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*Corresponding author: Tindara Capri,
University of Messina, Italy
E-mail: tcapri@unime.it

Reviewing editor:
Wei Meng, School of Information
Engineering, Wuhan University of
Technology, Wuhan, China

Additional information is available at
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ELECTRICAL & ELECTRONIC ENGINEERING | RESEARCH ARTICLE

Adult listening behaviour, music preferences and emotions in the mobile context. Does mobile context affect elicited emotions?

Rosa Angela Fabio¹, Giancarlo Iannizzotto², Andrea Nucita¹ and Tindara Capri^{*1}

Abstract: After the introduction of mobile computing devices, the way people listen to music has changed considerably. Although there is a broad scientific consensus on the fact that people show music preferences and make music choices based on their feelings and emotions, the sources of such preferences and choices are still debated. The main aim of this study is to understand whether listening in ecological (mobile) contexts differs from listening in non-mobile contexts in terms of the elicited emotive response. A total of 328 participants listen to 100 classical music tracks, available through an ad-hoc mobile application for mobile devices. The participants were asked to report their self-evaluation of each of the tracks, according to the Pleasure-Arousal-Dominance model and filled out a questionnaire about their listening behaviour. Our findings show that the same factors that affect music listening in non-mobile contexts also affect it in a mobile context.

Subjects: Computer Science; Engineering & Technology; Psychological Science

Keywords: music; emotion recognition; mobile context; music listening in ecological contexts

1. Introduction

In recent years, the way people listen to music has changed considerably (Avdeeff, 2012; Crawford, 2017). The spread of mp3 players first, and then, even more significantly, the wide diffusion of

ABOUT THE AUTHORS

Rosa Angela Fabio is Full Professor of General Psychology at the University of Messina. She mainly works in the area of experimental psychology on automatic and controlled processes of attention.

Tindara Capri is a researcher and psychologist. She mainly works in cognitive processes, general psychology and experimental psychology.

Giancarlo Iannizzotto is Associate Professor of Human-Computer Interaction at the University of Messina. He works in the areas of Artificial Intelligence and Computer Vision applied to Human-Computer Interaction and assistive technologies.

Andrea Nucita is Assistant professor of Web Programming at the University of Messina, Italy. His research interests include Data Management and Medical Informatics.

PUBLIC INTEREST STATEMENT

This study aims at understanding whether listening to music in a mobile context affects the emotions of the listener in a different way than in non-mobile contexts. Such an understanding will provide a deeper insight into the mechanisms involved in emotion elicitation and help to better inform the automatic content selection and suggestion engines. More than three hundreds participants were involved in the experimentation, listening to one hundred classical music tracks and providing their feedback through a mobile app specifically developed for this investigation. Our findings show that there is no sensible difference in the factors affecting the user's emotions between the mobile and non-mobile contexts. A possible explanation is that the users tend to use the same devices and streaming services in both contexts, thus enjoying very similar experiences.

streaming services and music apps for smartphones, shifted music listening towards more ecological contexts, induced by the use of mobile devices while immersed in the different activities of everyday life (Krause & North, 2016; Srivastava, 2010). The world of music is remarkably complex and varied and although there is a broad scientific consensus on the fact that people show music preferences and make music choices based on their feelings and emotions, the sources of such preferences and choices are still debated (Picking, 2010).

Previous research concerning music preference studied music attributes that describe psychological characteristics of musical pieces. One of the first analyses concerned the putative inverted-U relationship between the degrees of pleasure and arousal evoked by music (Kellaris, 1992; North & Hargreaves, 1996). Berlyne's theory (1971) argues that there is an inverted-U between liking for music and the degree of arousal it evokes so that moderately arousing music is liked the most. Laboratory research confirmed such an inverted-U relationship. Other studies mainly focused on the factor structure of music attribute preference and its relationship with personality. Rentfrow and Gosling (2007) rated music excerpts based on 14 sonic and psychological attributes and showed that much of the variance in music genre preferences can be attributed to the liking of musical features. Ju-Chiang Wang, Yi-Hsuan, Hsin-Min and Shyh-Kang (2015) statistically modelled the affective reaction of the users while listening to music excerpts, by means of a Gaussian Mixture Model (GMM) on the valence-arousal (VA) plane. Xiao Hu and Yi-Hsuan Yang (2017) investigated the effects of different cultural background of the users and of different choices of datasets on the mood estimation of musical excerpts, again assuming a two-factor VA structure. Greenberg, Rentfrow and Baron-Cohen (2016) had subjects rate 102 song excerpts on 38 attributes. They found a three-factor structure: Arousal (e.g. tense, strong, warm), Depth (e.g. sophisticated, relaxing, party music) and Valence (e.g. joyful, lively, sad). Also Fricke and Herzberg (2017) aimed to confirm this three-factor structure and the relationships with the personality domains. The authors used self-reported music attribute preference and replicated the findings of Greenberg et al. (2016). In studying music attributes that describe psychological characteristics of musical pieces, Juslin (2000) and Bradley and Lang (1994) used the Self-Assessment Manikin (SAM) scale to evaluate pleasure, arousal and dominance. The SAM scale is based on an environmental psychology theory that states that human emotional responses result from variations in pleasure, arousal and dominance. According to the theory, these three dimensions are necessary and sufficient to characterize a subject's feelings, which are influenced both by the personal and environmental stimuli. In turn, a subject's emotional state regulates his behaviour in a situation. In the present study, we used the SAM scale for two reasons: 1) it is based on a consolidated theory and 2) SAM-based evaluations can be easily collected through an automatized procedure realized by a client-server mobile application.

