PAPER

A multi-dimensional study of the emotion in current Japanese popular music

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Abstract: Musical psychologists illustrated musical emotion with various numbers of dimensions ranging from two to eight. Most of them concentrated on classical music. Only a few researchers studied emotion in popular music, but the number of pieces they used was very small. In the present study, perceptual experiments were conducted using large sets of popular pieces. In Experiment 1, ten listeners rated musical emotion for 50 J-POP pieces using 17 SD scales. The results of factor analysis showed that the emotional space was constructed by three factors, “evaluation,” “potency” and “activity.” In Experiment 2, three musicians and eight non-musicians rated musical emotion for 169 popular pieces. The set of pieces included not only J-POP tunes but also Enka and western popular tunes. The listeners also rated the suitability for several listening situations. The results of factor analysis showed that the emotional space for the 169 pieces was spanned by the three factors, “evaluation,” “potency” and “activity,” again. The results of multiple-regression analyses suggested that the listeners like to listen to a “beautiful” tune with their lovers and a “powerful” and “active” tune in a situation where people were around them.

Keywords: Musical emotion, Popular music, J-POP, Semantic differential method, Factor analysis

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1. INTRODUCTION

Musical emotion is expressed by various adjectives such as cheerful, tender, majestic, etc. This implies that musical emotion is illustrated by a multi-dimensional space. Many musical psychologists illustrated this space with various numbers of dimensions. For example, Hevner illustrated the musical emotion using a simple two-dimensional space. She selected short pieces of music and manipulated their mode, melodic direction, harmony, and rhythm, systematically [1]. In another study, she also manipulated tempo and pitch level [2]. These variants as well as the original versions were presented, and the listeners were requested to show the emotional features of the stimuli on the two-dimensional space in her experiments.

Osgood and his colleagues invented SD (semantic differential) method to clarify dimensions of an emotional space for a set of concepts, and they showed that the emotional spaces for various sets of concepts were constructed by three factors: “evaluation,” “potency” and

“activity” [3]. Using the SD method, Russell showed that general affection was illustrated by a circumplex model, which was spanned by “valence” and “arousal” factors [4]. This model was almost identical to the two-dimensional space by which Hevner illustrated the musical emotion. Schubert pointed out that the “valence” and “arousal” dimensions agree, in principle, with two of the three dimensions Osgood and his colleagues proposed; “evaluation” and “activity” [5]. Taniguchi proposed more complex structure to illustrate the musical emotion. He used 90 excerpts of classical music works as stimuli, and showed that the emotional space for them was constructed by five or eight factors [6].

Most of the dimensional studies described above concentrated on classical music, and only a few studies illustrated the musical emotion in popular music using multi-dimensional spaces. Iwamiya conducted a perceptual experiment using popular music, in the contexts of car audio with music [7]. He illustrated the impression of music using three-dimensional spaces. Yamada, Fujisawa and Komori also investigated musical emotion in the context of a video racing game, and showed that the musical emotion in a set of popular music was illustrated

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by a three-dimensional space [8]. However, the number of musical pieces used in these studies was small, and the dimensions of musical emotion in popular music have not been clarified yet, using a large number of pieces.

Therefore, in the present study, perceptual experiments were conducted, using large sets of pieces of popular music which reflects the current popular music scene in Japan, to reveal the dimensions of musical emotion in Japanese popular music. The number of listeners and the number of musical pieces have a compensating relationship for a given time during the listening experiment. In the present study, the number of musical pieces was given priority over the number of listeners.

Moreover, the correlations between the emotional features and suitable situations of listening to popular music were also investigated, in the present study. The relationship between musical emotion and acoustic parameters has been studied by many researchers. They suggested that tempo was one of the most important parameters for musical emotion [9–11]. However, most of these studies used short musical materials which varied performing tempo, and the relation between musical emotion and tempo has not been clarified in a large number of various musical pieces. In the present study, the relationship between the tempo and the musical emotion is also investigated.

