups were randomly matched to each of the subjects as a counterbalance consideration.

2.5. EXPRRIMENT2_Stimuli

The use of music and colors were identical to those employed in experiment1.

2.6. EXPRRIMENT2_EvaluationItems

The author of this paper created an expression of music by colors application on an Apple iPod touch. The application consisted of four screens: the first for listening to a musical composition; the second to evaluate the music through PCCS tones and achromatic color; the third to assess the music through hues; and the last presenting white noise to represent a 10 second break (Figure2).

2.7. EXPRRIMENT2_Environment and Subjects

The environment for this experiment was same as the one used in experiment1. There were 40 subjects in this experiment. (average age of 21.9±1.6, 14 males, and 26 females).

2.8. EXPRRIMENT2_Procedure

Subjects listened to a piece of music on screen 1. On the evaluation screens (2 and 3), the subject expressed the presented music by increasing or decreasing the size of the color bands. If they felt that the colors did not apply at all, they could turn off the color circle. For example, if a subject experienced a moderate impression of the piece of music, the size of the color was halved. The size of a color could be manipulated through a slide-rule displayed at the bottom of the screen. Several groups were set up for the presentation of the stimuli and for the ordering of the tones or hues, and these groups were randomly matched to each of the subjects as a counterbalance consideration. Each color was recorded at 0-100.

3. Results

3.1. Factor Analysis

Factor analysis(maximum likelihood method, promax rotation) was conducted to find attributes common to music and color and was accomplished using the average values obtained from the assessment of impressions using the SD method (Experiment1). The results indicated four factors common to music and color (Table2).

3.2. Cluster Analysis (1)

Cluster analysis was performed on the average value of data expressing music by color (Experiment2) to narrow down the number of colors. The examination was accomplished with tones matched to achromatic color and hue, respectively. Euclidean distance and Ward methods were used for these two cluster analyses. Color sorting was achieved by classification into 4 clusters by tone and achromatic colors, and 4 clusters by tone and hue (Figure3 and 4).

3. 3. Regression Analysis

Regression analysis was performed to ascertain whether or not the impression of music could be estimated using data expressing music by color (Experiment2). The factor score of music was used as the dependent variable. The color-specific color expression data that calculated the average value of each group obtained by cluster analysis was used as the independent variables. No effective outcome was obtained in instances when the hue was an independent variable. However, in cases where the tone was the independent variable, a valid regression equation was obtained with factor 1, factor 2, factor 3 (Table3).

3. 4. Cluster Analysis (2)

Since the influence of tone was demonstrated by the results obtained from the regression analysis, the representation of music using tone was analyzed in detail using cluster analysis. The cluster analysis was performed on the average value of the data of tone and achromatic color in expressing music by color (Experiment2).

The results classified the representation into six clusters (figure 5). Data expressing music by color and data pertaining to the impression evaluation are shown via line graphs for each cluster (Figures 6 and7). The tendency of similar lines within particular clusters was demonstrated through the graphs of the impressions.

4. Discussion and Conclusion

Four factors were obtained for impressions common to music and color. The regression analysis did not yield effective results for hue, while significant outcomes were obtained for tone. This finding indicates that tone is effective in capturing the impression created on a subject

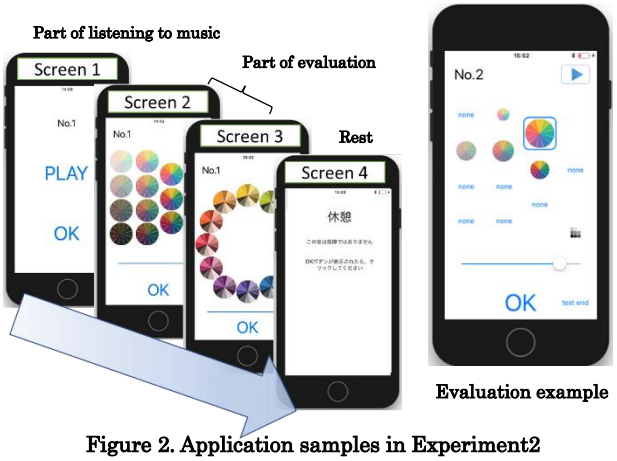

Figure 2. Application samples in Experiment2

Table 2. Result of factor analysis (factor loadings and correlations)

