Individual differences in music reward sensitivity influence the perception of emotions represented by music

Journal:	*Musicae Scientiae*
Manuscript ID	MS-21-0005.R2
Manuscript Type:	Original Manuscript
Keywords:	emotion perception, music reward, gender, music discrimination skills, musicianship

Abstract: Although music is one of the most important sources of pleasure for many people, there are considerable individual differences in music reward sensitivity. Behavioural and neurobiological characterizations of music reward variability have been topics of increasing scientific interest over the last two decades. However, it is not clear how differences in music reward sensitivity might influence the perception of emotions represented by music and, specifically, how music reward sensitivity could influence subjective music evaluation when the affective valence of music is considered. In the present study we investigated the relationship between music reward sensitivity and the perception of emotions in music, taking into account the emotional category of stimuli (pleasant, neutral, or unpleasant music clips). Music reward and emotion perception were also explored as a function of gender, musicianship, and music discrimination skills. We used the Barcelona Music Reward Questionnaire and the previously validated Film Music Stimulus Set (FMSS); participants rated FMSS excerpts for affective dimensions (valence, energy, and tension arousal) and discrete emotions (happiness, anger, fear, tenderness, and sadness). Our results showed that music reward was the main factor influencing FMSS evaluation, particularly for excerpts associated with positive affect. Gender had an important influence on evaluations linked to the negative pole of emotions, and music discrimination skills seemed to be associated with cognitive aspects of music analysis, rather than with the emotional architecture of pleasant music excerpts. Our findings highlight the need to consider music reward sensitivity and gender in studies of music and emotion and open the possibility of using the FMSS in studies exploring the neurobiological and psychosocial bases of music emotion.

Individual differences in music reward sensitivity influence the perception of emotions represented by music

Abstract

Although music is one of the most important sources of pleasure for many people, there are considerable individual differences in music reward sensitivity. Behavioural and neurobiological characterizations of music reward variability have been topics of increasing scientific interest over the last two decades. However, it is not clear how differences in music reward sensitivity might influence the perception of emotions represented by music and, specifically, how music reward sensitivity could influence subjective music evaluation when the affective valence of music is considered. In the present study we investigated the relationship between music reward sensitivity and the perception of emotions in music, taking into account the emotional category of stimuli (pleasant, neutral, or unpleasant music clips). Music reward and emotion perception were also explored as a function of gender, musicianship, and music discrimination skills. We used the Barcelona Music Reward Questionnaire and the previously validated Film Music Stimulus Set (FMSS); participants rated FMSS excerpts for affective dimensions (valence, energy, and tension arousal) and discrete emotions (happiness, anger, fear, tenderness, and sadness). Our results showed that music reward was the main factor influencing FMSS evaluation, particularly for excerpts associated with positive affect. Gender had an important influence on evaluations linked to the negative pole of emotions, and music discrimination skills seemed to be associated with cognitive aspects of music analysis, rather than with the emotional architecture of pleasant music excerpts. Our findings highlight the need to consider music reward sensitivity and gender in studies of music and emotion and open the possibility of using the FMSS in studies exploring the neurobiological and psychosocial bases of music emotion.

Keywords: emotion perception, music reward, gender, music discrimination skills, musicianship

Individual differences in music reward sensitivity influence the perception of emotions represented by music

Over the last two decades we have seen an increasing scientific interest in the use of music as an emotional stimulus. Standardized music databases specifically created for experimental purposes have been particularly helpful in the understanding of individual differences in the processing of emotions through music (Eerola & Vuoskoski, 2011; Imbir & Golab, 2017; Lepping et al., 2016; Song et al., 2016; Vieillard et al., 2008). Eerola & Vuoskoski (2011) developed the Film Music Stimulus Set (FMSS), in which perceived emotions conveyed by music were studied through the comparison of two different theoretical approaches: a dimensional model that evaluated valence, energy arousal and tension arousal, and a discrete model that evaluated happiness, anger, fear, sadness and tenderness. An analysis of subjective ratings indicated that all targeted emotions were significantly well discriminated, with a strong congruence between the two models (Eerola & Vuoskoski, 2011). The original FMSS results were obtained using a Finnish population (Eerola & Vuoskoski, 2011), and were recently replicated and validated in a Spanish population (Fuentes-Sánchez et al., 2020).

The study of emotional processing through music, particularly in relation to positive emotions and reward, has also been of growing interest in the field of neuroscience. To better understand the behavioural and biological bases of individual differences in music reward, Mas-Herrero et al. (2013) developed the Barcelona Music Reward Questionnaire (BMRQ), which is divided into five subscales that define the global BMRQ score: Musical Seeking, Emotion Evocation, Mood Regulation, Sensory-Motor behaviour, and Social Reward. Mas-Herrero and colleagues (2013, 2014) reported that this instrument can be used to identify important differences in music reward sensitivity, with some individuals presenting high reward sensitivity values and others showing an inability to experience pleasure, a phenomenon known as musical anhedonia (Martínez-Molina et al., 2016). Individual differences in BMRQ scores have been associated with central and peripheral physiological correlates. It has been suggested that music reward sensitivity arises from the interaction between subcortical reward system regions such as the nucleus accumbens (NAcc) and related limbic structures (amygdala and hippocampus), and higher-order cortical areas such as the superior temporal gyrus, including the auditory cortex, and the orbitofrontal cortex (Cheung et al., 2019; Martinez-Molina et al., 2016; Mas-Herrero et al., 2018; Salimpoor et al., 2013). Interestingly, the functional connectivity between some of these areas has been shown to be stronger when individuals listen to more desirable music excerpts (Salimpoor et al., 2013) and in those with higher BMRQ scores (Martinez-Molina et al., 2016). Recent data have also indicated that structural connectivity between the orbitofrontal cortex and NAcc can predict individual BMRQ differences (Martínez-Molina et al., 2019), and higher BMRQ scores have also been associated with reduced striatal (caudate and left NAcc) volume (Hernández et al., 2019). In addition, studies using physiological measures have shown greater reactivity for electrodermal activity or heart rate (indexes of emotional arousal and hedonic valence, respectively) in individuals with higher BMRQ values (Mas-Herrero et al., 2014). Altogether, these findings suggest that the BMRQ is a reliable instrument that can capture individual variability in music reward and is sensitive to the plausible neurobiological mechanisms underlying such variability.