2. EXPERIMENT 1

2.1. Musical Stimuli

The musical pieces used in Experiment 1 were defined in the following way: First, the top 50 musicians were selected based on the download ranking from June to October 2009 in LISMO, which provides the most popular music retrieval services in Japan. Then the top-selling piece until December 2010 was selected for each of the 50 musicians based on the web site, Oricon Style (<http://www.oricon.co.jp/>), the most famous music ranking site in Japan. The selected musical pieces are shown in Table 1. The play time of the pieces was ranged from 3.5 to 7.0 min.

2.2. Procedure

Ten listeners, nine of whom were male and one was female, listened to the 50 pieces and rated the emotional features of them. Their ages ranged from 20 to 31 years old. Two of the listeners were musicians, and listened to music at least several pieces from various musical genres a day. The other eight listeners were non-musicians, but listened to J-POP tunes through music players, car audio, TV programs, and internet at least once a day. In one trial, a listener was presented a piece through headphones. The listener was not allowed to rate while a piece of music was presented. After the piece was finished, the listener rated the emotional features of it using 17 semantic

Table 1 Musical pieces used in Experiment 1.

Best-selling piece	Artist
A-RA-SHI	ARASHI
Kiseki	GReeeeN
Good-bye days	YUI
Tada...Aitakute	EXILE
Sakurazaka	Masaharu Fukuyama
Arigatou	Ikimonogakari
Sekai ni Hitotsu Dake no Hana	SMAP
Tomorrow never knows	Mr. Children
Ningyo Hime	Kumi Koda
BREAK OUT!	Tohoshinki
Honnou	Sheena Ringo
I LOVE YOU	Yutaka Ozaki
Order Made	RADWIMPS
Ai wo Komete Hanataba wo	Superfly
monochrome	Ayumi Hamasaki
Asita ga Kurunara	JUJU
Uso	SID
Dear Lonely Girl	Miliyah Kato
Himawari	Yuusuke
Jyunrenka	Shonannokaze
GOLDFINGER '99	Hiroshi Go
Aitakute Aitakute	Kana Nishino
Ai no Mama ni Wagamama ni Boku	B'z
wa Kimi Dake wo Kizutsukenai	
Hitomi wo Tozite	Ken Hirai
Tentai Kansoku	BUMP OF CHICKEN
Zenryoku Shounen	Sukimaswitch
Mikazuki	Ayaka
HONEY	L'Arc~en~Ciel
Make my day	Yui Aragaki
STARS	Mika Nakashima
Winter, again	GLAY
Tsubomi	Kobukuro
Rirura Riruha	Kaela Kimura
Tobenai Tori	Yuzu
CAN YOU CELEBRATE?	Namie Amuro
Lovin' Life	FUNKY MONKEY
Addicted To You	BABYS
ANOTHER WORLD	Hikaru Utada
Gekkouka	GACKT
Guuzenno Kakuritu	Janne Da Arc
SOS	GIRL NEXT DOOR
White Love	TAMURAPAN
love the world	SPEED
TSUNAMI	Perfume
Boyfriend	Southern All Stars
Hakanaku mo Towa no Kanashi	aiko
Real Face#1	UVERworld
Here We Go feat. VERBAL	KAT-TUN
Around The World	May J.
Sakuranbo	MONKEY MAJIK
	Ai Otsuka

differential (SD) scales shown in Table 2. The SD scales were shown in Japanese on the response sheets, in fact. These were bipolar seven-step scales, e.g., “very happy,” “fairly happy,” “slightly happy,” ..., “very sad.” The SD scales appeared on a response sheet in a random order for

Table 2 Semantic differential (SD) scales and factor loadings of them in Experiment 1.

