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

Ryo Yoneda* and Masashi Yamada

Graduate School of Engineering, Kanazawa Institute of Technology, 7–1 Ohgigaoka, Nonoich, 921–8501 Japan

(Received 22 March 2012, Accepted for publication 5 September 2012)

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

PACS number: 43.75.Cd [doi:10.1250/ast.34.166]

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

*e-mail: r.yoneda@venus.kanazawa-it.ac.jp
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 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

| 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!                 | Toshoshinki    |
| Honnou                     | Sheena Ringo   |
| I LOVE YOU                 | Yutaka Ozaki   |
| Order Made                 | RADWIMPS       |
| Ai wo Komete Hanataba wo monochrome | Superfly  |
| Asita ga Kurunara          | JUJU           |
| Uso                        | SID            |
| Dear Lonely Girl           | Miliyah Kato   |
| Himawari                   | Yusuake        |
| Jyunrenka                  | Shonannakaze   |
| GOLDFINGER ’99             | Hiromi Go      |
| Aitakute Aitakute          | Kana Nishino   |
| Ai no Mama ni Wagamama ni Boku wa Kimi Dake wo Kizutsuenai | B’z |
| Hitomi wo Tozite           | Ken Hirai      |
| Tentai Kamoku              | 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       |
| Riruha 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          |
| Guuzenko Kakuritsu         | 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 | UVERworld    |
| Real Face#1                | KAT-TUN        |
| Here We Go feat. VERBAL    | May J.         |
| Around The World           | MONKEY MAJIK   |
| Sakuranbo                  | Ai Otsuka      |

Table 1 Musical pieces used in Experiment 1.
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 song), 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

| SD scale     | Factor |
|--------------|--------|
|              | Evaluation | Potency | Activity |
| Mixed–Neat   | 0.856     | -0.383 | -0.132 |
| Clean–Dirty  | -0.825    | 0.140  | 0.140  |
| Showy–Humble | 0.540     | -0.685 | -0.294 |
| Agitated–Calm| 0.713     | -0.507 | -0.332 |
| Fresh–Sordid | 0.757     | 0.226  | -0.293 |
| Heavy–Light  | 0.338     | -0.349 | 0.759  |
| Dark–Bright  | 0.118     | 0.025  | 0.984  |
| Cheerful–Gloomy | 0.133 | -0.063 | -0.977 |
| Weak–Strong  | -0.245    | 0.856  | 0.040  |
| Hard–Soft    | 0.784     | -0.539 | 0.011  |
| Loose–Tight  | -0.168    | 0.866  | -0.209 |
| Powerful–Powerless | 0.318 | -0.890 | 0.022 |
| Monotonous–Varied | 0.045  | 0.613  | -0.043 |
| Tranquil–Restless | 0.633 | 0.604  | -0.047 |
| Pleasant–Unpleasant | -0.892 | -0.243 | -0.238 |
| Happy–Sad    | 0.158     | -0.107 | -0.961 |
| Warm–Cold    | -0.669    | 0.202  | -0.482 |

| Contribution rate | 0.319 | 0.264 | 0.243 |
| 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 Bashi | 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        | 84          |
| Hana                   | Mr. Children    | J                        | J-POP        | 136         |
| Unabara No Tsuki       | Yuko Ando       | J                        | J-POP        | 128         |
| One more time, One more chance | Masayoshi Yamazaki | J                        | J-POP        | 154         |
| Momoiro No Kataomoi    | Aya Matsuura    | J                        | J-POP        | 72          |
| A-i-shi-te-ru no Sign  | Dreams Come True| J                        | J-POP        | 182         |
| ~Watashitachi no Mirai Yosouzu~ | Ai Otsuka | J                        | J-POP        | 99          |
| Happy Days             | MY LITTLE LOVER | J                        | J-POP        | 88          |
| Shirori Kaito          | Mr. Children    | J                        | J-POP        | 68          |
| See-Saw Game           | Mika Nakashima  | J                        | J-POP        | 72          |
| ~Yukan Na Koi No Uta~  | ARASHI          | J                        | J-POP        | 73          |
| CHE.R.RY               | YUI             | J                        | J-POP        | 134         |
| 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        | 118         |
| Wanderin’Destiny       | globe           | J                        | J-POP        | 105         |
| Junior Sweet           | CHARA          | J                        | J-POP        | 88          |
| Haneuma Rider          | Porno Graffitti | 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 Graffitti | J                        | J-POP        | 120         |
| Happy Summer Wedding   | Morning Musume  | J                        | J-POP        | 126         |
| Guts daze!!            | Ulfuls         | 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         |
| Domnani Tokutemo       | JUUU           | J                        | J-POP        | 72          |
| Aiuta                  | GReeeEN        | J                        | J-POP        | 85          |
| Yume No Uta            | Kumi Koda      | J                        | J-POP        | 72          |
| Kaeritaku Nattayo      | Ikimonomakari   | 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          |
| 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 |
| Kumi 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 |
| Eenin | Ulfils | 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 |
| Mitsuubii? Mistuubii? | 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 | Pop | 113 |
| Iron Man | The Cardigans | W | Pop | 71 |
| Top Of The World | The Carpenters | W | Pop | 92 |
| Good Enough | Cyndi Lauper | W | Pop | 137 |
| Wannabe | Spice Girls | W | Pop | 110 |
| Fairground | Simply Red | W | Pop | 123 |
| Been To Canaan | Carol King | W | Pop | 129 |
| New Soul | Yael Nairn | W | Pop | 101 |
| Miles Away | Madonna | W | Pop | 116 |
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