The BMRQ has also been used to investigate the relationship between music reward sensitivity and the subjective evaluation of emotions represented by music. People with higher scores on the BMRQ are more likely to rate musical excerpts as more pleasurable (Ferreri et al., 2019; Mas-Herrero et al., 2014, 2017; Martinez-Molina et al., 2016), suggesting that music reward sensitivity could reflect individual differences in processing emotions associated with music, and in particular positive emotions and affect. These studies did not, however, consider the explicit effects of music reward sensitivity on subjective ratings as a function of hedonic valence of music (Martinez-Molina et al., 2016). In the present study we used the BMRQ together with the FMSS (Eerola & Vuoskoski, 2011; Fuentes-Sánchez et al., 2020). With the comprehensive collection of music clips used in the FMSS we explored BMRQ scores in association with positive and negative aspects of music-influenced valence, arousal, as well as discrete emotion descriptors (happiness, fear, anger, tenderness, and sadness). Additionally, FMSS excerpts were classified as pleasant, neutral, or unpleasant, which allowed us to investigate whether the hedonic valence of music clips can mediate BMRQ's influence on subjective evaluation. Previous studies have also reported that BMRQ results can be modulated by musicianship, music discrimination skills (i.e., music processing abilities associated with scale, rhythm, metre, and music memory) and gender (Hernández et al., 2019; Mas-Herrero et al., 2013). Regarding music experience, musicians (who generally exhibit greater music discrimination skills) tend to score higher on BMRQ items (Anderson & Kraus, 2011; Hernández et al., 2019; Mas-Herrero et al., 2013) and present larger auditory cortex volumes (Palomar-García et al., 2017). Research using the FMSS has shown that personality traits can influence the perception of emotions represented by music (Vuoskoski & Eerola, 2011a; Vuoskoski & Eerola, 2011b). It might therefore seem reasonable to hypothesise that individual differences in musicianship and music discrimination skills could also affect FMSS evaluation. Interestingly, however, there is evidence indicating that music discrimination skills and BMRQ scores contribute separately to individual differences in neural correlates associated with reward sensitivity (Hernández et al., 2019). These findings suggest a non-direct relationship between music discrimination skills, BMRQ, and FMSS measures. Music reward is a broad construct that includes components associated with emotion, but also with motivation and learning and memory processes. The fact that music expertise can influence BMRQ scores does not necessarily mean that music expertise translates into higher average ratings of evaluation of positive emotions conveyed by music excerpts. To investigate this, in the present study we used not only the BMRQ and the FMSS but also the Montreal Protocol for the Identification of Amusia (MPIA; Vuvan et al., 2018), which allowed us to determine music discrimination skills and detect potential cases of amusia among our participants. Finally, with regards to gender, previous research has shown that women tend to score higher overall on the BMRQ (Mas-Herrero et al., 2013). Also, women show a general predisposition to react with greater intensity both subjectively (with higher scores in arousal ratings) and physiologically (with higher EDA reactivity and cardiac deceleration) to aversive emotional stimuli of different modalities such as pictures (Bradley et al., 2001) and music (Nater et al., 2006). Taken together, these findings suggest that it is necessary to consider the contribution of gender when studying the processing of emotions.

Using a combination of correlational analysis, linear and multiple regression, as well as structural equation modelling, our main objective was to investigate the relationship between music reward and the perception of emotions represented by music in healthy participants. As an additional aim, we investigated the influence of gender, musicianship, and music discrimination skills on music reward sensitivity as well as on the subjective evaluation of music. Based on literature linking music reward sensitivity and felt emotion (Martínez-Molina et al., 2016; Mas-Herrero et al., 2014), and prior results showing a high relationship between felt and perceived music-evoked emotion (Gabrielsson, 2001), we expected that individual differences in music reward sensitivity would influence emotional music evaluation evaluated through self-ratings (affective dimensions and discrete emotions). Specifically, we expected that higher BMRQ scores would be associated with higher ratings of music excerpts associated with positive affect (e.g., happiness in pleasant clips). As previous findings on musical expertise and music discrimination skills were based on inconsistent patterns of observations, we had no strong predictions as to their role in the perception of emotions. However, the impact of gender on the perception of emotions has been demonstrated in a number of studies (Bradley et al., 2001; Fuentes-Sánchez et al., 2020; Nater et al., 2006), in which women generally show higher sensitivity to the negative pole of emotions. We therefore expected to find that women would show higher emotional responses associated with unpleasant music excerpts (e.g., fear and anger, as well as arousal).

Method

Participants

The sample size was calculated using G*Power (Faul et al., 2007), in accordance with previous studies (Vuoskoski & Eerola, 2011a). Considering an R^2 of .21 (f^2 = 0.27) with an alpha of .05, a power value of .95, and four predictors (gender, music expertise, BMRQ, and MPIA), the minimum sample size was 75 participants, but a larger sample size was planned as a conservative measure. To allow for a more nuanced exploration of the sub-components of each instrument (the BMRQ and MPIA), the number of predictors was adjusted to 12 (4 + 8), and thus the minimum required sample size was 135 participants. Consequently, a total of 136 Spanish-speaking undergraduate students (95 females) from Universitat Jaume I aged between 18 and 50 years (M = 22.04, SD = 4.63) were enrolled in this study. A total of 15 participants were excluded: 7 due to technical problems during data acquisition, and 8 who scored as potentially amusic in the MPIA test (Vuvan et al., 2018). Statistical analyses were performed with a total of 121 participants (87 females; 25 musicians and 96 non-musicians). Musicians had received at least 3 years of formal studies (conservatory or private school) and were active musicians at the time of data collection (M years of formal studies = 7.24, SD = 3.47). Ethical approval was granted by the Deontological Commission at Universitat Jaume I and a signed consent form was obtained from all participants.

Measures

Barcelona Music Reward Questionnaire (BMRQ; Mas-Herrero et al., 2013)

The BMRQ was used to evaluate individual differences in sensitivity to musical reward. In addition to the overall score, the questionnaire contains five latent factors: Musical Seeking, Mood Regulation, Emotion Evocation, Sensory-Motor, and Social Reward. Each factor is represented by four items, leading to a total of 20 items with scores provided using a 5-point Likert scale (*completely disagree - completely agree*). Musical Seeking refers to an interest in "knowing about music" and doing music-related everyday activities (e.g., attending live concerts, seeking information associated with the music they listen to). Emotion Evocation is related to the emotional impact of music on the listener. Mood Regulation refers to the ability of the listener to use music to modulate their emotions. Social Reward is related to the cohesion effect of music on individuals and groups. Finally, Sensory-Motor behaviour refers to the capacity of music to induce simple or complex movements such as toe-tapping or dancing.

The Montreal Protocol for the Identification of Amusia (MPIA; Vuvan et al., 2018)

MPIA screening consists of three subtests: the Scale, Off-Beat, and Out-of-Key tests. The Scale test consists of 31 pairs of melodies; half of these are identical, and the other half contain one melody with one different note. Participants have to judge whether the two melodies are the same or different. The Off-Beat test contains 24 melodies, of which half are manipulated to contain an unusual delay, and participants must judge whether each melody contains a temporal incongruency (delay). Finally, the Out-of-Key test contains 24 melodies, half of which are manipulated to be out of key, and participants judge whether each melody contains a pitch incongruity.

Stimuli, apparatus, and design

A total of 102 film excerpts were selected from the FMSS (Eerola & Vuoskoski, 2011), which has recently been standardized to the Spanish population (Fuentes-Sánchez et al., 2020). The excerpts did not contain lyrics, dialogue, or sound effects, and their duration was between 11 and 31 s (*M* = 17.63, *SD* = 3.73). Based on the Spanish normative ratings for hedonic valence obtained with the same sample as the one used in the present study (Fuentes-Sánchez et al., 2020), and for the purposes of statistical analysis, the excerpts were classified into three experimental categories. Accordingly, 22 excerpts were classified as unpleasant and 43 as pleasant, with affective valence ratings below 4 and above 6 on a 9-point Likert scale, respectively, while 37 excerpts were classified as neutral, with valence ratings between 4 and 6 (see Figure 1)[1]. Considering the specific emotions, within the unpleasant excerpts, 14 excerpts were fearful, 6 angry, and 2 sad; within the neutral excerpts, 22 were sad, 6 fearful, 7 angry, and 2 tender; and, finally, within the pleasant excerpts, 20 were happy, 21 tender, and 2 sad.

[INSERT FIGURE 1 ABOUT HERE]

Auditory stimuli and rating scales were presented using E-Prime 2.0 software (Psychology Software Tools, Inc. Sharpsburg, PA) on a standard 17-inch computer monitor, and responses were collected using a response panel. Musical excerpts were played through external noise-attenuating Sennheiser HD-205 headphones. Volume was kept constant across participants.