The digitization of music has altered consumption practices (Avdeeff, 2012), particularly by allowing more interactivity (Kibby, 2009) so that listeners are no longer constrained by, for instance, albums and track orders (Molteni & Ordanini, 2003). Moreover, due to the introduction of mobile computing devices (e.g. mp3 players and smartphones and tablets), people are able to exert greater control than ever before on how, when and where they experience music (Bryan-Kinns & Hamilton, 2012; Franco & Cataluna, 2009; Heye & Lamont, 2010; Juslin, Liljeström, Västfjäll, Barradas, & Silva, 2008; Krause, North, & Hewitt, 2013; North & Hargreaves, 2008; Sloboda, Lamont, & Greasley, 2009; Tseng & Hsieh, 2018). As a consequence, the music listening scenario has completely changed and further investigation is needed on the effect of music listening on user emotions and mood in such mutated context.

Randall and Rickard (2013) developed a Mobile Experience Sampling Method (M-ESM) to collect real-time data on personal music listening. In a subsequent work (2016), the same authors used this method to provide empirical data to further investigate the different motivations for music listening preferences and the corresponding affective outcomes. In both studies, the aim of the authors was to determine the conditions under which personal listening to some musical track, chosen by the participant, results in either short-term hedonic increase or decrease. The participants recorded

their initial mood in terms of valence and arousal, then they chose and listen to a musical piece, and finally they recorded their final mood in terms of valence and arousal (Randall & Rickard, 2013).

The aim of our study is different: we are interested in understanding whether listening in ecological (mobile) contexts differs from listening in non-mobile contexts in terms of the elicited emotive response. As we are interested in providing an “emotional rating” of the musical track (in the case of mobile listening), we evaluate the emotional response to a randomly ordered sequence of specific classical music tracks, disregarding the initial condition of the listener and the reasons that could lead them to prefer or not a piece. To our knowledge in the relevant literature, no other studies focused on estimating the emotional response of users in the mobile context with a specific set of music excerpts.

To reach this objective, we firstly assessed the perceived pleasure, arousal and dominance levels induced by each track, secondly, we analysed how different factors, including gender, age, music preferences, place, time and modality of listening, can be related to the perceived emotions (Antonietti et al., 2015; Fabio, 2017; Fabio & Antonietti, 2012; Fabio & Capri, 2015, 2017; Fabio et al., 2018; Fabio, Castriciano, & Rondanini, 2015; Fabio & Urso, 2014; Martino, Capri, Castriciano, & Fabio, 2017). We included gender because in Western culture women perceive more emotions compared to men and, in particular, are more reactive to unpleasant scenes, especially to those more aversive and traumatic (Bradley, Codispoti, Sabatinelli, & Lang, 2001). Also, based on the evidence, women tend to report experiencing more pleasure and joy (Deng et al., 2016). Age of participants is another important factor as participants of different generations might have different perceptions of musical genres and could perceive pleasure, arousal and dominance in different ways (Paule-Ruiz et al., 2017; Rentfrow, Goldberg, & Levitin, 2011). North and Hargreaves (2007a, 2007b, 2007c) also underlined that, according to several studies in the literature, musical preferences provide a way to discriminate between social groups and that such studies suggest indirectly that musical preferences might correlate with a variety of different lifestyle choices. In their study, 328 participants responded to questions regarding their musical preferences and provided data on various social class-related aspects of their lifestyle (namely travel, personal finances, education, employment, health and drinking and smoking). The reported results show that there are numerous associations between musical preference and the considered aspects of participants' lifestyle, for example, melancholic situations called for sad and moody music, while an arousal situation would call for loud, strong rhythm and invigorating music. Differently from the work by North and Hargreaves, in our work the location in which participants normally listen to music is also recorded, thus taking into consideration the *context* (both activities and environment) for listening. To this end, for example, melancholic situations called for sad and moody music, while an arousal situation would call for loud, strong rhythm and invigorating music. In our study, the participants could choose where and when to run the tests and reply to the questionnaires, so that data was collected in an ecological setting.

2. Method

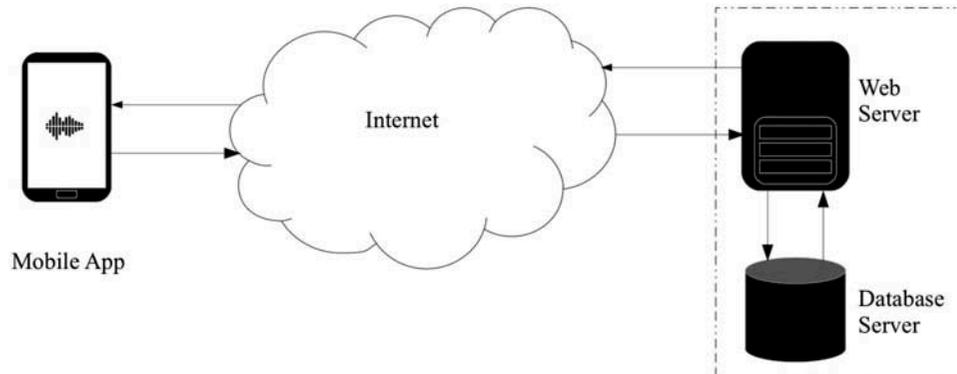
2.1. The system architecture

We collected the data through an automatized procedure realized by a client-server mobile application. The mobile application (App) was made available for both iOS and Android platforms, through their respective official application stores.

