The role of gender in emotional reactions elicited by music: Autonomic reactivity, facial expression, and self-reports

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Abstract

Studies in the field of emotions have yielded mixed findings regarding differences between women's and men's emotional reactivity. In the majority, emotional scenes, facial expressions, and movies were used as stimuli. However, music has been less frequently used, despite its capacity to evoke strong emotional responses in the listeners. In this study, we aimed to explore the role of gender in emotional reactivity to music. A sample of 110 healthy participants (60 women) listened to 42 excerpts (14 pleasant, 14 neutral, 14 unpleasant) from the Film Music Stimulus Set for 8 s, while their autonomic reactivity and facial expression were continuously recorded. Participants then rated each excerpt on affective dimensions (hedonic valence, tension arousal, and energy arousal), discrete emotions (happiness, anger, fear, tenderness, and sadness), musical preference, and familiarity. Some differences were found between women's and men's reactivity to the stimuli, such that women showed a greater deceleration of heart rate while listening to both emotional (pleasant and unpleasant) and neutral music, and rated unpleasant excerpts as less preferred. Women also scored higher on trait anxiety compared to men. These results suggest that women may have heightened sensitivity to emotional stimuli, particularly unpleasant music, which could have implications for better understanding clinical pathologies that vary in prevalence based on gender.

Keywords: Emotion, Soundtracks, HR, EDA, Corrugator, Affective ratings

Anxiety and depressive disorders are among the most common mental health conditions worldwide (GBD 2019 Diseases and Injuries Collaborators, 2020), with a higher prevalence in women compared to men, even during adolescence (Chaplin et al., 2005; Zahn-Waxler et al., 2008). It is well-established that both disorders are closely related to emotional dysregulation (Davidson, 2000; Gray et al., 2021), underscoring the importance of investigating gender differences in emotional reactivity.

Research on emotional processing and gender indicates that women tend to experience emotions more intensely, are more skilled in using non-verbal emotion-related cues, and are more expressive than men (Brody & Hall, 2008). Those differences are evident both in children (Chaplin & Aldao, 2013) and adults (Else-Quest et al., 2012). In relation to specific discrete emotions, women are stereotypically associated with shame, sadness, fear, and guilt, while men are more commonly associated with anger and other hostile emotions (Hess et al., 2000; Plant et al., 2006).

Nevertheless, the results of empirical research on this topic are mixed. In studies evaluating the experiential component of emotion using subjective ratings or questionnaires, women rated themselves as more expressive, with higher levels of trait anxiety, and reported themselves to be more likely than men to know other people's emotions (Abbruzzese et al., 2019; Brody & Hall, 2008; McLean & Anderson, 2009). Furthermore, they reported experiencing positive emotions such as joy, love, and feelings of well-being more frequently or intensely (Brody & Hall, 2008, Fischer & Manstead, 2000), as well as negative emotions such as disgust, sadness, fear, and anxiety (Hess et al., 2000). In one study, women rated unpleasant pictures as more arousing and unpleasant in comparison to men, whereas men evaluated pleasant pictures as more arousing and pleasant (Bradley et al., 2001a). In other studies, however, no differences were found between men's and women's subjective evaluations of emotions prompted by pictures (McManis et al., 2001), faces (Wild et al., 2011), movies (Carvalho et al., 2012) or music (Lundqvist et al., 2009). With regard to the expressive component of emotion, it has been found that women smile more than men when viewing pleasant pictures and frown more when viewing unpleasant scenes (Bradley et al., 2001a; Huang & Hu, 2009). Yet in a study of music-evoked emotions (Lundqvist et al., 2009) there were no differences between men's and women's facial expressions, measured by corrugator and zygomatic amplitude. This suggests that differences may or may not be found, depending on the type of stimulus to which research participants are exposed. Finally, there are inconsistencies in the results of studies measuring peripheral physiology. In some, women were more reactive than men to negative stimuli, with greater heart rate (HR) deceleration and enhanced electrodermal activity (EDA) (Bradley et al., 2001a; Nater et al., 2006); in others, no such differences were found (Codispoti et al., 2008; Kring & Gordon, 1998; Lundqvist et al., 2009). Indeed, Chaplin et al. (2008) reported that men are more reactive than women, with higher levels of blood pressure and cortical responses to arousing stressors.