SD scale		Factor		
English	Japanese	Evaluation	Potency	Activity
Mixed–Neat	ごちゃごちゃした–すっきりした	0.856	–0.383	–0.132
Clean–Dirty	きれいな–きたない	–0.825	0.140	0.140
Showy–Humble	派手な–地味な	0.540	–0.685	–0.294
Agitated–Calm	落ち着きのない–落ち着いた	0.713	–0.507	–0.322
Fresh–Sordid	さわやかな–むさくるしい	–0.757	0.226	–0.293
Heavy–Light	重い–軽い	0.338	–0.349	0.759
Dark–Bright	暗い–明るい	0.118	0.025	0.984
Cheerful–Gloomy	陽気な–悲しい	0.133	–0.063	–0.977
Weak–Strong	弱々しい–力強い	–0.245	0.856	0.040
Hard–Soft	かたい–やわらかい	0.784	–0.539	0.011
Loose–Tight	たるんだ–ひきしまった	–0.168	0.866	–0.209
Powerful–Powerless	迫力のある–もの足りない	0.318	–0.890	0.022
Monotonous–Varied	単調な–変化のある	0.045	0.613	–0.043
Tranquil–Restless	のどかな–せかせかした	–0.633	0.604	0.247
Pleasant–Unpleasant	快い–不快な	–0.892	–0.243	–0.238
Happy–Sad	楽しい–寂しい	0.158	–0.107	–0.961
Warm–Cold	温かい–冷たい	–0.669	0.202	–0.482
Contribution rate		0.319	0.264	0.243

each combination of listener and piece. The procedure described above was repeated for the 50 pieces. The listening level was decided by a preliminary experiment as follows: Eight pieces including the softest and the loudest pieces were selected from the 50 pieces. Maintaining the original relative-level-differences among the eight pieces, four listeners adjusted the volume dial in the headphone amplifier to the most suitable level for them. The most suitable levels for one of the pieces were averaged over the four listeners. The dial was fixed at the mean level for that piece. Then the listening level was measured for each piece. The measured level varied with pieces ranging from $L_{Aeq} = 74$ to 84 dB. Musical stimuli were recorded on CDs. Each CD consisted of 10 pieces. Before starting the experiment, the listeners practiced to rate the emotional features for five pieces which were selected from the 50 pieces. Then the listeners took a ten-minute rest, and started the experimental trials. After listening to a CD, the listener took a rest-interval for more than ten minutes. All listeners finished the experiment within three days. The CD tracks appeared in a random order for each listener.

2.3. Results and Discussion

Numbers –3 to 3 were given for each of the seven categories on the SD scales. The mean value was calculated from the listeners' responses for each combination of scale and stimulus. Then factor analysis was performed for these mean scores with the principal factor method and varimax rotation. The results of the analysis showed that the orthogonal three-factor solution accounted for 82.6% of data variance. Table 2 shows the resulting factor loadings. The three factors are labeled “evaluation,”

“potency” and “activity” respectively, after the scales which show large loadings for these factors. These results show that the emotional space of popular music is constructed by “evaluation,” “potency,” and “activity” factors. In principle, these factors are identical to the three dimensions of semantic space proposed by Osgood and his colleagues, and the number of the factors agrees with the results from Iwamiya [7], and Yamada, Fujisawa and Komori [8], although not all the names of the factors coincided.

The results shown above are for the top selling pieces in Japan. All of the pieces listed in Table 1 were in the J-POP genre. However, some types of Japanese people often listen to Enka (a type of Japanese traditional popular song), rock, club music and Hip-Hop songs sung in Japanese. Moreover, Japanese listeners sometimes listen to American and European popular music, also. Therefore, using a different set of pieces including different musical genres other than J-POP, Experiment 2 was conducted.

3. EXPERIMENT 2

3.1. Musical Stimuli

A Japanese commercial company, Sockets Inc., which provides Japanese people extensively with music retrieval and supply systems, provided wave files of 169 musical pieces. The set of the pieces included J-POP and Enka (a type of Japanese traditional popular songs). The set also included, rock, club music and Hip-Hop songs sung in Japanese, as well as western (American and European) popular music sung in English, but did not include classical pieces of music. These 169 pieces are listed in Table 3. The labels Japanese or Western music and the genres for the

Table 3 Musical pieces used in Experiment 2.