The App is modular, each module dedicated to a specific task, so that the user can autonomously and easily access the system and fill in the questionnaires. On the server side, the data are automatically collected in a database and made available for analysis.

In this section, we present the architecture of the system implemented for data collection and storage. Figure 1 illustrates the architecture for data collection.

Figure 1. Sketch of the architecture used to collect users' data.



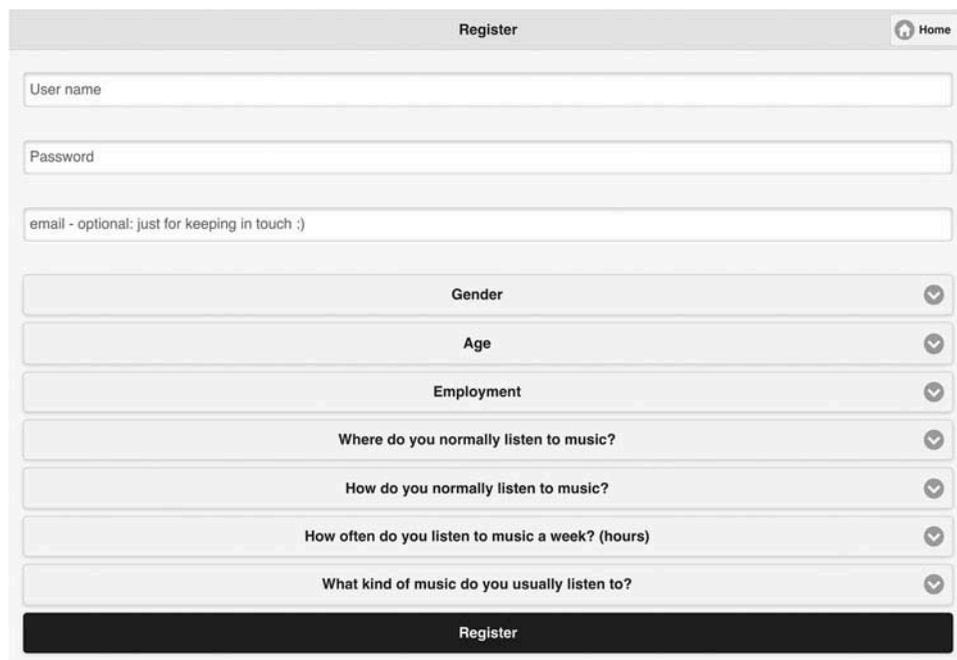
The App was developed using Cordova (cordova.apache.org), an open source Apache project that allows the development of mobile applications using languages that are typically used in the Web context, namely HTML, CSS and JavaScript. The advantage of this approach is that, starting from the same application project, Cordova provides different packages for the most common mobile application markets.

After the development, we published the App through the official app markets and made the respective links available, together with an adequate description, through the project website (nisclab.wordpress.com).

The App allows a new user to register or a registered user to login and choose between the two available languages (either English or Italian) for the user interface. The data are collected and stored anonymously, even though the user can optionally register his/her own email address to be contacted for further news about the research project. By accessing the application, the user can listen to different musical tracks and provide a self-evaluation of the emotions elicited while listening to the tracks.

In the registration page, the user can add information about her social condition and musical preferences. The registration questionnaire is composed of seven questions, as shown in Figure 2.

Figure 2. Mobile application screenshot showing a questionnaire about user data.



The screenshot shows a registration form titled "Register" with a "Home" button in the top right corner. The form contains the following fields and questions:

- User name
- Password
- email - optional: just for keeping in touch ;)
- Gender (dropdown menu)
- Age (dropdown menu)
- Employment (dropdown menu)
- Where do you normally listen to music? (dropdown menu)
- How do you normally listen to music? (dropdown menu)
- How often do you listen to music a week? (hours) (dropdown menu)
- What kind of music do you usually listen to? (dropdown menu)

A "Register" button is located at the bottom of the form.

When clicking on the Register button, the app sends a SOAP (www.w3.org/TR/soap/) request to a Web service through a Php (www.php.net) page provided by the Web server. Subsequently, the server sends a SOAP message, alerting about the success of the registration. All the collected data are then stored in a MySQL (www.mysql.com) database hosted by the same server.

2.2. Participants

A total of 328 participants were enrolled, 176 women and 152 men. The participants were divided into three groups: 116 subjects under the age of 18 (35.4%); 88 subjects between 19 and 21 years old (26.8%); 124 subjects over 22 years old (37.8%).

All participants were asked to register through the mobile application and to provide personal and social information anonymously: gender; age; employment; place where the participant listens to music (where); time spent listening to the music per week (when); activities during the listening (how); what kind of music the participant usually listens to (what). A summary of the participants' data is shown in Table 1.

2.3. Materials

The set of songs used for the analysis was created by selecting 100 audio fragments, e.g. ten audio fragments for each of the following authors: W. A. Mozart, L. van Beethoven, F. Lizst, A. Vivaldi, S. V. Rachmaninov, F. Shubert, J. S. Bach, M. Ravel, P. I. Tchaicovsky, S. S. Prokofiev. The audio files were collected from www.musopen.org and are shown in Table 2.