+	−	Fac1	Fac2	Fac3	Fac4
loud(騒がしい)	quiet(静かな)	**1. 046**	−0. 321	−0. 001	−0. 094
dynamic(動的な)	static(静的な)	**1. 039**	−0. 192	0. 073	−0. 068
gaudy(派手な)	subdued(地味な)	**0. 961**	0. 076	0. 023	−0. 134
cheerful(陽気な)	gloomy(陰気な)	**0. 787**	0. 163	0. 438	0. 031
composured(落ち着く)	**fidgety(落ち着かない)**	**−0. 765**	**0. 657**	0. 218	−0. 101
distinctly(はっきり)	blurred(ぼんやり)	**0. 692**	0. 338	**−0. 534**	−0. 055
sour(すっぱい)	not sour(すっぱくない)	**0. 617**	−0. 076	−0. 010	0. 089
bright(明るい)	dark(暗い)	**0. 602**	0. 376	0. 395	0. 072
beautiful(美しい)	ugly(醜い)	−0. 226	**1. 015**	0. 031	−0. 110
clear(澄んだ)	muddy(濁った)	−0. 104	**0. 990**	−0. 057	0. 063
refreshed(すっきりした)	not refreshed(すっきりしない)	0. 166	**0. 916**	−0. 234	0. 074
preferable(好きな)	hateful(嫌いな)	**0. 863**	0. 189	−0. 079	
manly(男性的な)	**feminine(女性的な)**	0. 117	**−0. 469**	−0. 353	−0. 064
strained(緊張した)	loosen(緩んだ)	0. 086	0. 248	**−0. 976**	−0. 123
warm(あたたかい)	cool(つめたい)	**0. 408**	0. 237	**0. 760**	−0. 270
soft(やわらかい)	hard(かたい)	−0. 258	0. 318	**0. 744**	0. 081
sweet(甘い)	not sweet(甘くない)	−0. 009	0. 328	**0. 696**	−0. 059
sharp(鋭い)	**dull(鈍い)**	**0. 588**	**0. 413**	**−0. 651**	0. 162
plain(淡白な)	rich(濃厚な)	−0. 186	−0. 064	−0. 062	**0. 975**
light(軽い)	heavy(重い)	0. 266	0. 148	0. 389	**0. 687**
Factor Correlation	Fac1	1. 000	0. 299	−0. 041	0. 214
	Fac2	0. 299	1. 000	0. 412	0. 353
	Fac3	−0. 041	0. 412	1. 000	0. 132
	Fac4	0. 214	0. 353	0. 132	1. 000

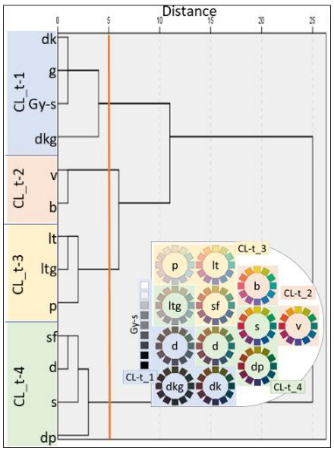

Figure 3. Dendrogram of cluster analysis(1): for data of tone in Experiment2. Classification of color selection tendency

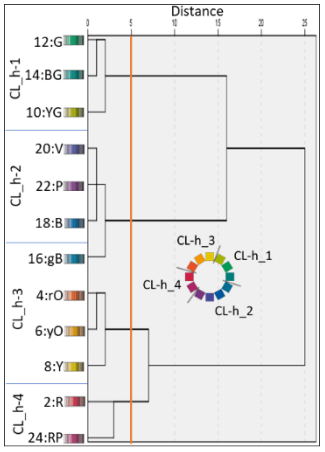

Figure 4. Dendrogram of cluster analysis(1): for data of hue in Experiment2. Classification of color selection tendency