Participants were randomly assigned to one of two experimental groups, counterbalancing the task assignment and the order of stimuli. Group 1 (*n* = 60) rated half of the excerpts (Set 1) for discrete emotions (happiness, anger, fear, tenderness and sadness), and the other half of the excerpts (Set 2) for affective dimensions (valence, energy arousal

[1] The mean normative ratings for each category were as follows: unpleasant (valence: *M* = 3.11, *SD* = .57; energy arousal: *M* = 6.48, *SD* = .85; tension arousal: *M* = 7.13, *SD* = .85; happiness: *M* = 1.41, *SD* = .43; anger: *M* = 5.41, *SD* = 1.41; fear: *M* = 6.77; *SD* = .83; tenderness: *M* = 1.34, *SD* = .34; sadness: *M* = 3.30, *SD* = .84), neutral (valence: *M* = 4.90, *SD* = .55; energy arousal: *M* = 4.81, *SD* = 1.70; tension arousal: *M* = 4.96, *SD* = 1.63; happiness: *M* = 2.38, *SD* = .67; anger: *M* = 3.13, *SD* = 1.64; fear: *M* = 3.78; *SD* = 1.27; tenderness: *M* = 3.04, *SD* = 1.37; sadness: *M* = 4.82, *SD* = 1.69), and pleasant (valence: *M* = 6.90, *SD* = .49; energy arousal: *M* = 4.97, *SD* = 1.74; tension arousal: *M* = 3.94, *SD* = 1.41; happiness: *M* = 5.63, *SD* = 1.32; anger: *M* = 1.37, *SD* = .34; fear: *M* = 1.55; *SD* = .40; tenderness: M = 5.20, *SD* = 1.52; sadness: *M* = 3.31, *SD* = 1.56).

and tension arousal). Group 2 (n = 61) started by rating Set 2 for discrete emotions, and then rated the excerpts of Set 1 for affective dimensions. The same order was used for both groups. The aim of assigning the task in this way was to keep the total duration of the experiment as short as possible and avoid the possibility that asking participants to rate the same excerpts twice, once for discrete emotions and once for affective dimensions, would contaminate the results. There was a 5-minute break between the two parts of the task.

Excerpts were distributed between two sets of five blocks with 10 excerpts each (with the exception of two blocks of 11 excerpts); no more than two consecutive excerpts conveyed similar affective valence. The order of block presentation was individually randomized within each set, although the order of the excerpts within each block remained constant for all participants. Each trial began with a cue in the form of a white cross shown in the centre of a black screen for 1 s, followed by presentation of the excerpts. After each excerpt was presented, participants rated it on either the discrete emotions or the affective dimensions, as appropriate.

Procedure

Each participant carried out the task individually in one laboratory session that lasted approximately 90 min. Participants read an overview of the task, signed a consent form, and completed a survey regarding sociodemographic and health-related variables such as age, gender, educational level, history of musical training, and hearing problems. Music reward sensitivity was then evaluated using the BMRQ (Mas-Herrero et al., 2013). Before beginning the main task, participants were instructed to rate the emotions conveyed by the music excerpts using a 9-point scale for both for the categorical emotions (1 = *low*; 9 = *high*) and affective dimensions: valence (1 = *unpleasant/bad/negative*; 9 = *pleasant/good/positive*), energy arousal (1 = *sleepy/tired/drowsy*; 9 = *awake/wakeful/alert*), and tension arousal (1 = *relaxed/calm/at rest*; 9 = *tense/clutched up/jittery*). Then there were two practice trials, and the main experimental task began, which lasted approximately one hour. When participants had completed the experimental task, their music discrimination skills were evaluated using the MPIA (Vuvan et al., 2018), and participants were debriefed.

Data analysis

In order to investigate the relationship between music reward and emotion perception conveyed by music, we calculated Pearson's correlations between participants' overall scores on the BMRQ (and its subscales) and the mean of the ratings across all clips within the same category for each participant (i.e., affective dimensions and discrete emotions), considering the classification of the film music excerpts as pleasant, neutral, unpleasant as described above. Additionally, we performed a linear regression analysis with participants' valence and happiness ratings for pleasant excerpts as dependent variables, and their overall scores on the BMRQ as the independent variable.

Secondly, we investigated the plausible differences and relationships between music reward and other individual variables such as gender, musicianship, and music discrimination skills by calculating (1) *t*-test comparisons and effect sizes for women vs. men and musicians vs. non-musicians; (2) pairwise correlations between music reward (BMRQ) and music discrimination skills (MPIA).

Thirdly, to investigate the influence of these individual variables on the relationship between music reward and emotion evaluation, we carried out two analyses. First, we performed separate multiple regressions for each experimental condition (pleasant, neutral, unpleasant music excerpts), with the ratings for the affective dimensions (valence, energy arousal, and tension arousal) and discrete emotions (happiness, anger, fear, tenderness, and sadness) as dependent variables, and the four predictors (gender, music expertise, music reward, and music discrimination skills) as factors. Second, to investigate specific effects on pleasant emotions further, we tested a structural equation model with three latent variables:

Reward (Musical Seeking + Emotional Evocation + Mood Regulation + Sensory Motor + Social), Musical Discrimination Skills (Scale test + Off-Beat Test + Out of Key Test) and Emotion (Valence + Happiness for pleasant excerpts). The Durbin–Watson test was performed to analyse the potential autocorrelation of regression residuals (a lack of autocorrelation was assumed with Durbin–Watson test values of 2 ± 0.5). Considering that our analyses separated affective dimensions and discrete emotions, which significantly reduced the error rate for multiple comparisons, and that the analyses were pre-defined based on a priori hypotheses driven by a proposed theoretical framework (Rubin, 2021), we considered that correction adjustment for multiple comparisons was not mandatory. All statistical analyses were carried out using SPSS IBM Statistics version 26, JMP 15, R, and G*Power.

Results

Relationship between music reward (BMRQ) and emotion perception (FMSS)

The relationship between music reward and subjective evaluations of music excerpts is summarized in Table 1. A significant positive relationship between music reward sensitivity (Overall BMRQ score) and valence ratings was found, specifically for pleasant excerpts. Valence ratings for pleasant excerpts also correlated with Mood Regulation, Sensory-Motor, and Social BMRQ subscale scores. There was a near-significant relationship between Emotional Evocation and Valence for pleasant excerpts (p = .06). Energy ratings of pleasant excerpts correlated with Sensory-Motor subscale scores. With regards to the relationship between music reward and discrete emotion ratings, overall BMRQ score was positively correlated with happiness and anger for pleasant and unpleasant excerpts, respectively, and a positive correlation was found between Musical Seeking and anger ratings for unpleasant and neutral excerpts. Furthermore, the Mood Regulation and Social subscales correlated with fear ratings for unpleasant excerpts and tenderness ratings for pleasant excerpts, respectively. Regression analyses showed that music reward was a significant predictor for valence and happiness ratings of pleasant excerpts, R^2 adj = .06 ($p < .01$) and R^2 adj = .03 ($p < .05$) respectively (see Figure 2).

[INSERT TABLE 1 ABOUT HERE]

[INSERT FIGURE 2 ABOUT HERE]

Music reward and emotion perception as a function of gender, musicianship, and music discrimination skills

Descriptive statistics, t-test comparisons, and pairwise correlations

Descriptive statistics and *t*-test comparisons between men and women, and effect sizes, are summarized in Table 2. The results show that women obtained higher overall BMRQ scores, particularly on the Emotional Evocation and Sensory-Motor subscales. The analysis of differences between musicians and non-musicians (see Table 3) revealed that musicians obtained higher overall BMRQ scores and scored higher on the Musical Seeking and Social subscales.