To obtain an evaluation of the emotional state elicited by the music for each participant, we adopted the SAM (Self-Assessment Manikin) scale, a non-verbal pictorial evaluation technique that allows the participant to express degrees of pleasure, arousal and dominance feeling. Designed by Mehrabian and Russell (1974), this elaborated semantic differential scale is a widely used tool to evaluate the three-dimensional structure of objects, events and situations. The three dimensions of the scale refer to pleasure, arousal and dominance. The Pleasure-Displeasure Scale measures how pleasant or unpleasant one feels about something. The Arousal-Nonarousal Scale measures how energized or soporific one feels. The Dominance-Submissiveness Scale represents the controlling and dominant feeling versus the submissive feeling. The SAM scale was originally implemented to become an interactive computer program but later expanded to include a paper version. Figure 3 shows the SAM figure with pleasure, arousal and dominance scales on the top, middle and bottom rows, respectively.

As already mentioned, we used a mobile application to collect user data that includes the SAM scale questionnaires, to collect emotion-related data about participants.

Figure 4 shows a screen page of the mobile application where the user is asked to respond to a SAM questionnaire. Every time a new user registers to the mobile application, the Web service is invoked to build a new random list of audio excerpts for that specific user, as we thought it might not be realistic that a single user could evaluate each of the audio fragments. We have therefore collected 2631 user evaluations over 100 audio excerpts; the mean of tracks evaluated for each user was 26.31 (SD = 5.06).

2.4. Data analysis

Data analysis was performed assuming gender, age, music preferences, place, time and modality of listening as independent variables, and the SAM subscales as dependent variables.

Firstly, we analysed the following: 1) the correlation of the subscales using two-tailed Pearson correlations (with an alpha value of 0.05) of the SAM subscales and 2) the general performances on the subscales for each track.

Table 1. Characteristics of the participants

Variables	n	%
<i>Gender</i>		
Female	176	53.7
Male	152	46.3
<i>Age</i>		
8-18	116	35.4
19-22	88	26.8
22-77	124	37.8
<i>Employment</i>		
Student	292	89.0
Worker	11	3.4
Professional	4	1.2
Retired	4	1.2
Unemployed	10	3.0
Other	7	2.1
<i>Where</i>		
Home	218	66.5
Outdoor	61	18.6
Disco	5	1.5
Other	44	13.4
<i>Time</i>		
Seven	137	41.8
Two	117	35.6
One	74	22.6
<i>How</i>		
Music-only	112	34.1
Work-Study	48	14.6
Manual work	46	14.0
Physical activity	56	17.1
Other	66	20.1
<i>Musical Genre (What)</i>		
Classical	11	3.4
Pop	105	32.0
Rock	40	12.2
Jazz	4	1.2
Rap - Hip Hop	67	20.4
Other	101	30.8

Secondly, we tested specific hypotheses regarding gender, age, music preferences, place, time and modality of listening. Independent samples t-tests (with an alpha value of 0.05) were used to determine differences in the SAM scores when the levels of the variable were two (as in gender: male and female) and F-tests (with an alpha value of 0.05) were used to determine differences in the SAM scores when the levels of the variables were higher than two.

3. Results

To assess the association among the three dimensions of the SAM scale (pleasure, arousal and dominance (PAD)), Pearson's correlation coefficients were calculated. There were strong and

Table 2. Music tracks from which excerpts were selected (from www.musopen.org)

Id	ID	Author	Title
1	9	W. A. Mozart	Piano Concerto no. 10 in E flat major K. 365/316a.I.Allegro
2	10	W. A. Mozart	Piano Concerto no. 14 in E flat major K. 449—Complete Performance
3	11	W. A. Mozart	Clarinet Concerto in A major K. 622—I. Allegro
4	13	W. A. Mozart	Horn Concerto no. 1 in D major K. 412 5/14—I. Allegro (horn violin cello and piano arr.)
5	14	W. A. Mozart	Mozart—Concerto No.6 in B flat major—III. Rondo allegro
6	15	L. Van Beethoven	Wind Octet in E flat major, Op.103—III. Menuetto
7	16	W. A. Mozart	Violin Sonata no. 26 in Bb, K. 378
8	17	L. Van Beethoven	Piano Concerto No.3, Op.37—I. Allegro con brio
9	18	L. Van Beethoven	Violin Concerto in D, Op. 61—I. Allegro ma non troppo
10	19	L. Van Beethoven	Leonore Overture no. 1, Op. 138
11	20	L. Van Beethoven	Quartet No. 6 in B Flat Major, Op. 18, No. 6—II. Adagio ma non troppo
12	21	W. A. Mozart	Overture to The Magic Flute, K. 620
13	22	W. A. Mozart	Don Giovanni, K. 527—Overture
14	23	W. A. Mozart	String Quartet No. 15 In D Minor, K 421—IV. Allegro Ma Non Troppo
15	24	W. A. Mozart	02 Violin Sonata in G Major
16	25	L. Van Beethoven	Sextet in E flat major, Op. 81b
17	26	L. Van Beethoven	Variations in F major, Op. 34
18	27	L. Van Beethoven	Variations on Bei Männern, welche Liebe fühlen
19	28	L. Van Beethoven	Allegretto for Piano Trio
20	29	L. Van Beethoven	Symphony No. 3 in E Flat Major Eroica, Op. 55—III. Scherzo Allegro vivace
21	30	F. Lizst	Transcendental Etudes, S. 139-8. Wilde Jagd
22	31	F. Lizst	La notte, S. 112/2
23	32	F. Lizst	Mephisto Polka
24	33	F. Lizst	Hungarian Rhapsody no. 9 Carnival in Pest, S. 244/9
25	34	F. Lizst	Valse no.1 from Valses oubliées, S. 215

(Continued)

Table 2. (Continued)