Table 3. Results of Regression Analysis

Tone

Y_{Fac1} =-1.09+**6.75**$X_{CL\ t\text{-}1}$-2.35$X_{CL\ t}$ **-4.49**$X_{CL\ t\text{-}3}$ +3.13$X_{CL\ t\text{-}4}$ [R^2=0.43]

Y_{Fac2} =-3.99+**4.93**$X_{CL\ t\text{-}1}$-1.83$X_{CL\ t\text{-}2}$+**7.17**$X_{CL\ t\text{-}3}$ +0.12$X_{CL\ t\text{-}4}$ [R^2=0.63]

Y_{Fac3} =-2.26 -1.49$X_{CL\ t\text{-}1}$+**8.23**$X_{CL\ t\text{-}2}$+3.01$X_{CL\ t\text{-}3}$ **-8.08**$X_{CL\ t\text{-}4}$ [R^2=0.55]

Y_{Fac4} =1.32 +3.10$X_{CL\ t\text{-}1}$-5.30$X_{CL\ t\text{-}2}$ +0.56$X_{CL\ t\text{-}3}$+0.38$X_{CL\ t\text{-}4}$ [R^2=0.03]

Hue

Y_{Fac1} =-5.76+3.12$X_{CL\ h\text{-}1}$+4.80$X_{CL\ h\text{-}2}$+0.03$X_{CL\ h\text{-}3}$+3.80$X_{CL\ h\text{-}4}$ [R^2=0.03]

Y_{Fac2} =-4.06+1.53$X_{CL\ h\text{-}1}$+4.05$X_{CL\ h\text{-}2}$+2.84$X_{CL\ h\text{-}3}$+0.24$X_{CL\ h\text{-}4}$ [R^2=0.15]

Y_{Fac3} =-2.54+2.04$X_{CL\ h\text{-}1}$+4.26$X_{CL\ h\text{-}2}$+0.31$X_{CL\ h\text{-}3}$-1.91$X_{CL\ h\text{-}4}$ [R^2=0.19]

Y_{Fac4} =-1.09-1.01$X_{CL\ h\text{-}1}$ -0.56$X_{CL\ h\text{-}2}$+5.54$X_{CL\ h\text{-}3}$ -0.74$X_{CL\ h\text{-}4}$ [R^2=0.04]

___ : $p. < .05$

Dependent value: Factor Score
Independent value: Value obtained by averaging data of experiment 2 for each cluster(cluster analysis1)