Pairwise correlations also showed a positive relationship between overall music reward sensitivity and music discrimination skills, Overall and Out-of-Key subtest scores, $p < .05$ (see Table 4).

[INSERT TABLE 2 ABOUT HERE]

[INSERT TABLE 3 ABOUT HERE]

[INSERT TABLE 4 ABOUT HERE]

Multiple regressions

To explore the combined contributions of gender, music expertise, music reward sensitivity, and music discrimination skills on the subjective evaluation of FMSS clips, multiple regressions were performed (see Table 5). For affective dimensions, analyses showed that the global model (aggregate of the four predictors) did not predict valence of pleasant excerpts (p = .061). Gender, musicianship, and discrimination skills did not add to the significant contribution of BMRQ. However, gender did push the predictive strength of the global model to significant values for unpleasant excerpts. Gender was also a significant predictor of energy arousal ratings for unpleasant excerpts, and MPIA was an important variable predicting tension arousal for unpleasant excerpts, although both global models did not reach significance. For discrete emotions, the global model did not predict happiness, with BMRQ contributing in an only marginally significant way (p = .053). The combined model did, however, predict fear (unpleasant) and tenderness (neutral) with gender being the most important predictor of subjective ratings for discrete emotions. Music reward sensitivity was a significant predictor for tenderness ratings of pleasant excerpts, although the model was not significant. Finally, MPIA scores had a negative, yet significant contribution to predicting happiness ratings of neutral and unpleasant excerpts, as well as a positive relationship with evaluations of fear and tenderness clips (neutral).

[INSERT TABLE 5 ABOUT HERE]

The results of the Durbin–Watson test showed a lack of autocorrelation of the residuals, reported for pleasant, neutral, and unpleasant excerpts, respectively, for the models that predicted valence (2.33, 1.61, and 2.14), energy (2.01, 1.78, and 2.07), and tension arousal (1.99, 1.90, and 2.01), as well as for the models that predicted happiness (2.14, 2.06, and 1.66), anger (2.19, 2.06, and 1.88), fear (2.17, 1.90, 2.12), tenderness (2.04, 2.23, 2.05), and sadness (2.32, 2.05, and 1.75).

Structural equation modelling

Structural equation modelling (MacCallum & Austin, 2000) was used in order to provide additional information on the relationship between BMRQ (reward sensitivity), MPIA (music discrimination skills), gender, music expertise, and the perception of pleasant emotions, incorporating all measured variables in the analysis simultaneously. We specified a model in which one latent construct representing positive emotions (Happiness and Valence ratings for all positive excerpts) was predicted by two latent constructs, BMRQ and MPIA, which in turn are represented by several measured components (Musical Seeking, Emotional Evocation, Mood Regulation, Sensory-Motor, and Social Reward for BMRQ, and Scale test, Off-beat test, and Out-of-key test for MPIA). Any specific residual correlations between the measurement variables were not specified, and the model coefficients were estimated in Lavaan (Rosseel, 2012, version 0.6.8). This analysis provided a moderately good fit with the data, $X^2(32) = 53.38$ ($p = .010$), where all components of the BMRQ were significant at the $p < .001$ level, all components of the MPIA were significant at the $p < .005$ level, and emotion components at the $p < .05$ level. Crucially, the prediction of emotion ratings by the latent BMRQ construct was significant with a positive standardized coefficient, $b = .035$, 95% *CI* .006- .064, $Z = 2.38$ ($p = .018$), but the latent MPIA was not a significant contributor to the emotions in the model, $b = -.009$, 95% *CI* -0.036-0.018, $Z = -.65$ ($p =.515$) (for a visual summary, see Figure 3).

After we added gender and musical expertise to the regression equation in our model, the results showed that neither gender, $b =.139$, Z = 1.195 ($p = .232$), nor musical expertise, $b = .076$, Z = .598 ($p = .550$), were statistically significant in the prediction of emotion evaluation for pleasant excerpts.

[INSERT FIGURE 3 ABOUT HERE]

Discussion

In the present study we investigated the influence of individual differences in music reward sensitivity on the perception of emotions in music. Additionally, we explored how other variables such as gender, musicianship, and music discrimination skills –variables that modulate the music reward sensitivity– could have an influence over the perception of emotions represented by music. As hypothesized, our results showed a positive relationship between music reward sensitivity and different aspects of the perception of emotions in music. Higher overall BMRQ scores in music reward were associated with higher ratings in hedonic valence (dimensional model) and happiness (discrete model) for pleasant excerpts. These results suggest that participants who obtained greater pleasure from music and music-associated activities also seemed to rate pleasant excerpts included in the FMSS with higher values in pleasantness and happiness. These data extend previous findings demonstrating that music reward sensitivity influences the evaluation of emotion in music (Martinez-Molina et al., 2016), and indicates that this effect is particularly important for pleasant excerpts. These results also suggest that the FMSS might be sensitive to those underlying mechanisms associated with individual differences in music reward sensitivity. As previous research has demonstrated that BMRQ scores are sensitive to neurobiological differences in areas related to emotion and reward (Hernández et al., 2019), our findings open up the possibility of using the FMSS in studies exploring the neurobiological and psychosocial bases of music emotion.

In line with previous findings (Hernández et al., 2019; Mas-Herrero et al., 2013), our results showed that music reward sensitivity can be influenced by other individual factors such as gender, musicianship, and music discrimination skills. Specifically, our findings reveal that women scored higher both on overall music reward (total BMRQ) and the Emotional Evocation and Sensory-Motor subscales. Also, supporting previous findings (Hernandez et al., 2019; Mas-Herrero et al., 2013), our data reveal a positive association between musical expertise and BMRQ and between music discrimination skills and BMRQ. Individual variations in connectivity between auditory and reward networks have been linked to differences in reward sensitivity, with increased connectivity being associated with a greater response to music (Hernandez et al., 2019; Salimpoor et al., 2013; Shany et al., 2019). Interestingly, Loui et al. (2017) proposed that lower volume and increased myelination or coherence between certain regions of these networks could be associated with musical anhedonia. Based on a parsimonious hypothesis linking expertise, music discrimination skills, and music reward it could therefore be postulated that extensive music learning promotes neural changes that enhance music discrimination skills, and in turn reward sensitivity. While further research is needed to better understand the role of music expertise in music reward and its association with music discrimination skills, current data have failed to support the postulated association (Belfi et al., 2017; Gosselin et al., 2015). Hernandez et al. (2019) showed that pitch discrimination skills and striatal volume contributed separately towards explaining individual differences in engaging in pleasure-related activities associated with music, measured using the BMRQ. The findings of some previous research have also suggested that both pitch discrimination and auditory cortex anatomy are, to a large extent, genetically determined (Drayna et al., 2001), suggesting that musicians are somehow predisposed to music before training.