26	35	F. Lizst	Neal O Doan—Totentanz
27	36	F. Lizst	Tristan und Isolde—Liebestod, S.447
28	37	F. Lizst	Widmung, no. 1 from Myrthen, S. 566
29	38	F. Lizst	Années de pèlerinage I, s.160—Complete Performance
30	39	F. Lizst	Liebesträume, S. 541
31	40	A. Vivaldi	Concerto for 2 Cellos in G minor, Viva
32	41	A. Vivaldi	Concerto for 2 Violins in A minor, RV 522—I. Allegro
33	42	A. Vivaldi	Concerto in C major Op.8 No.12—I. Allegro II. Largo III. Allegro
34	43	A. Vivaldi	Vivaldi—Cello Sonata 5 (I) Largo
35	44	A. Vivaldi	Vivaldi—Cello Sonata 5 (IV) Allegro
36	45	A. Vivaldi	The Four Seasons, Violin Concerto in E major, RV 269 Spring—I. Allegro
37	46	A. Vivaldi	Concerto for 2 Flutes in C major, RV 533—Largo
38	47	A. Vivaldi	Concerto for 2 Flutes in C major, RV 533—Allegro molto
39	48	A. Vivaldi	Concert n.8 op.3 in Amin for 2 violins and orchestra, Allegro
40	49	A. Vivaldi	Concerto for 2 Trumpets in C major, RV. 537 (Rondeau arr.)—I. Allegro
41	50	S. Rachmaninov	Prelude no.4 from Op.23
42	51	S. Rachmaninov	Piano Concerto no. 3, Op. 30—I. Allegro ma non tanto
43	52	F. Shubert	Fantasy in C Major Op.15 D.760 Wanderer—I. Allegro con fuoco
44	53	F. Shubert	Octet in F major, D. 803
45	54	F. Shubert	Quartetsatz
46	55	S. Rachmaninov	Piano Concerto no. 3, Op. 30—III. Finale: Alla breve
47	56	F. Shubert	Piano Sonata no. 4 in Am, D. 537—III. Allegro vivace
48	57	S. Rachmaninov	Études Tableaux, Op. 33—VI. Allegro con fouco
49	58	S. Rachmaninov	Moment musicaux in E flat minor Op.16 no. 2 Live
50	59	F. Shubert	Violin Sonata in A, D. 574 II. Scherzo
51	60	F. Shubert	Symphony no. 8 in C major the Great, D. 944—I. Andante, allegro ma non troppo

(Continued)

Table 2. (Continued)

52	61	F. Schubert	Piano Trio no. 1 in B flat major, D. 898—Rondo. Allegro vivace
53	62	F. Schubert	Marche militaire in D, D. 733 no. 1 (2 hands version)
54	63	F. Schubert	Impromptu no. 4 in F minor, D. 935
55	64	F. Schubert	Six Musical Moments, D. 780—III. Allegro moderato [F# concert arr. by Leopold Godowsky]
56	65	S. Rachmaninov	Piano Sonata no. 2, Op. 36 [Second version]
57	66	J. S. Bach	Toccata in G minor, BWV 915
58	67	J. S. Bach	Prelude and Fugue in G minor, BWV 535 (Piano version)
59	68	J. S. Bach	Concerto for 3 Harpsichords in D minor, BWV 1063—III. Allegro
60	69	J. S. Bach	Harpisichord Concerto no. 2 in E, BWV 1053
61	70	J. S. Bach	Invention in Am, BWV 784
62	71	S. Rachmaninov	Symphony no. 2, Op. 27—I. Largo—Allegro moderato
63	72	J. S. Bach	6 Little Preludes, BWV 933–938 I. Prelude in C major, BWV 933
64	73	J. S. Bach	Toccata in E minor, BWV 914
65	74	J. S. Bach	Chaconne from BWV 1004 (piano arr.)
66	75	S. Rachmaninov	Symphony no. 2, Op. 27—III. Adagio
67	76	S. Rachmaninov	Symphony no. 2, Op. 27—IV. Allegro vivace
68	77	S. Rachmaninov	Rachmaninoff—Symphonic Dances, Op. 45
69	78	J. S. Bach	Blessed is the man, BWV 57-7. Aria (For Trumpet and Organ—Rondeau)
70	79	J. S. Bach	Gott fährt auf mit Jauchzen, BWV 43-7. Aria (For Trumpet and Organ—Rondeau)
71	80	M. Ravel	Adagio from Piano Concerto in G [piano solo arr.]
72	81	M. Ravel	Menuet sur le nom de Haydn
73	82	M. Ravel	Miroirs—III. Une barque sur l ocean
74	83	M. Ravel	Jeux d eau
75	84	M. Ravel	String Quartet in F major—I. Allegro moderato
76	85	M. Ravel	Pavane de la belle au bois dormant
77	86	M. Ravel	Laideronnette, imperatrice des pagodes

(Continued)

Table 2. (Continued)