| 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 |
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 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 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

| Situation                                | Coefficient of determination ($R^2$) | 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     |

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

*Table 5. The correlations between emotional features vs. suitable situations for listening and tempo in BPM.*
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 $A$, $S_{Aj}$. Then the perceptual distance between two pieces, $A$ and $B$, was defined as follows:

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

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
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 should be compared.

### Table 6

| Listener | 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 |

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.
ACKNOWLEDGEMENT

The authors thank Sockets Inc. for their cooperation. This work was partly supported by a Grant-in-Aid for Scientific Research (C), No. 22615043, from the Ministry of Education, Culture, Sports, Science and Technology, Japan.

REFERENCES

[1] K. Hevner, “Expression in music: A discussion of experimental studies and theories,” Psychol. Rev., 42, 186–204 (1935).
[2] K. Hevner, “The affective value of pitch and tempo in music,” Am. J. Psychol., 49, 621–630 (1937).
[3] C. E. Osgood, G. J. Suci and P. H. Tannenbaum, The Measurement of Meaning (University of Illinois Press, Urbana, 1957).
[4] J. A. Russell, “A circumplex model of affect,” J. Pers. Soc. Psychol., 39, 1161–1178 (1980).
[5] E. Schubert, “Continuous measurement of self-report emotion response to music,” in Music and Emotion: Theory and Research, P. Juslin and J. Sloboda, Eds. (Oxford University Press, New York, 2001), pp. 393–414.
[6] T. Taniguchi, Ongaku to Kanjoh (Music and Emotion) (Kitaohji Shobo, Kyoto, 1998), pp. 89–117 (in Japanese).
[7] S. Iwamiya, “Interaction between auditory and visual processing in car audio: Simulation experiment using video reproduction,” Appl. Hum. Sci., 16, 115–119 (1997).
[8] M. Yamada, N. Fujisawa and S. Komori, “The effect of music on the performance and impression in a video racing game,” J. Music Percept. Cognit., 7, 65–76 (2001).
[9] H. dela Motte-Haber, Ein Beitrag zur Klassifikation musikalischer Rhythmen (Arno Volk Verlag, Köln, 1968).
[10] A. Gabrielsson, “Adjective ratings and dimension analysis of auditory rhythm patterns,” Scand. J. Psychol., 14, 244–260 (1973).
[11] A. Gabrielsson and E. Lindstöm, “Emotional expression in music performance: Between the performer’s intention and the listener’s experience,” Psychol. Music, 24, 8–91 (1995).

Ryo Yoneda was born in Toyama in 1986. He received B.E. and M.E. degrees from the Kanazawa Institute of Technology in 2009 and 2011, respectively. He is currently a doctoral candidate in the Graduate School of Engineering, Kanazawa Institute of Technology, and has been since 2011. His research interests include music perception and emotion. He is a member of the ASJ and the JSMPC.

Masashi Yamada received his B.A. in Music from the Osaka Univ. of Arts in 1982, and B.S. in Mathematics from the Osaka Pref. Univ. in 1985, and his M. Design and Ph. D. from the Kyushu Institute of Design in 1987 and 1998, respectively. He worked for the Osaka Univ. of Arts from 1987 to 1994 as a Research Associate and an Assistant Professor. He joined the Kanazawa Institute of Technology in 1994 as an Associate Professor and is currently a Professor. The ASJ awarded him the AwaYa-Kiyoshi Prize in 1992, and also the Sato Paper Prize in 1999 and 2004, respectively. His research interests include music acoustics, music psychology and entertainment engineering.