Taken together, our findings suggest that individual differences in music reward sensitivity have a significant influence on the perception of emotions in music, specifically on the evaluation of positive emotions. Additionally, music reward was modulated by gender, music expertise, and music discrimination. To this extent, multiple regression analysis and structural equation modelling helped us understand that the contribution of gender and music training to BMRQ variability does not translate into a direct and linear effect on subjective music evaluation (FMSS). In this regard, it is important to mention that music reward, as a construct, includes components that involve emotion, motivation, psychomotor, and social processes. In the case of gender, our data suggest that it is important to consider the hedonic valence of the excerpts. Gender might not be key to explaining the overall effect of BMRQ on FMSS evaluation of music associated with positive affect, but it would seem influential when evaluating unpleasant excerpts. Apart from valence ratings, this effect of gender on unpleasant excerpts was also seen in energy arousal evaluation. The current findings reveal that women subjectively rated unpleasant excerpts with higher energy and fear scores, whereas men rated those same excerpts with higher values for valence, happiness, and tenderness, and also rated neutral excerpts with higher values of happiness and tenderness. These results replicate previous findings on gender differences using other stimuli modalities such as affective pictures (Bradley et al., 2001; Carretié et al., 2019), and emotional facial expressions (Duesenberg et al., 2016), in which women rated the unpleasant material as more unpleasant and arousing, in comparison to men, suggesting a possible bias towards the negative pole in women (Bradley et al., 2001). It has been suggested that this bias contributes to the development and maintenance of affective disorders such as anxiety and depression, which are more prevalent in women (Nolen-Hoeksema & Aldao, 2011).

The influence of music training and discrimination skills on FMSS evaluation was also found to be complex. Musicianship did not influence general FMSS evaluation, and MPIA scores did not contribute towards explaining the evaluation of pleasant excerpts. However, MPIA did influence ratings of unpleasant (tension arousal and happiness) and neutral excerpts (fear, happiness and tenderness). Participants with higher MPIA scores considered unpleasant excerpts to be more tense and evaluated neutral excerpts as less happy and tender. These results suggest that people with higher music perception abilities could identify emotional aspects of unpleasant or neutral excerpts with a level of analysis that would differentiate them from individuals with more limited discrimination skills. Previous findings have demonstrated that people with amusia present deficits in emotional recognition in music, possibly due to their difficulties in differentiating between major and minor musical modes (Gosselin, et al., 2015; Lévêque et al., 2018). At least for the pleasant excerpts included in the FMSS this hypothesis is challenged by our data, as musicianship (a variable that generally does affect MPIA scores) did not seem to influence the affective ratings of film music excerpts from this stimulus set. Further research will be needed to better understand the role of music expertise and music discrimination skills in music-associated reward and emotion perception. It is important to mention that the MPIA test was created as a screening tool to identify clinical signs of amusia such as poor pitch perception (Vuvan et al., 2018). In the present study, the MPIA test was originally used to exclude eight potential cases of amusia, but the authors also wished to investigate whether MPIA scores were informative of reward sensitivity or self-reported properties of the FMSS. A relationship between music reward (BMRQ) and music discrimination skills has been previously investigated using other music discrimination tests such as the Jake Mandell tone-deaf test (Hernández et al., 2019). The fact that in the present study a positive association between MPIA and BMRQ scores was found, in line with the results obtained by Hernandez et al. (2019), indicates that this instrument is indeed sensitive to music discrimination skills beyond the identification of amusia. This, however, does not mean that these instruments overlap with Jake-Mandell test measures, although some other recent tests such as the Profile of Music Perception Skills (Law & Zentner, 2012), the Musical Ear Test (Wallentin et al., 2010), and the Mistuning Perception Test (Larrouy-Maestri et al., 2019) may be better tools for capturing variability in music discrimination skills.

In summary, linked to our *a priori* hypotheses, it is important to mention that the structural equation model explored here, which included a central latent variable focusing on positive affect and pleasant excerpts, was supported statistically significantly by BMRQ scores but was not directly influenced by gender or music skills. This result indicates that music reward was the main factor influencing the subjective ratings for the excerpts from the FMSS and suggests that gender and music skills can influence certain constructs that, although measured by the BMRQ, might not be closely associated with positive valence and affect. By contrast, gender had an important influence on subjective ratings linked to unpleasant music excerpts, and music discrimination seemed to be associated with an enhancement of cognitive analysis of music, rather than with the emotional architecture of pleasant music excerpts *per se*.

It is also worth noting that there were some limitations to our study that might have influenced the results, besides the use of the MPIA as a music sensitivity tool. While our study was well-powered, this investigation used an imbalanced sample with respect to gender and musicianship, which could have affected the results, although it should be emphasized that this limitation was, to some extent, controlled in the statistical analysis. This imbalance is often observed in studies focused on music and emotions (Ferreri & Rodriguez-Fornells, 2017; Klepzig et al., 2020). The relevance of our findings and those of others will increase with support and replication from future studies using carefully balanced samples, especially regarding gender and musicianship.

Conclusions

The present study evaluated the role of individual differences in the perception of emotions in music and reward. Vuoskoski & Eerola (2011a) showed that the FMSS can be a robust and reliable tool to investigate mood and personality in the perception of emotions represented by music. Here we extended this line of research to music reward, defined as pleasure in music and music-associated activities, including at the same time other individual variables that have been related to music reward sensitivity such as gender, musicianship, and music discrimination skills. Music reward was a key predictor of FMSS evaluation, especially for pleasant music excerpts. Our data also support the need to consider gender and personality differences in future neuroimaging, psychophysiological, and behavioural studies of music-evoked emotion. These results might have clinical implications with regard to music education and training, and are also relevant to therapeutic interventions, particularly for those disorders in which emotion reactivity plays an important role such as anxiety, depression, or even dementia (Ihara et al., 2018; Steward et al., 2019).

References

Anderson, S., & Kraus, N. (2011). Neural encoding of speech and music: Implications for hearing speech in noise. *Seminars in Hearing*, *32*(2), 129-141. https://doi.org.10.1055/s-0031-1277234

Belfi, A. M., Evans, E., Heskje, J., Bruss, J., Tranel, D. (2017). Musical anhedonia after focal brain damage. *Neuropsychologia*, *97*, 29-37. https://doi.org.10.1016/j.neuropsychologia.2017.01.030

Bradley, M. M., Codispoti, M., Sabatinelli, D., & Lang, P. J. (2001). Emotion and motivation II: sex differences in picture processing. *Emotion*, *1*(3), 300-319. https://doi.org.10.1037/1528-3542.1.3.300

Brody, L. R., & Hall, J. A. (2008). Gender and emotion in context. In M. Lewis, J. M. Haviland-Jones, & L. F. Barrett (Eds.), *Handbook of emotions* (pp. 395-408). The Guilford Press.

Carretié, L., Tapia, M., López-Martín, S., & Albert, J. (2019). EmoMadrid: An emotional pictures database for affect research. *Motivation and Emotion*, *43*(6), 929-939. https://doi.org.10.1007/s11031-019-09780-y

Cheung, V. K. M., Harrison, P. M. C., Meyer, L., Pearce, M. T., Haynes, J-D., & Koelsch, S. (2019). Uncertainty and surprise jointly predict musical pleasure and amygdala, hippocampus, and auditory cortex activity. *Current Biology*, *29*(23), 1-9. https://doi.org.10.1016/j.cub.2019.09.067

Drayna, D., Manichaikul, A., de Lange, M., Snieder, H., & Spector, T. (2001). Genetic correlates of musical pitch recognition in humans. *Science*, *291*(5510), 1969-1972. https://doi.org.10.1126/science.291.5510.1969

Duesenberg, M., Weber, J., Schulze, L., Schaeuffele, C., Roepke, S., Hellmann-Regen, J., Otte, C., & Wingenfeld, K. (2016). Does cortisol modulate emotion recognition and empathy? *Psychoneuroendocrinology*, *66*, 221-227. https://doi.org.10.1016/10.1016/j.psyneuen.2016.01.011

Eerola, T., & Vuoskoski, J. K. (2011). A comparison of the discrete and dimensional models of emotion in music. *Psychology of Music*, *39*(1), 18-49. https://doi.org.10.1177/0305735610362821