78	87	M. Ravel	Le Jardin féerique
79	88	P. I. Tchaicovsky	Swan Lake Op.20—Act II Pt.1
80	89	P. I. Tchaicovsky	Swan Lake Op.20—Act II Conclusion
81	90	P. I. Tchaicovsky	The Nutcracker Suite—Act I, No.1. Overture
82	91	P. I. Tchaicovsky	The Nutcracker Suite—Act I, No.2. March
83	92	P. I. Tchaicovsky	The Nutcracker Suite—Act I, No.3. Dance of the Sugar Plum Fairy
84	93	P. I. Tchaicovsky	The Nutcracker Suite—Act I, No.4. Russian Dance
85	94	P. I. Tchaicovsky	The Nutcracker Suite—Act I, No.8. Waltz of the Flowers
86	95	P. I. Tchaicovsky	Nutcracker Suite—Act II, No.12. Pas de Deux variations
87	96	P. I. Tchaicovsky	The Nutcracker Suite—Act II, No.15. Final Waltz and Apotheosis
88	97	P. I. Tchaicovsky	Romeo and Juliet (Overture-Fantasia)
89	98	S. Prokofiev	Prokofiev Piano Concerto no. 1, Op. 10—I. Allegro brioso
90	99	S. Prokofiev	Prokofiev Piano Concerto no. 1, Op. 10—II. Andante assai
91	100	S. Prokofiev	Prokofiev Piano Concerto no. 1, Op. 10—III. Allegro scherzando
92	101	S. Prokofiev	Prokofiev Piano Sonata no. 3, Op. 28
93	102	S. Prokofiev	Prokofiev Piano sonata no.7, Op.83 I. Allegro inquieto—Andantino
94	103	S. Prokofiev	Prokofiev Piano sonata no.7, Op.83 II. Andante caloroso
95	104	S. Prokofiev	Prokofiev Piano sonata no.7, Op.83 III. Precipitato
96	105	S. Prokofiev	Prokofiev Sonata No. 5 in C Major, Op. 38-135—Un poco allegretto
97	106	M. Ravel	Pavane for a Dead Princess
98	107	M. Ravel	Le tombeau de Couperin—Complete piece
99	108	S. Prokofiev	Sonata No. 5 in C Major, Op. 38-135—Allegro tranquillo
100	109	S. Prokofiev	Sonata No. 5 in C Major, Op. 38-135—Andantino

Figure 3. SAM scale on a nine-point scale to assess for pleasure, arousal and dominance.

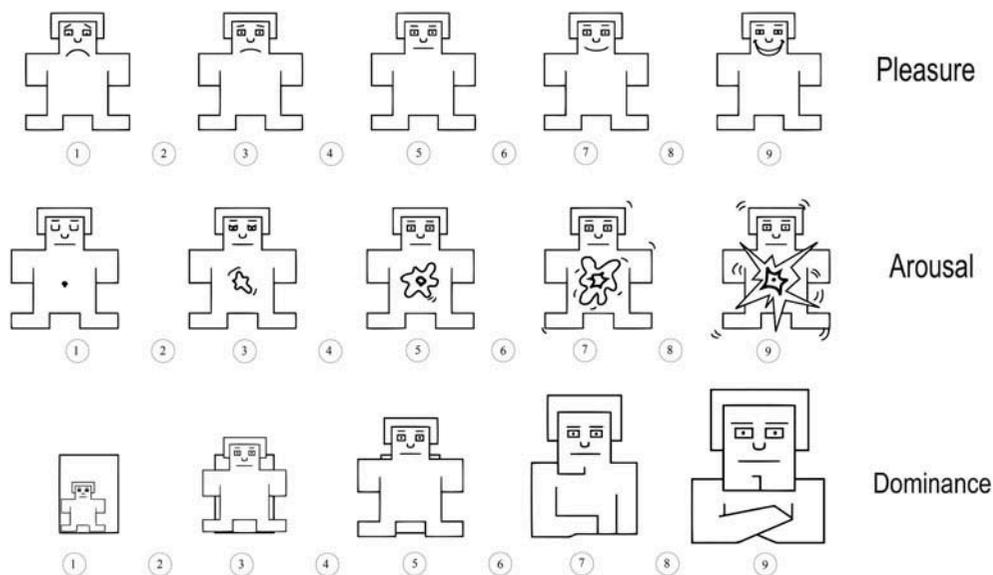
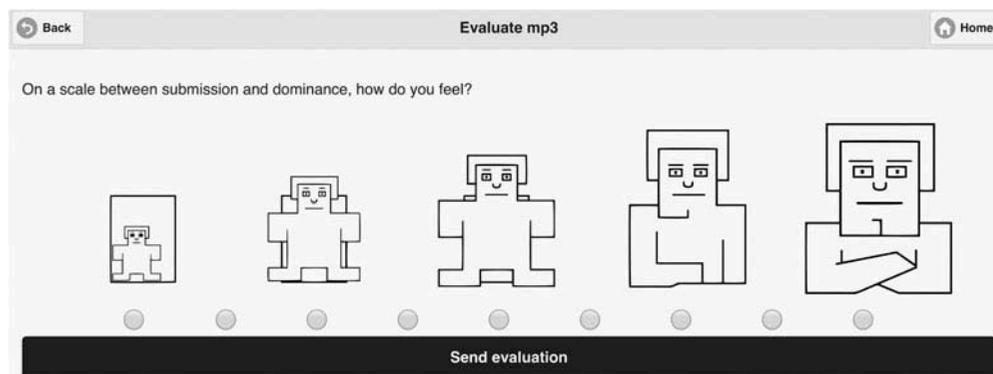


Figure 4. Mobile application screenshot showing a questionnaire about emotion-related music evaluation with SAM scales.



statistically significant correlations between the pleasure sub-scale and the arousal sub-scale ($r = 0.594, p < 0.001$), between the pleasure sub-scale and the dominance sub-scale ($r = 0.837, p < 0.001$) and between the arousal sub-scale and the dominance sub-scale ($r = 0.614, p < 0.001$). These results mean that the tracks that elicited a high feeling in one dimension also elicited high feeling in the other two dimensions. The strong covariation between reports of pleasure, arousal and dominance have been also reported in other studies (Bradley & Lang, 1994) and indicate that SAM is an effective method for measuring existing feeling states.