Overall, the inconsistency of the findings may stem from important methodological differences among the studies. First, most research to date has investigated gender differences using emotional stimuli such as scenes, facial expressions, or movies, with few studies exploring music, despite its emotional potency (Baumgartner et al., 2006; Fuentes-Sánchez et al., 2021a). Second, researchers have used different criteria for selecting stimuli. Some have selected emotional stimuli representing discrete emotions such as happiness or sadness (Lundqvist et al., 2009), while others have selected them according to affective dimensions such as unpleasant/pleasant or calming/arousing without considering specific emotions (Bradley et al., 2001a). However, to the best of our knowledge, few previous studies investigating the role of gender in emotional processing have used both types of stimuli, even though the discrete and dimensional approaches are complementary and provide more specific information. The Film Music Stimulus Set (FMSS) (Eerola & Vuoskoski, 2011), recently standardized for the Spanish population (Fuentes-Sánchez et al., 2021a) has an advantage over other databases in that it includes music stimuli representing the normative values of both discrete emotions and affective dimensions. Finally, only a few studies have measured different correlates of emotion within the same experimental protocol. Since emotion is a complex phenomenon producing responses at three different levels – experiential, expressive, and neurophysiological (Lang, 2010)–, the most informative studies are those evaluating the correlates of at least two components of emotion using physiological measures of both hedonic valence (e.g., corrugator, startle reflex) and arousal (e.g., EDA, pupil dilation) (Fuentes-Sánchez et al., 2021b).

In the present study, we investigated gender differences in emotional responses elicited by film music soundtracks. To address the methodological issues detailed above, we used standardized excerpts selected from the FMSS (Fuentes-Sánchez et al., 2021a). Specifically, we explored differences between women's and men's autonomic reactivity (HR and EDA); facial expressions (corrugator activity); subjective ratings of both discrete emotions (happiness, anger, fear, tenderness, and sadness) and affective dimensions (hedonic valence, energy, and tension); music preferences; and music familiarity. Also, given that emotional dysregulation has been shown to be related to anxiety and negative affect (Gray et al., 2021), we examined differences between women's and men's trait anxiety and positive/negative affect, using two questionnaires. We expected that women would react more strongly than men to unpleasant music (Bradley et al., 2001a; Nater et al., 2006). Specifically, we predicted that unpleasant music would prompt enhanced EDA responses, greater HR deceleration, and increased corrugator activity. Similarly, we predicted that women would rate unpleasant excerpts as more arousing and unpleasant, rate them higher for fear and anger, and rate them as less preferred. In contrast, we did not expect to find differences between women's and men's emotional responses to neutral or pleasant music, since Bradley et al. (2001a) found that men are more reactive to erotic scenes but not other categories of pleasant material. In addition, based on prior research, we anticipated that women would score higher than men on trait-anxiety, as well as on positive and negative affect (Hess et al., 2000).

Method

Participants

The sample size was determined by an a priori statistical power analysis using G*Power (Faul et al., 2007). Following Roy et al. (2008) and Lundqvist et al. (2009), we considered an f^2 = .25 with an alpha of .05, a power value of .95, two groups (women and men), and three measurements (unpleasant, neutral, and pleasant music). The analysis produced a minimum sample size of 44 participants per group, but we took the conservative measure of planning a larger sample. Consequently, the final sample comprised a total of 110 participants (60 women) from [Corresponding author's institution], between 18 and 41 years of age (*M* = 22.15, *SD* = 3.98). They were recruited via advertisements distributed to a range of university faculties. Volunteers who wanted to participate contacted our laboratory via email, and were subsequently interviewed by telephone and screened by researchers according to the inclusion/exclusion criteria before arranging the appointment to participate in the experiment. The planned sample targeted healthy adults aged 18 to 50, with no history of mental disorder, no current pharmacological treatment, and no hearing, visual, auditory or cardiovascular impairments. Ethical approval was obtained from the Deontological Commission at [Corresponding author's institution], and the study was conducted in accordance with the Declaration of Helsinki. All participants provided written informed consent and were compensated with 5€ for their participation.