Title	Artist	Japanese (J)/ Western (W)	Genre	Tempo [BPM]
Polyrhythm	Perfume	J	Club Music	128
Electro World	Perfume	J	Club Music	143
Kiyoshi No Soran Bushi	Kiyoshi Hikawa	J	Enka	99
Ame No Bojo	Aki Yashiro	J	Enka	79
Suterarete	Yoko Nagayama	J	Enka	105
Mitinoku Hitori Tabi	Gerorge Yamamoto	J	Enka	70
Kyoudaibune	Ichiro Toba	J	Enka	78
Ora Tokyo Sa Iguda	Ikuzo Yoshi	J	Enka	118
Tsugunai	Teresa Teng	J	Enka	111
Chindo Monogatari	Yoshimi Tendo	J	Enka	94
Yozora	Hiroshi Itsuki	J	Enka	117
Amagigoe	Sayuri Ishikawa	J	Enka	81
Cherry	SPITZ	J	J-POP	97
A Perfect Sky	Bonnie Pink	J	J-POP	90
NAO	HY	J	J-POP	78
Hana	Mr. Children	J	J-POP	84
Unabara No Tsuki	Yuko Ando	J	J-POP	136
One more time, One more chance	Masayoshi Yamazaki	J	J-POP	128
Momoiro No Kataomoi	Aya Matsuura	J	J-POP	154
A-i-shi-te-ru no Sign	Dreams Come True	J	J-POP	72
~Watashitachi no Mirai Yosouzu~				
Happy Days	Ai Otsuka	J	J-POP	182
Shiroi Kaito	MY LITTLE LOVER	J	J-POP	99
See-Saw Game	Mr. Children	J	J-POP	134
~Yukan Na Koi No Uta~				
CHE.R.RY	YUI	J	J-POP	109
Gekkou	Chihiro Onitsuka	J	J-POP	75
Kodoku No Kakera	Angela Aki	J	J-POP	68
Gogo No Parade	Suga Shikao	J	J-POP	125
Koishikute	BEGIN	J	J-POP	73
Yuki No Hana	Mika Nakashima	J	J-POP	72
Happiness	ARASHI	J	J-POP	115
milk tea	Masaharu Fukuyama	J	J-POP	73
Wanderin'Destiny	globe	J	J-POP	105
Junior Sweet	CHARA	J	J-POP	88
Haneuma Rider	Porno Graffiti	J	J-POP	126
Deatta Korono Youni	Every Little Thing	J	J-POP	129
Ame To Namida	Yuzu	J	J-POP	108
Kibun Jo Jo	mihimaru GT	J	J-POP	125
19 Memories	Miliyah Kato	J	J-POP	80
LOVE LOVE LOVE	DREAMS COME TRUE	J	J-POP	83
PEACH	Ai Otsuka	J	J-POP	147
It's only love	Masaharu Fukuyama	J	J-POP	118
Saudade	Porno Graffiti	J	J-POP	120
Happy Summer Wedding	Morning Musume	J	J-POP	126
Guts daze!!	Ulfu	J	J-POP	123
Nada Sousou	Ryoko Moriyama	J	J-POP	72
Memories	Yui Aragaki	J	J-POP	107
Eikou No Kakehashi	Yuzu	J	J-POP	82
Arigatou...	KOKIA	J	J-POP	69
Makenaide	ZARD	J	J-POP	125
Donnani Tokutemo	JUJU	J	J-POP	72
Aiuta	GReeeeN	J	J-POP	85
Yume No Uta	Kumi Koda	J	J-POP	72
Kaeritaku Nattayo	Ikimonogakari	J	J-POP	79
Kaerouka	mihimaru GT	J	J-POP	100
1/2	Shoko Nakagawa	J	J-POP	246
Yoroshiku Aisyu	Hiromi Go	J	J-POP	65
Sakura	Kobukuro	J	J-POP	84
DON'T WANNA CRY	Namie Amuro	J	J-POP	99

Table 3 continued.