To identify those tracks that gave rise to significantly higher or lower scores we assessed pleasure, arousal and dominance scores across the 100 tracks. We report each track's mean in Figure 5, and we indicate the highest and lowest scores as follows: 'X's show track values that are below the mean minus one standard deviation ($< M - 1SD$), and circles show track values are above the mean plus one standard deviation ($> M + 1SD$).

As such, this analysis identified the highest and lowest scores in terms of each of pleasure, arousal and dominance dimensions. These results demonstrate that the PAD dimensions can distinguish between the different tracks.

Figure 5. Means of each dimension of the SAM for each track with stacked line chart.

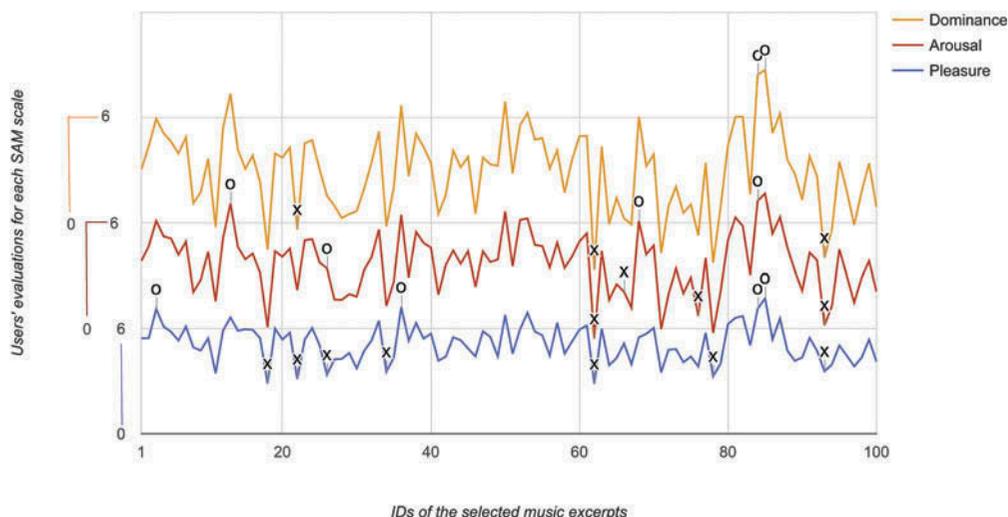


Table 2 shows the author and the title of each track presented in the X-axis of Figure 5. Tracks 3, 36, 84 and 85 were perceived as eliciting a high level of pleasure (see Table 2).

Tracks 18, 22, 26, 34, 62, 78 and 93 were perceived as eliciting a low level of pleasure. Tracks 13, 26, 68 and 84 were perceived as eliciting a high level of arousal, while tracks 62, 66, 76 and 93 as eliciting a low level of arousal. Furthermore, tracks 84 and 85 were perceived as eliciting a high level of dominance, and track 22, 62, 93 were perceived as eliciting as low level of dominance. Table 2 shows the mean evaluation values, with their standard deviation, for the above-mentioned audio excerpts, together with the source musical pieces and their mode and tempo attributes. To explain these first results, we considered some musical characteristics of the audio excerpts. It is well known from the literature that musical mode (major or minor) and tempo (slow or fast) affect the user's emotional reactions (Antonietti, Cocomazzi, & Iannello, 2009; Colombo & Antonietti, 2017; Hunter, Schellenberg, & Schimmack, 2010; Husain, Thompson, & Schellenberg, 2002; Mehrabian & Russell, 1974; Stalinski & Schellenberg, 2012). According to these findings, as shown in Table 3, excerpts in major mode are associated with high levels of pleasure, while excerpts in minor mode correspond to low levels of pleasure. Moreover, tempo affects the activation of the users in the arousal and dominance scales. We considered that user's response is also related to past experiences about known music pieces.

All the considerations above agree with prior research on music listening in non-mobile context.

To address the second aim, we analysed how different factors, including gender, age, employment, music preferences, place and time may influence perceived pleasure, arousal and dominance. Owing to the high number of variables, a Bonferroni correction was applied to each analysis. With reference to gender, as the data were normally distributed, t-test for independent measure was applied. As in the study of Fricke and Herzberg (2017) women tend to report a higher level of pleasure with the musical tracks than men in tracks 10, 11, 12, 15, 26, 35, 48, 50, 62, 96 and 97. With reference to arousal, score t-tests were statistically significant in tracks 62, 44, 59, 68, 69, 81, 99: again, women report experiencing more arousal with the musical tracks than men. With reference to dominance, score t-tests were statistically significant in tracks 25, 35, 55, 73, 90, 97; in this case, women report experiencing more dominance in tracks 15 and 35 and men report experiencing more dominance in tracks 55, 73, 90, 97. For all the above-mentioned tracks we obtained p values of t-test lower than 0.01. With reference to age, F tests were significant in tracks 18, 22, 23, 42, 43, 56, 57 and 72. People with age higher than 22 report experiencing more pleasure, arousal and dominance than younger people do.