Stimuli and design

A total of 42 musical excerpts (14 unpleasant, 14 pleasant and 14 neutral)[1] were selected from the Film Music Stimulus Set (FMSS: Eerola & Vuoskoski, 2011) based on the Spanish normative values for affective hedonic valence and energy arousal (Fuentes-Sánchez et al., 2021b).[2] The mean normative values for the selected excerpts are shown in Table 1. Musical excerpts were distributed into seven blocks with six excerpts in each one (2 unpleasant, 2 neutral, and 2 pleasant). Additionally, two musical excerpts were presented at the beginning of the experimental task as practice trials but were not included in the statistical analyses.

"INSERT TABLE 1 ABOUT HERE"

Each trial began with a cross (+) presented at the center of a black screen for 1 s. Next, a musical excerpt was presented for 8 s. Following this, participants reported their affective responses on various affective dimensions (hedonic valence, energy arousal, and tension arousal), and discrete emotions (happiness, anger, fear, tenderness, and sadness) using a 9-point scale. Afterward, they evaluated the musical preference and familiarity. Finally, each trial ended with an inter-stimulus interval (ITI), which varied randomly between 8 and 10 s (see Figure 1).

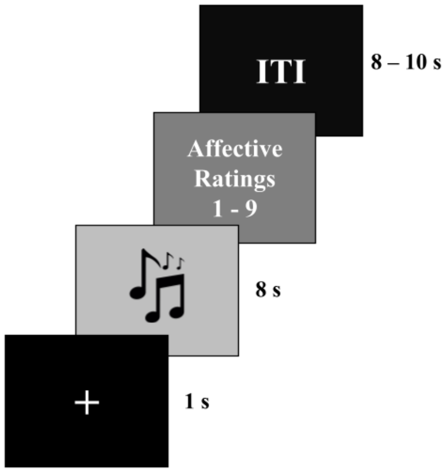

Figure 1. Trial structure of the experimental task

Measures

Subjective ratings

Participants rated each excerpt along three affective dimensions (hedonic valence, energy arousal, and tension arousal) and for five discrete emotions (happiness, anger, fear, tenderness, and sadness) using 9-point Likert-type scales from 1 (minimum) to 9 (maximum). For hedonic valence, the adjectives used for the extremes of the scale were *pleasant–unpleasant*, *good–bad*, and *positive–negative*. For the energy-arousal dimension, the adjectives were *awake–sleepy*, *wakeful–tired*, and *alert–drowsy*. Finally, for the tension-arousal dimension, the adjectives were *tense–relaxed*, *clutched up–calm*, and *jittery–at rest.*[3] Following Fuentes-Sánchez et al. (2022), participants also evaluated excerpts for preference (i.e., how much they liked the music) using a 9-point Likert-type scale from 1 (*not at all*) to 9 (*a lot*) and familiarity using a 3-point scale (0 = *unfamiliar*, 1 = *somewhat familiar*, 2 = *very familiar*).

Trait Anxiety Questionnaire

The Trait Anxiety Questionnaire (STAI-T; Spielberger et al., 1970; Buela-Casal et. al., 1995 [Spanish Version]) consists of 20 items designated to assess trait anxiety, including both cognitive and somatic components of anxiety as a general personality trait. Responses were given on a 4-point Likert-type scale (1 = *not at all*; 2 = *somewhat*; 3 = *quite a lot*; 4 = *very much*). Internal consistency coefficients range from .65 to .75 in its original version, and around .90 in the Spanish version.