Title	Artist	Japanese (J)/ Western (W)	Genre	Tempo [BPM]
SEASONS	Ayumi Hamasaki	J	J-POP	80
Summer Dream	Tohoshinki	J	J-POP	115
Kandagawa	Kaguyahime	J	J-POP	95
Boku Wa Kuma	Hikaru Utada	J	Nursery song	113
Kimi Ni BUMP	Ketsumeishi	J	R&B/Hip-Hop	96
THE SHOW	KREVA	J	R&B/Hip-Hop	87
Rakuen Beibey	RIP SLYME	J	R&B/Hip-Hop	115
Kurenai	X JAPAN	J	Rock	156
Fantasista	Dragon Ash	J	Rock	192
Sekai Ga Owaru Yoruni	Chatmonchy	J	Rock	77
Tsumi To Batsu	Ringo Sheena	J	Rock	82
Last Smile	LOVE PSYCHEDELICO	J	Rock	89
Kasou	L'Arc~en~Ciel	J	Rock	110
Cassis	The Gazette	J	Rock	101
Space Sonic	ELLEGARDEN	J	Rock	208
ZINNIA	OVER ARM THROW	J	Rock	216
Eenen	Ulfus	J	Rock	172
Taiyou Ha Tsumi na Yatsu	Southern All Stars	J	Rock	100
Konayuki	Remioromen	J	Rock	83
Cage	Dir en grey	J	Rock	176
Romance	PENICILLIN	J	Rock	146
1/3 No Jyunjo Na Kanjo	SIAM SHADE	J	Rock	152
Rosie	aiko	J	Rock	85
AM11:00	HY	J	Rock	98
Love is Here	Janne Da Arc	J	Rock	154
D-tecnoLife	UVERworld	J	Rock	172
Mitsuyubi? Mistuyubi?	Sid	J	Rock	207
Sora Ha Marude	MONKEY MAJIK	J	Rock	92
Buttobasuzo	Tamurapan	J	Rock	130
Ai no corrida	Quincy Jones	W	Black Music	126
Love You Inside Out	Bee Gees	W	Black Music	95
No More Pain	2Pac	W	Black Music	154
Runnin' Away	Sly & The Family Stone	W	Black Music	103
Hot Stuff	Craig David	W	Black Music	114
Inner City Blues	Marvin Gaye	W	Black Music	94
Country Grammar	Nelly	W	Black Music	82
You Make Me Wanna	Usher	W	Black Music	82
London Bridge	Fergie	W	Black Music	91
#1	Nelly	W	Black Music	90
Low feat. T-Pain	Flo Rida	W	Black Music	128
One Sweet Day	Mariah Carey	W	Black Music	64
Piece Of Me	Britney Spears	W	Black Music	115
Umbrella	Rihanna	W	Black Music	87
Yeah	Usher	W	Black Music	105
The Rockafeller Skank	Fatboy Slim	W	Club Music	152
Machine Gun	Portishead	W	Club Music	106
Scatman's World	Scatman John	W	Club Music	146
Scarborough Fair	Simon & Garfunkel	W	Country/Folk	87
Blowin' In The Wind	Bob Dylan	W	Country/Folk	100
Watermark	Enya	W	Easy Listening	68
Don't Know Why	Norah Jones	W	Jazz	88
There Must Be An Angel	Eurythmics	W	Pops	113
Iron Man	<i>The Cardigans</i>	W	Pops	71
Top Of The World	The Carpenters	W	Pops	92
Good Enough	Cyndi Lauper	W	Pops	137
Wannabe	Spice Girls	W	Pops	110
Fairground	Simply Red	W	Pops	123
Been To Canaan	Carol King	W	Pops	129
New Soul	Yael Naim	W	Pops	101
Miles Away	Madonna	W	Pops	116

Table 3 continued.