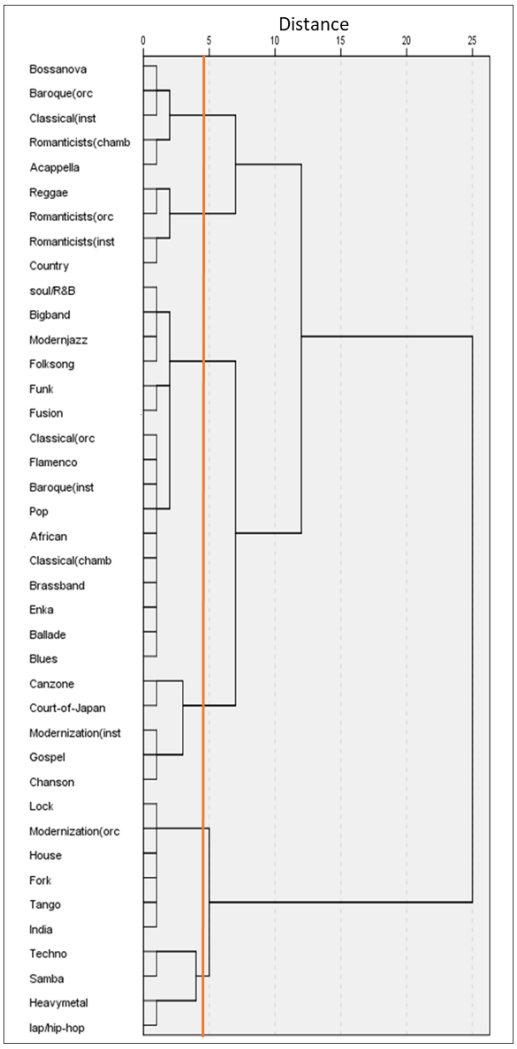

Figure 5. Dendrogram of cluster analysis(2): for data of tones and achromatic color in Experiment2. Classification of music by color evaluation

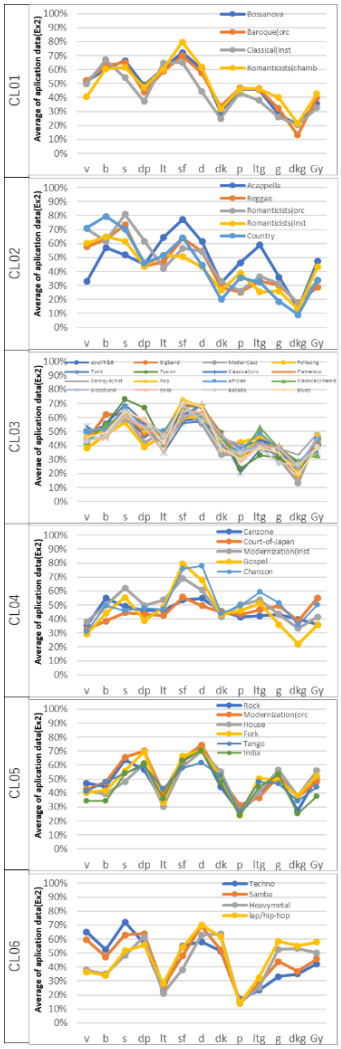

Figure 6. Data of tones and achromatic color in Experiment2 summarized for each cluster (cluster analysis2)

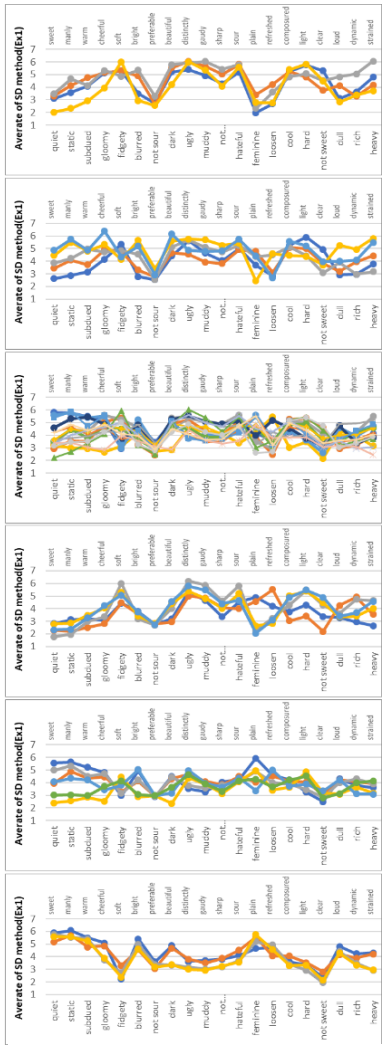

Figure 7. The average values of the SD method of Experiment1 was summarized for each cluster (cluster analysis2)

by a piece of music (Wakata & Saito; 2012) [4]. Tones were divided into four groups through cluster analysis1, and regression coefficients suggested that each tone group represents corresponding impressions. Further, the impressions that were created were similar even for the classification of music with expressions in color as variables. As suggested by Yamawaki & Shizuka (2005), this investigation evinced a commonality between the impressions created by music and color[6].

The results of the present study thus indicate the possibility of expressing music using color.

ACKNOWLEDGMENTS

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