Positive and Negative Affect Scale

The Positive and Negative Affect Schedule (PANAS; Watson et al., 1988; López-Gómez et. al., 2015 [Spanish version]) consists of 20 items, each rated on a 5-point Likert-type scale (1 = *very slightly or not at all*; 2 = *a little*; 3 = *moderately*; 5 = *quite a lot*; 5 = *very much*). Internal consistency coefficients range from .86 to .90 for the positive affect scale, and .84 and .87 for the negative affect scale in the original version; and from .83 to .92 for the positive affect scale, and .81 and .88 for the negative affect scale in the Spanish version.

Psychophysiological data acquisition and reduction

All raw psychophysiological signals were recorded using a Biopac MP36 four-channel data acquisition and analysis system (Inc., Goleta, CA, USA). Acqknowledge 4.2 software was used to collect, rectify, integrate, and smooth the physiological data.

EDA was recorded through a Biopac SS57LA transductor with disposable snap electrodes that was placed on the hypothenar eminence of the left palm. Electrodes were attached 10 minutes before beginning the experiment to ensure the stability of the recording. Prior to testing, the hand was gently cleaned using a tissue with distilled water. The signal was calibrated for each participant before the experiment began and was continuously recorded using a sampling rate of 1000 Hz and low pass filters (LP: 66.5 Hz, Q = 0.5 and LP: 38.5 Hz, Q = 1). For each trial, the peak response was scored as the maximum EDA value within a 1–6 s time window following the onset of the music excerpt, and amplitude was computed as the maximum electrodermal change score with respect to a baseline of 1 s prior to the music excerpt onset. Logarithms of raw scores (log (SCR +1)) were calculated to normalize the data.

The electrocardiogram was recorded at lead II using Ag/AgCl electrodes with electrolyte paste, using a band-pass filter of 0.5–35 Hz and a sampling rate of 1000 Hz. HR was obtained online from the ECG, which measured the time interval between consecutive R waves (cardiac period). R-wave detection and artifact correction were performed prior to statistical analyses, for which different parameters were calculated based on the visual inspection of HR waveforms and prior research (e.g., Fuentes-Sánchez et al., 2021b). More specifically, HR waveform scores were computed by determining, for each participant and each trial, the maximum deceleration within the first 3 s of music listening, the maximum acceleration from 3 to 5.5 s of music presentation, and the maximum deceleration from 5.5s to the end of the trial. Change scores were calculated as the difference from baseline (1 s prior to the onset of the excerpt), following Fuentes-Sánchez et al. (2019) and Pastor et al. (2008).

Facial EMG activity was recorded from corrugator supercilii muscle, placed directly over the left eye, with two Ag/AgCl electrodes (4mm diameter). The EMG was continuously sampled at 1000 Hz and filtered online with a high pass (30 Hz) and a low pass (500 Hz). The signal was integrated and rectified online using rectify integration with a time constant of 500 ms. For analysis purposes, corrugator was averaged over the 8-s music presentation interval, and change scores were calculated from a 1-s baseline period before the onset of the excerpt.

For EDA amplitude, HR minimum and maximum, and averaged corrugator activity, statistical analyses were conducted using the average values from the trials within each condition (unpleasant, neutral, pleasant) for each participant.

Procedure

Each participant completed a single laboratory session lasting approximately one hour. Upon arrival at the laboratory, participants first read an overview of the task, provided written informed consent, and completed a survey to collect socio-demographic information along with two questionnaires (STAI-T and PANAS). This initial phase took approximately 15 minutes and allowed participants to acclimate to the laboratory environment. Next, they were given instructions and undertook two practice trials to ensure they understood the procedure. Participants were seated in an armchair in a dimly lit room, and sensors were attached to them. They were instructed to listen attentively to a series of musical excerpts, each lasting 8 s, and were asked to rate each excerpt on three affective dimensions, five discrete emotions, as well as their preference for and familiarity with each excerpt. This training phase lasted around 10 minutes. Following the practice trials, participants performed the experimental task, which took approximately 30 minutes. Finally, the sensors were removed, and participants were debriefed.