Title	Artist	Japanese (J)/ Western (W)	Genre	Tempo [BPM]
My Heart Will Go On	Celine Dion	W	Pops	50
Sound of Silence	Simon & Garfunkel	W	Pops	107
Sing	Carpenters	W	Pops	70
Yesterday Once More	Carpenters	W	Pops	83
Inconsolable	Backstreet Boys	W	Pops	80
Thriller	Michael Jackson	W	Pops	118
Blank Sabbath	Black Sabbath	W	Rock	65
Roxette	Dr. Feelgood	W	Rock	127
China White	Scorpions	W	Rock	82
Riders On The Storm	The Doors	W	Rock	103
Analyse	Thorn Yorke	W	Rock	100
Won't Go Home Without You	Maroon 5	W	Rock	110
Today	The Smashing Pumpkins	W	Rock	82
Girlfriend	Avril Lavigne	W	Rock	164
Can't Stand Me Now	The Libertines	W	Rock	165
Sunshine Of Your Love	Cream	W	Rock	115
Who's Crying Now	Journey	W	Rock	121
Lady Madonna	The Beatles	W	Rock	109
Nude	Radiohead	W	Rock	128
Don't Stop Me Now	Queen	W	Rock	156
Bring Me To Life	Evanescence	W	Rock	95
Message In A Bottle	The Police	W	Rock	151
If I Had Eyes	Jack Johnson	W	Rock	92
Ruby Tuesday	The Rolling Stones	W	Rock	106
Muse	Hysteria	W	Rock	93
Someday I'll Be Saturday Night	Bon Jovi	W	Rock	126
Love Today	MIKA	W	Rock	124
Tears In Heaven	Eric Clapton	W	Rock	79
Saturday In The Park	Chicago	W	Rock	114
Bulls On Parade	Rage Against The Machine	W	Rock	83
Call Me	Blondie	W	Rock	142
Town Called Malice	The Jam	W	Rock	202
People=Shit	Slipknot	W	Rock	121
You Give Love A Bad Name	Bon Jovi	W	Rock	123
Nobody's Home	Avril Lavigne	W	Rock	92
What I've Done	Linkin Park	W	Rock	120
How Long	Eagles	W	Rock	140
Underclass Hero	SUM 41	W	Rock	190
Wait and Bleed	Slipknot	W	Rock	186
Jump	Van Halen	W	Rock	129
Change The World	Eric Clapton	W	Rock	97
To Be With You	Mr. Big	W	Rock	82
Stairway to Heaven	Led Zeppelin	W	Rock	89
Yesterday	The Beatles	W	Rock	100
We Will Rock You	Queen	W	Rock	82
Heart-Shaped Glasses	Marilyn Manson	W	Rock	125
Going Under	Evanescence	W	Rock	87
Detroit Rock City	Kiss	W	Rock	190
Jigsaw Falling Into Place	Radiohead	W	Rock	164
Heartbeat	Tahiti 80	W	World Music	109
Mas Que Nada	Sergio Mendes & BRASIL '66	W	World Music	175

pieces were provided by Sockets Inc. The number of the pieces for each genre may reflect the practical ratio in the situation of Japanese people's listening behavior. None of the pieces in Table 3 was used in Experiment 1. The play time of the pieces ranged from 3.5 to 7.0 min.

3.2. Procedure

Three musicians who graduated from the Department of Music, Osaka University of Arts, and eight non-musicians from the Kanazawa Institute of Technology participated in Experiment 2. All of the three musicians

were male, and their ages ranged from 31 to 50. Non-musicians consisted of seven males and one female and their ages ranged from 20 to 23. Two of the musicians participated also in Experiment 1 and none of the non-musicians participated in Experiment 1. The musicians listened to at least several pieces from various genres a day, and non-musicians listened to J-POP pieces at least once a day. They listened to the 169 pieces and rated them. The listeners rated the emotional features for each piece, using the same SD scales as in Experiment 1. The listeners also rated the degree of suitability of it using seven-step scales for four different situations; “listening alone,” “listening with his/her lover,” “listening with people around him/her,” “listening with a high level of concentration.” The SD scales and the scales of the suitability for four situations appeared on a response sheet in a random order for each combination of listener and piece. For deciding the listening level, the same procedure was used as Experiment 1. The listening level varied with pieces ($L_{Aeq} = 70\text{--}84\text{ dB}$). Musical stimuli were presented by CD. Each CD consisted of 10 pieces. Before starting the experiment, the listeners practiced to rate the emotional features for five pieces which were selected from the 169 pieces. Then the listeners took a ten-minute rest, and started the experimental trials. After listening to a CD, a listener took a rest interval for more than ten minutes. All listeners finished the experiment within a week. The CD tracks appeared in a random order for each listener.

3.3. Results and Discussion

The mean value was calculated for each combination of scale and stimulus. Then factor analysis was performed for the mean scores with the principal factor method and varimax rotation. The results of the analysis showed that the orthogonal three-factor solution accounted for 85.1% of data variance. Table 4 shows the resulting factor loadings. The three factors are labeled “evaluation,” “potency” and “activity” respectively, after the scales which show large loadings for these factors. In principle, these factors are identical to the three factors in Experiment 1.