Faul, F., Erdfelder, E., Lang, A-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175-191. https://doi.org.10.3758/bf03193146

Ferreri, L., & Rodriguez-Fornells, A. (2017). Music-related reward responses predict episodic memory performance. *Experimental Brain Research*, *235*(12), 3721-3731. https://doi.org.10.1007/s00221-017-5095-0

Ferreri, L., Mas-Herrero, E., Zatorre, R.J., Ripollés, P., Gomez-Andres, A., Alicart, H., Olivé, G., Marco-Pallarés, J., Antonijoan, R. M., Valle, M., Riba, J., & Rodríguez-Fornells. (2019). Dopamine modulates the reward experiences elicited by music. *PNAS*, *116*(9), 3793-3798. https://doi.org.10.1073/pnas.1811878116

Fuentes-Sánchez, N., Pastor, R., Eerola, T., & Pastor, M. C. (2020). Standardization of a film music stimulus set (FMSS) to the spanish population: Cultural and gender differences in the perception of emotions prompted by music excerpts. *Psychology of Music*. Pre-published October, 8, 2020. https://doi.org.10.1177/0305735620958464

Gabrielsson, A. (2001-2002). Emotion perceived and emotion felt: Same or different? *Musicae Scientiae, Spec Issue, 2001-2002*, 123-147. https://doi.org/10.1177/10298649020050S105

Gosselin, N., Paquette, S., & Peretz, I. (2015). Sensitivity to musical emotions in congenital amusia. *Cortex*, *71*, 171-182. https://doi.org.10.1016/j.cortex.2015.06.022

Haber, S. N., & Knutson, B. (2010). The reward circuit: Linking primate anatomy and human imaging. *Neuropsychopharmacology*, *35*(1), 4-26.

Hernández, M., Palomar-García, M-A., Nohales-Nieto, B., Olcina-Sempere, G., Villar-Rodríguez, E., Pastor, R., Ávila, C., & Parcet, M-A. (2019). Separate contribution of striatum volume and pitch discrimination to individual differences in music reward. *Psychological Science*, *30*(9), 1352–1361. https://doi.org.10.1177/0956797619859339

Ihara, E. S., Tompkins, C. J., Inoue, M., & Sonneman, S. (2018). Results from a person-centered music intervention for individuals living with dementia. *Geriatrics & Gerontology International*, *19*(1), 30-34. https://doi.org.10.1111/ggi.13563

Imbir, K., & Golab, M. (2017). Affective reactions to music: Norms for 120 excerpts of modern and classical music. *Psychology of Music*, *45*(3), 432-449. https://doi.org.10.1177/0305735616671587

Klepzig, K., Horn, U., Köning, J., Holtz, K., Wendt, J., Hamm, A. O., & Lotze, M. (2020). Brain imaging of chill reactions to pleasant and unpleasant sounds. *Behavioural Brain Research*, *380*, 112417. https://doi.org.10.1016/j.bbr.2019.112417

Larrouy-Maestri, P., Harrison, P. M. C., & Müllensiefen, D. (2019). The mistuning perception test: A new measurement instrument. *Behavior Research Methods*, *51*, 663-675. https://doi.org.10.3758/s13428-019-01225-1

Law, L. N. C., & Zentner, M. (2012). Assessing musical abilities objectively: Construction and validation of the profile of music perception skills. *Plos One*, *7*(12): e52508. https://doi.org.10.1371/journal.pone.0052508

Lepping, R. J., Atchley, R. A., & Savage, C. R. (2016). Development of a validated emotionally provocative musical stimulus set for research. *Psychology of Music*, *44*(5), 1012-1028. https://doi.org.10.1177/0305735615604509

Lévêque, Y., Teyssier, P., Bouchet, P., Bigand, E., Caclin, A., & Tillmann, B. (2018). Musical emotions in congenital amusia: Impaired recognition, but preserved emotional intensity. *Neuropsychology*, *32*(7), 880-894. https://doi.org.10.1037/neu0000461

Loui, P., Patterson, S., Sachs, M. E., Leung, Y., Zeng, T., & Przysinda, E. (2017). White matter correlates of musical anhedonia: Implications for evolution of music. *Frontiers in Psychology*, *8*: 1664. https://doi.org.10.3389/fpsyg.2017.01664

Martinez-Molina, N., Mas-Herrero, E., Rodríguez-Fornells, A., Zatorre, R. J., & Marco-Pallarés, J. (2019). White matter microstructure reflects individual differences in music reward sensitivity. *Journal of Neuroscience*, *39*(25), 5018-5027. https://doi.org/10.1523/JNEUROSCI.2020-18.2019

Martínez-Molina, N., Mas-Herrero, E., Rodríguez-Fornells, A., Zatorre, R. J., & Marco-Pallarés, J. (2016). Neural correlates of specific musical anhedonia. *PNAS*, *113*(46), E7337-E7345. https://doi.org.10.1073/pnas.1611211113

Mas-Herrero, E., Dagher, A., & Zatorre, R. J. (2018). Modulating music reward sensitivity up and down with transcranial magnetic stimulation. *Nature human behaviour*, *2*(1), 27-32. https://doi.org.10.1038/s41562-017-0241-z

Mas-Herrero, E., Marco-Pallarés, J., Lorenzo-Seva, U., Zatorre, R. J., & Rodríguez-Fornells, A. (2013). Individual differences in music reward experiences. *Music Perception*, *31*(2), 118-138. https://doi.org.10.1525/mp.2013.31.2.118

Mas-Herrero, E., Zatorre, R. J., Rodríguez-Fornells, A., & Marco-Pallarés, J. (2014). Dissociation between musical and monetary reward responses in specific musical anhedonia. *Current Biology*, *24*(6), 699-704. https://doi.org.10.1016/j.cub.2014.01.068

MacCallum, R. C., & Austin, J. T. (2000). Applications of structural equation modeling in psychological research. *Annual Review of Psychology, 51,* 201 226. https://doi.org/10.1146/annurev.psych.51.1.201

Nater, U. M., Abbruzzese, E., Krebs, M., & Ehlert, U. (2006). Sex differences in emotional and psychophysiological responses to musical stimuli. *International Journal of Psychophysiology*, *62*(2), 300-308. https://doi.org/10.1016/j.ijpsycho.2006.05.011

Nolen-Hoeksema, S., & Aldao, A. (2011). Gender and age differences in emotion regulation strategies and their relationship to depressive symptoms. *Personality and Individual Differences*, *51*(6), 704-8. https://doi.org.10.1016/j.paid.2011.06.012

Palomar-García, M-A., Zatorre, R. J., Ventura-Campos, N., Bueichekú, E., & Ávila, C. (2017). Modulation of functional connectivity in auditory-motor networks in musicians compared with nonmusicians. *Cerebral Cortex*, *27*(5), 2768-2778. https://doi.org.10.1093/cercor/bhw120

Rosseel, Y. (2012). Iavaan: An R package for structural equation modeling. *Journal of Statistical Software*, *48*(2), 1-36. https://doi.org.10.18637/jss.v048.i02

Rubin, M. (2021). When to adjust alpha during multiple testing: A consideration of disjunction, conjunction, and individual testing. *Synthese.* https://doi.org.10.22541/au.162569018.85105015/v1

Salimpoor, V. N., van den Bosch, I., Kovacevic, N., McIntosh, A. R., Dagher, A., & Zatorre, R. J. (2013). Interactions between the nucleus accumbens and auditory cortices predict music reward value. *Science*, *340*(6129), 216-219. https://doi.org.10.1126/science.1231059