Table 3. Subset of the audio excerpts with users' evaluations and their musical attributes (musical mode and tempo)

Music Excerpt From	Mode	Tempo (bpm)	Mean Pleasure	Standard Deviation Pleasure	Mean Frenzy	Standard Deviation Frenzy	Mean Dominance	Standard Deviation Dominance
S. Rachmaninov—Symphony no. 2, Op. 27	Minor	90	2.84	1.64	2.58	2.09	3.89	2.18
L. Van Beethoven—Variation 4 on Bei Männern	Minor	90	2.86	1.69	3.21	2.36	4.39	2.53
F. Liszt—La notte, S. 112/2	Minor	66	3.12	1.7	5.08	2.43	3.42	2.10
M. Ravel—Le jardin féerique	Major	54	3.27	2.18	2.48	1.64	3.97	2.10
F. Liszt—Neal O Doan—Totentanz	Minor	90	3.36	1.89	6.05	2.63	4.14	2.53
A. Vivaldi—Vivaldi—Cello Sonata 5	Minor	90	3.53	1.67	3.76	1.74	4.50	1.94
S. Prokofiev—Prokofiev Piano sonata no.7	Minor	66	3.56	1.89	2.63	1.47	3.81	2.02
M. Ravel—Pavane de la belle au bois dormant	Minor	110	3.84	2.19	2.88	1.81	4.56	1.96
S. Rachmaninov—Symphony no. 2, Op. 27	Minor	74	5.15	2.11	2.95	1.57	4.15	1.90
S. Rachmaninov—Symphonic Dances, Op. 45	Minor	117	5.5	1.43	6.60	2.04	5.95	2.65
W. A. Mozart—Clarinet Concerto in A major K. 622	Major	130	7.12	1.87	5.00	2.21	5.82	2.16
P. I. Tchaicovsky—The Nutcracker Suite	Major	160	7.13	2.16	6.13	2.68	7.19	1.68
A. Vivaldi—The Four Seasons	Major	100	7.23	1.6	5.23	2.00	6.23	1.80
P. I. Tchaicovsky—The Nutcracker Suite	Major	125	7.73	1.51	5.94	2.55	7.06	1.95

With reference to employment, employed people report experiencing more pleasure and arousal than students and the unemployed (tracks 22, 23, 28, 43, 56, 59, 72). Both these results are similar to the results of the work of Rentfrow et al. (2011).

We found that the results referred to the location are weak and not significant and with regard to the time spent in music listening we found that subjects who spend more time listening to music experience more pleasure and dominance than subjects that spend less time (tracks 14, 16, 23, 24, 25, 56, 42, 69, 73, 93). For all the above-mentioned tracks we obtained p values of F-test lower than 0.01.

As seen in the introduction of this work, the same variables that influence the perceived emotions such as gender, age, music preferences, place, time and modality of listening in non-mobile contexts influence also the perceived emotions in mobile context. Far from considering this as a negative result, we think that it suggests that the way to listen to music has a low impact on the perceived emotions and that the challenge could be to understand if it has a greater impact on other aspects of the social relationship such as communication or lack of communication.

4. Discussion

Music listening in the mobile context has grown in the past years together with the massive spread of mobile devices. This modality in music listening, and the enhanced technical capabilities of mobile devices, has led to new ways to conceive the fruition of music by users. Prior research focused on measuring the reasons that motivate users to listen to music in mobile context, and how this different context may change the listening experience (Randall & Rickard, 2013, 2016). Moreover, the possibility to propose musical playlists based on the mood of the user has also raised the interest of industry (U.S. Patent No. 9,788,777 B1, 2017).

However, to the best of our knowledge, the relevant literature lacks studies focused on measuring the specificity in emotional response of users in the mobile context with a specific set of music excerpts. On the basis of prior research, we considered the behavioural and social parameters that are known to influence the music listening, and measured the emotive response of the users within an ecological context, by the means of an original mobile application.

Our results show how, for each musical track, different sources, i.e. gender, age, employment, place, time and music preferences, differently affect the Pleasure–Arousal–Dominance measures. Thus, substantially agreeing with the findings of prior literature and suggesting that the mobile context does not sensibly affect the way music listening elicits emotions in the users.

5. Conclusion

In conclusion, the adoption of a mobile application has confirmed to be a valuable method to collect users' data in an ecological context, and we proposed an original research showing that also in a more ecological (mobile) context the music characteristics and the social data that affect emotive responses corroborate and generalize those already known from prior research conducted in non-mobile contexts.

One limitation of the present study is the low heterogeneity of users, being most of them students. Hence, as part of future work, we plan to extend the number of users, increasing their variety in age and employment, to study more deeply the discussed findings. In fact, our findings suggest that it would be possible to get more precise music emotional evaluation within a specific user group.

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Author details

Rosa Angela Fabio¹
E-mail: rafabio@unime.it
Giancarlo Iannizzotto²
E-mail: ianni@unime.it
ORCID ID: <http://orcid.org/0000-0003-1275-7433>
Andrea Nucita¹
E-mail: anucita@unime.it
ORCID ID: <http://orcid.org/0000-0001-6257-5529>
Tindara Capri
E-mail: tcapri@unime.it

¹ Department of Clinical and Experimental Medicine, University of Messina, Via Bivona, Messina 98122, Italy.

² Department of Cognitive Sciences, Psychological, Educational and Cultural Studies, University of Messina, Via Concezione, 6, Messina 98122, Italy.

Author statement

The Authors belong to a research group “Cognition and Interaction Technology” at the University of Messina (Italy), focusing on human and technological factors related to the effects of current and future media and interaction technologies on human emotions, performance and cognitive activities.

Declaration of interest statement

The authors declare no conflict of interest and no source of funding. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from parents of the participants included in the study.

Data availability statement

The data that support the findings of this study are openly available at <http://www.mysql.com>

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