In the next stage, multiple-regression analyses were performed to investigate the correlations between the

Table 4 Semantic differential (SD) scales and factor loadings of them in Experiment 2.

SD scale	Factor		
	Evaluation	Potency	Activity
Mixed–Neat	0.741	−0.524	−0.204
Clean–Dirty	−0.925	0.203	−0.016
Showy–Humble	0.267	−0.762	−0.463
Agitated–Calm	0.639	−0.573	−0.435
Fresh–Sordid	−0.869	0.159	−0.310
Heavy–Light	0.489	−0.384	0.735
Dark–Bright	0.277	0.157	0.935
Cheerful–Gloomy	0.008	−0.083	−0.972
Weak–Strong	−0.301	0.850	−0.003
Hard–Soft	0.768	−0.563	0.042
Loose–Tight	−0.154	0.803	−0.149
Powerful–Powerless	0.273	−0.925	0.057
Monotonous–Varied	0.086	0.631	0.150
Tranquil–Restless	−0.609	0.622	0.320
Pleasant–Unpleasant	−0.869	−0.120	−0.303
Happy–Sad	0.044	−0.191	−0.951
Warm–Cold	−0.646	0.197	−0.533
Contribution rate	0.311	0.285	0.255

emotional features and suitable situations for listening. Factor scores of the “evaluation,” “potency” and “activity” were used as explanation variables, and the degree of the suitability for a situation was used as a criterion variable in each analysis. The results showed that the coefficient of determination, R^2 , was larger than 0.5 for the situations of “listening with his/her lover” and “listening with people around him/her” (Table 5). Figure 1 shows the multiple-regression lines for the two situations as vectors. Figure 1 suggests that Japanese listeners like to listen to a “beautiful” tune of popular music with their lovers, and a “powerful” and “active” tune in a situation where people are around them.

Moreover, the tempo for each piece was measured in BPM. In this measurement, one of the authors matched the tempo of a metronome for each piece. The measured tempi are shown in Table 3. The correlation between the tempo and the emotional features was investigated with multiple-regression analysis. The results showed that the coefficient

Table 5 The correlations between emotional features vs. suitable situations for listening and tempo in BPM.

Situation	Coefficient of determination (R^2)	Multiple-regression coefficient		
		Evaluation	Potency	Activity
listening with people around him/her	0.58	−0.01	0.28	0.45
listening with his/her lover	0.68	0.80	−0.03	0.29
listening with a high level of concentration	0.45	0.29	0.35	−0.21
listening alone	0.35	0.38	0.06	−0.14
BPM	0.01	−3.85	−2.07	2.50

Fig. 1 The results of multiple-regression analyses. Each vector shows the degree of suitability for a listening situation.

Fig. 2 The vectors, evaluation, potency and activity, which are obtained by the factor analysis are potted on the three-dimensional space spanned by I, II and III dimensions, obtained by multi-dimensional scaling.

of determination, R^2 , was 0.01 (Table 5). The results suggest that only one parameter of tempo was not enough to illustrate any part of the emotional features in popular music.

In Experiment 2, three musicians and eight non-musicians participated as listeners. In the final stage of the analysis, a multi-dimensional scaling was performed to reveal whether the perception of the emotional features was different or not between the three musicians and the eight non-musicians. Let the score of an SD scale j by a listener i for a piece A, S_{Aij} . Then the perceptual distance between two pieces, A and B, was defined as follows:

$$d_{AB} = \sum_{i=1}^{11} \sum_{j=1}^{17} |S_{Aij} - S_{Bij}|. \quad (1)$$

Using these distances, a multi-dimensional scaling was performed using Proxscal. The results showed that the stress value was 0.06 for the three-dimensional solution. Then, multiple-regression analyses were performed using the three coordination values of the pieces as explanation variables, and with the factor score of each factor of the “potency,” “activity” and “evaluation” as criterion variables. The resulting coefficients of determination were 0.9. Figure 2 shows the “evaluation,” “potency” and “activity” factors as vectors on the three-dimensional space which was acquired from the multi-dimensional scaling. Figure 2 shows that each of the three dimensions almost completely coincides with the three factors “evaluation,” “potency” and “activity,” respectively. Proxscal also calculated the individual space for each listener. The individual space was

Table 6 The ratio of the weights of “potency” and “activity” to that of the “evaluation” for each listener.