Shany, O., Singer, N., Gold, B. P., Jacoby, N., Tarrasch, R., Hendler, T., & Granot, R. (2019). Surprise-related activation in the nucleus accumbens interacts with music-induced pleasantness. *Social Cognitive and Affective Neuroscience*, *14*(4), 459–470. https://doi.org.10.1093/scan/nsz019

Song, Y., Dixon, S., Pearce, M., & Halpern, A.R. (2016). Perceived and induced emotion responses to popular music: Categorical and dimensional models. *Music Perception*, *33*(4), 472-492. https://doi.org.10.1525/mp.2016.33.4.472

Stewart, J., Garrido, S., Hense, C., & McFerran, K. (2019). Music use for mood regulation: Self-awareness and conscious listening choices in young people with tendencies to depression. *Frontiers in Psychology*, *10*: 1199. https://doi.org.10.3389/fpsyg.2019.01199

Vieillard, S., Peretz, I., Gosselin, N., Khalfa, S., Gagnon, L., & Bouchard, B. (2008). Happy, sad, scary and peaceful musical excerpts for research on emotions. *Cognition and Emotion*, *22*(4), 720-752. https://doi.org.10.1080/02699930701503567

Vuoskoski, J. K., & Eerola, T. (2011a). The role of mood and personality in the perception of emotions represented by music. *Cortex*, *47*(9), 1099-1106. https://doi.org.10.1016/j.cortex.2011.04.011

Vuoskoski, J. K. & Eerola, T. (2011b). Measuring music-induced emotion: A comparison of emotion models, personality biases, and intensity of experiences. *Musicae Scientiae*, *15*(2), 159-173. https://doi.org/10.1177/1029864911403367

Vuvan, D. T., Paquette, S., Goulet, G. M., Royal, I., Felezeu, M., & Peretz, I. (2018). The montreal protocol for identification of amusia. *Behavior Research Methods*, *50*(2), 662-672. https://doi.org.10.3758/s13428-017-0892-8

Wallentin, M., Nielsen, A. H., Friis-Olivarius, M., Vuust, C., & Vuust, P. (2010). The Musical ear test, a new reliable test for measuring musical competence. *Learning and Individual Differences*, *20*(3), 188-196. https://doi.org.10.1016/j.lindif.2010.02.004

Zatorre, R. J., & Zatorre, V. N. (2013). From perception to pleasure: Music and its neural substrates. *PNAS*, *110*(Supplement 2), 10430-10437. https://doi.org/10.1073/pnas.1301228110

Tables

Table 1. Pearson's correlations between BMRQ with affective dimensions and discrete emotions as a function of the hedonic valence of excerpts

		BMRQ					
		Overall	Musical Seeking	Emotional Evocation	Mood Regulation	Sensory-Motor	Social
Affective Dimensions	**Valence**						
	Pleasant	.26**	.09	.17	.20*	.22*	.20*
	Neutral	.11	.10	.05	-.006	.13	.08
	Unpleasant	.11	.15	.10	-.05	.04	.15
	Energy Arousal						
	Pleasant	.15	.16	.08	-.02	.18*	.13
	Neutral	-.04	.05	-.05	-.12	-.02	.06
	Unpleasant	.08	.13	-.03	.03	.12	.02
	Tension Arousal						
	Pleasant	.02	.04	.09	-.13	.004	.06
	Neutral	-.11	-.05	-.08	-.12	-.14	.07
	Unpleasant	.15	.14	.07	.07	.13	.08
Discrete Emotions	**Happiness**						
	Pleasant	.19*	.17	.08	.10	.16	.16
	Neutral	.04	.16	-.04	-.12	.05	.07
	Unpleasant	-.03	.09	-.03	-.11	-.04	-.004
	Anger						
	Pleasant	-.05	.16	-.09	-.10	-.05	-.06
	Neutral	.14	.18*	.06	.08	.10	.10
	Unpleasant	.19*	.18*	.10	.12	.12	.16
	Fear						
	Pleasant	-.08	.05	-.16	-.04	-.13	.08
	Neutral	.15	.07	.06	.18	.11	.16
	Unpleasant	.10	.02	.02	.19*	.13	.01
	Tenderness						
	Pleasant	.18	.17	.14	.04	.07	.20*
	Neutral	.04	.09	.13	-.12	-.10	.14
	Unpleasant	-.11	.009	-.02	-.18	-.17	-.007
	Sadness						
	Pleasant	-.002	.08	-.005	-.03	-.01	-.04
	Neutral	.03	.06	.06	-.001	-.04	.03
	Unpleasant	.26	.12	.06	-.07	-.06	.08

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Table 2. Means (*M*), standard deviations (SD) and confidence intervals (CI) for the overall sample, as well as for men and women, plus *t*-test comparisons and effect sizes (*d*)

	Global (n = 121)				**Men (n = 35)**				**Women (n = 86)**					
			95% CI				95% CI				95% CI			
	M	SD	lower	upper	*M*	SD	lower	upper	*M*	SD	lower	upper	*t*	*d*
BMRQ														
Music Reward (overall)	54.54	8.04	53.09	55.98	51.46	8.37	48.58	54.33	55.79	7.60	51.16	57.42	2.76**	.54
Musical Seeking	53.08	9.32	51.41	54.76	53.11	10.37	49.55	56.68	53.07	8.92	51.16	54.98	< 1	.004
Emotional Evocation	53.88	8.07	52.43	55.34	51.54	7.68	48.91	54.18	54.84	8.08	53.11	56.57	2.06*	.42
Mood Regulation	52.44	6.81	51.21	53.66	51.03	7.60	48.42	53.64	53.01	6.42	51.64	54.39	1.46	.28
Sensory-Motor	52.54	8.59	50.99	54.08	46.31	9.95	42.90	49.73	55.07	6.50	53.68	56.47	4.81***	1.04
Social	53.93	8.46	52.41	55.46	54.29	7.75	51.62	56.95	53.79	8.78	51.81	55.67	<1	.06

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Table 3. Means (*M*), standard deviations (SD), and confidence intervals (CI) both for musicians and non-musicians, plus *t*-test comparisons and effect sizes (*d*)

	Musicians (n =25)				**Non-musicians (n = 96)**					
			95% CI				95% CI			
	M	SD	lower	upper	*M*	SD	lower	upper	*t*	*d*
BMRQ										
Music Reward (overall)	58.28	6.82	55.47	61.09	53.56	8.08	51.92	55.20	2.68**	.63
Musical Seeking	56.72	8.57	53.18	60.26	52.14	9.32	50.25	54.02	2.23*	.51
Emotional Evocation	55.84	8.44	52.35	59.33	53.34	7.94	51.77	54.98	1.37	.31
Mood Regulation	53.80	4.92	51.77	55.83	52.08	7.20	50.62	53.54	1.40	.28
Sensory-Motor	53.24	7.36	50.20	56.28	52.35	8.91	50.55	54.16	< 1	.11
Social	60.64	6.81	57.83	63.46	52.19	7.99	50.57	53.81	4.85***	1.14

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Table 4. Pairwise correlations between BMRQ and MPIA

	Music Reward (overall)	Musical Seeking	Emotional Evocation	Mood Regulation	Sensory-Motor	Social	Music Discrimination Skills (overall)	Scale Test	Off-Beat test
BMRQ									
Music Reward (overall)									
Musical Seeking	.71***								
Emotional Evocation	.72***	.28**							
Mood Regulation	.64***	.37***	.34***						
Sensory-Motor	.67***	.35***	.38***	.25**					
Social	.66***	.49***	.40***	.26**	.26**				
MPIA									
Music Discrimination Skills (overall)	.24***	.18*	.10	.08	.06	.36***			
Scale Test	.16	.07	.05	.02	.12	.34***	.77***		
Off-Beat test	.02	.06	.04	-.05	-.09	.16	.63***	.25**	
Out-of-Key	.26**	.24**	.14	.16	.08	.30***	.78***	.43***	.24**

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Table 5. Multiple regression analysis for affective dimensions and discrete emotions; adjusted R^2 for each model and the Beta coefficient (β) for each independent variable

		Model (Adjusted R^2)	Gender (β)	Musicianship (β)	BMRQ (β)	MPIA (β)
Affective Dimensions	**Valence**					
	Pleasant	.042	.07	.04	.22*	.05
	Neutral	.000	-.13	-.08	.15	.02
	Unpleasant	.066*	-.30**	-.09	.21*	-.05
	Energy Arousal					
	Pleasant	-.001	.09	-.03	.12	.07
	Neutral	-.025	.06	.01	-.07	.08
	Unpleasant	.030	.23*	-.08	.05	.01
	Tension Arousal					
	Pleasant	-.011	.04	.04	.03	-.15
	Neutral	-.012	.05	.06	-.15	.06
	Unpleasant	.045	.16	-.04	.07	.21*
Discrete Emotions	**Happiness**					
	Pleasant	.030	.06	.07	.19	-.14
	Neutral	.073*	-.19*	-.02	.15	-.30**
	Unpleasant	.040	-.19*	-.05	.08	-.22*
	Anger					
	Pleasant	-.009	-.12	-.002	.01	-.12
	Neutral	-.006	.09	.02	.10	.05
	Unpleasant	.045	.17	.07	.01	.13
	Fear					
	Pleasant	-.002	-.11	.08	-.08	.05
	Neutral	.042	.11	.04	.07	.21*
	Unpleasant	.066*	.27**	.02	-.01	.18
	Tenderness					
	Pleasant	.035	-.13	.05	.23*	-.17
	Neutral	.073*	-.27**	.09	.14	-.24*
	Unpleasant	.033	-.22*	.02	-.03	-.13
	Sadness					
	Pleasant	-.030	.03	-.04	-.01	.06
	Neutral	-.006	.04	.04	-.03	.16
	Unpleasant	-.008	-.10	-.002	.03	.11

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Note: Gender was coded as 0 for women and 1 for men; Musicianship was coded as 0 for non-musicians and 1 for musicians.

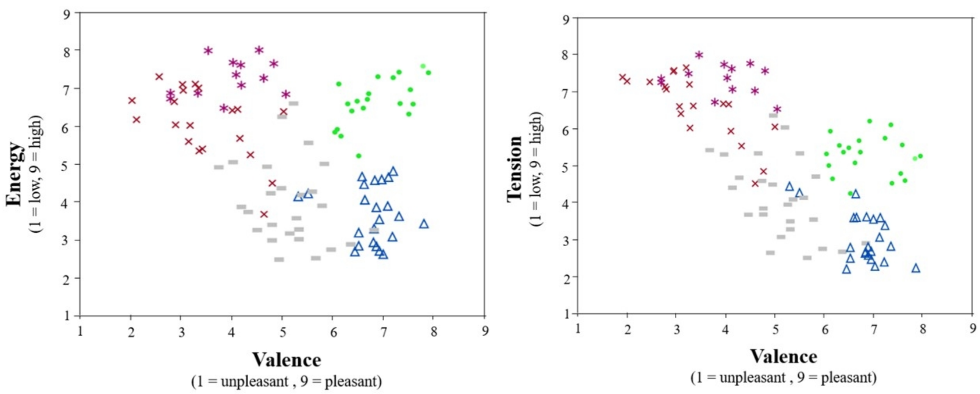
Figure captions

Figure 1. Plot of excerpts selected from the *Film Music Stimulus Set* (Eerola & Vuoskoski, 2011; Fuentes-Sánchez et al., 2020) on the basis of mean valence (x-axis) and energy arousal (y-axis) ratings. Each point represents a musical excerpt. Each shape represents the discrete emotion that characterizes each musical excerpt. Green points represent happiness excerpts; grey stripes represent sad excerpts; blue triangles represent tenderness excerpts; red crosses represent fearful excerpts; pink stars represent anger excerpts. Regarding discrete emotions, the dataset contains 20 happy excerpts, 23 tender excerpts, 13 anger, 20 fear, and 26 sadness. The figure also makes it possible to distinguish the excerpts rated as low or high energy/tension arousal.

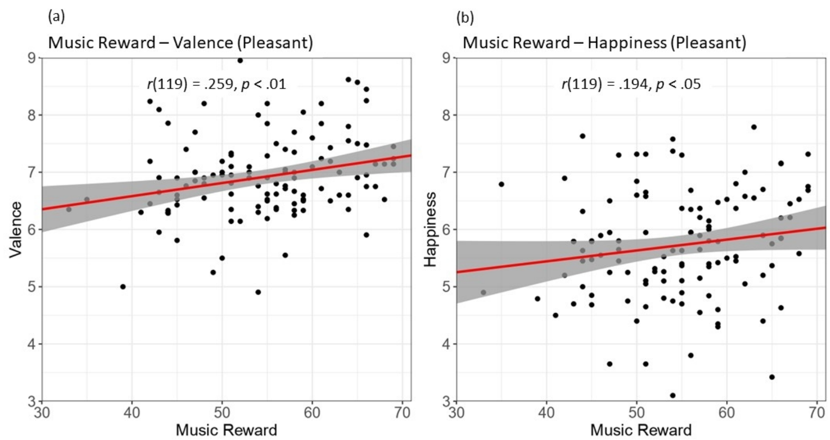
Figure 2. Linear regressions between (a) Music Reward and Valence ratings of pleasant excerpts, (b) Music Reward and Happiness ratings of pleasant excerpts.

Figure 3. Structural equation model pathways and standardised beta coefficients for predicting Valence and Happiness ratings of pleasant excerpts with two latent constructs (BMRQ and MPIA).

Figure 1

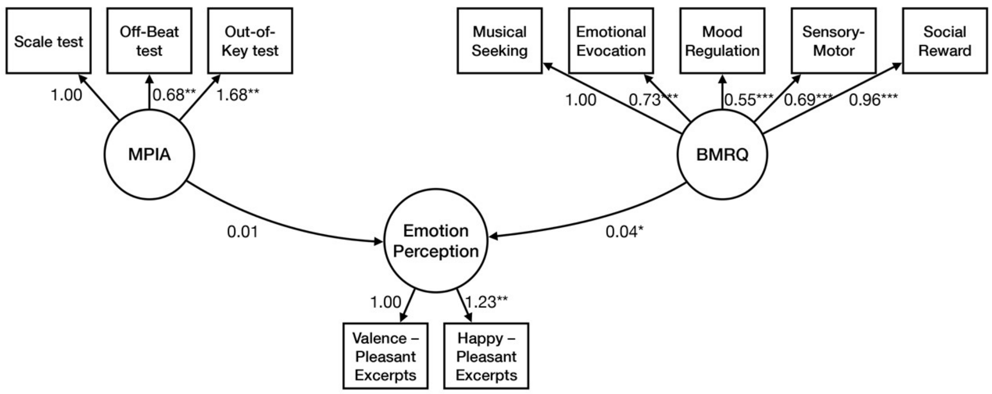


338x190mm (96 x 96 DPI)



338x190mm (96 x 96 DPI)

Figure 3



338x190mm (96 x 96 DPI)