Listener		Ratio of Weights		
		Evaluation	Potency	Activity
Non-musician	S1	1.00	1.01	1.03
	S2	1.00	1.01	1.01
	S3	1.00	1.01	1.08
	S4	1.00	1.00	1.10
	S5	1.00	1.01	1.08
	S6	1.00	1.01	0.98
	S7	1.00	1.01	1.05
	S8	1.00	1.03	0.85
Musician	S9	1.00	1.00	1.22
	S10	1.00	1.02	0.95
	S11	1.00	1.03	0.91

expressed with the weights for the three-dimensions. Then the ratios of the weights for “potency” and “activity” to the weight of “evaluation” were calculated for each listener. The resulting ratios are shown in Table 6. Table 6 shows that the weight-balance for the three dimensions does not vary largely among the listeners. This implies that there are no significant differences in the perception of emotional features between the musicians and non-musicians for popular music, in the case of the present experiment. It may be difficult to say that there are no significant differences in the perception of emotional features between musicians and non-musicians in general, because the number of musicians and non-musicians was limited in the present experiment. In the near future, the perception of emotional features between a large number of musicians and non-musicians in general should be compared.

4. GENERAL DISCUSSION

In Experiments 1 and 2, the practice trials were performed for five pieces before starting the experimental trials. The five pieces were selected from the pieces for the experimental trials. To test the effect of fatigue on the rating of the emotional features, the scores on the 17 SD scales for the five pieces were compared between the practice trials and experimental trials. The results showed that the accumulated difference of the scores for a piece was smaller than ten steps for all listeners in both experiments. This implies that the mean difference on a SD scale was within 0.6 steps between the practice and experimental trials. The experimental trial was apart several days, in maximum, from the practice trial for a piece. This may imply that the fatigue did not affect the rating of the emotional features significantly.

In Experiments 1 and 2, the rated scores were averaged over the listeners for each combination of scale and stimulus, and the factor analyses were performed for these

mean scores. The results of the analyses showed the three-factor solutions as shown in Tables 2 and 4. These three-factor solutions indicate the averaged features of the emotional perception over the listeners. Using the raw data in Experiment 2, factor analysis was also performed. The results showed that the four-factor resolution accounted for only 65.0% of the data variance. These results may imply that the perception of the emotional features of a specific piece was somehow different among different listeners, although the perception does not vary largely among the listeners throughout the 169 pieces as Table 6 shows. In other words, there may be interactions between the pieces and the individual listeners in the perception of emotional features. Such interactions should be investigated in the near future.

In Experiment 2, the multiple-regression analysis was performed using the factor scores of the “evaluation,” “potency” and “activity” as explanation variables, and tempo in BPM as the criterion variable. The results showed that the coefficient of determination, R^2 , was as small as 0.01. It is obvious that the results of a single regression analysis, using the tempo as an explanation variable and one of the factor scores as a criterion variable, will show a smaller value of R^2 than 0.01. This implies that only one parameter of tempo cannot illustrate any of the three factors, “evaluation,” “potency” or “activity.”

5. CONCLUSION

In the present study, emotional space of current Japanese popular music was investigated. The number of the listeners was limited, because the number of musical pieces was given priority over the number of listeners. The results showed that the emotional space of popular music is constructed by “evaluation,” “potency” and “activity” factors. Moreover, it is shown that Japanese listeners like to listen to a “beautiful” tune of popular music with their lovers, and a “powerful” and “active” tune in a situation where people are around them. Furthermore, it was shown that only one parameter of tempo was not enough to illustrate any part of the emotional features in popular music. Tempo may vary the emotional features significantly in the situation where simple musical materials are used as stimuli, and tempo varies systematically. However, in a large set of musical pieces, many parameters, such as tempo, spectral centroid, articulation, level and tonality, may cooperate to affect the emotional features in music.

The results shown above are for the current popular music in Japan, and rated by Japanese listeners. Similar studies should be carried out with different sets of popular musical pieces and listeners from different cultures. It would also be interesting to investigate the effects of sung language (mother language or not) on the emotional features.

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