Data analyses

First, repeated-measures analyses of variance (ANOVA) were carried out to investigate gender differences in emotional processing, with music category (unpleasant, neutral, and pleasant) as the within-subject factor, and gender (women, men) as the between-subject factor. The dependent variables were the measures of peripheral physiology (EDA amplitude, maximum and minimum HR change score, and averaged corrugator activity), and mean values for subjective ratings (affective dimensions, discrete emotions, musical preference and familiarity). Post-hoc comparisons using Bonferroni corrections were performed for the comparisons among the three categories. Second, *t*-tests were conducted to explore differences between women's and men's trait anxiety and positive and negative affect. The Greenhouse-Geisser correction was applied in cases where the assumption of sphericity was violated. Effect sizes were represented by partial eta squared (η^2_p) and Cohen's *d*. Statistical analyses were carried out using SPSS IBM Statistics version 27, and G*Power.

Results

Peripheral physiology

ANOVA revealed a significant main effect of music category for EDA amplitude, $F(2, 108) = 22.819$ ($p < .001$, $\eta^2_p = .174$), HR change scores in all three time intervals, $F(2, 108) = 3.636$ ($p = .028$, $\eta^2_p = .033$ for the 0–3 s interval); $F(2, 108) = 18.058$ ($p < .001$, $\eta^2_p = .143$ for the 3–5.5 s interval) and $F(2, 108) = 11.083$ ($p < .001$, $\eta^2_p = .093$ for the 5.5–8 s interval), and for averaged EMG corrugator, $F(2, 108) = 8.107$ ($p < .001$, $\eta^2_p = .070$). According to our predictions, post-hoc pairwise comparisons showed that pleasant music prompted enhanced EDA, greater HR acceleration for the 3–5.5-s interval, less HR deceleration during the 5.5–8-s time interval, and lower corrugator activity, as compared to both unpleasant music (corrected $p < .001$, corrected $p < .001$, corrected $p < .001$, corrected $p = .004$, respectively), and neutral music (corrected $p < .001$ for EDA; corrected $p = .002$ for HR maximum score).

A significant main effect of gender was found for HR minimum change scores, for both the 0–3 s and 5.5–8 s time intervals, $F(1, 108) = 10.221$ ($p < .002$, $\eta^2_p = .086$) and $F(1, 108) = 22.346$ ($p < .001$, $\eta^2_p = .171$), respectively) (see Figure 2).

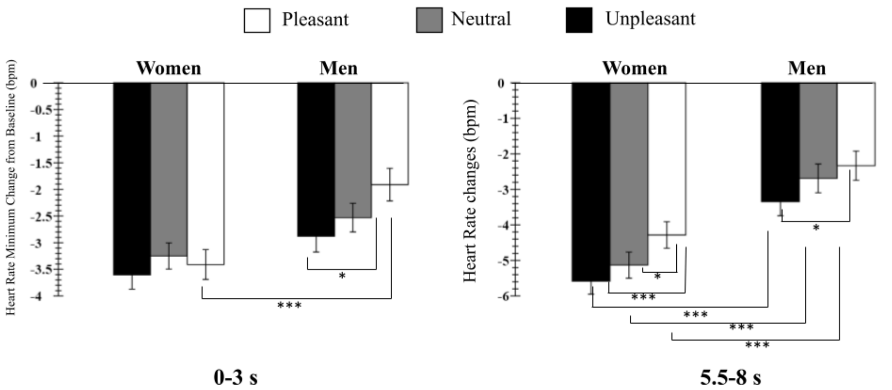

Figure 2. Heart rate changes (bmp) for the first deceleration period (left) and for the second deceleration period (right). Note: * *p* < .05; ** *p* < .01; *** *p* < .001

No significant main effect of gender was found, however, for EDA amplitude, $F(1, 108) = 1.918$ ($p = .169$, $\eta^2_p = .017$), HR maximum cardiac acceleration in the 5.5–8 s time interval, $F(1, 108) = 1.869$ ($p < .174$, $\eta^2_p = .017$), nor for averaged EMG corrugator, $F(1, 108) = .276$ ($p = .600$, $\eta^2_p = .003$).

Contrary to our predictions, no significant interactions were found between music category and gender for any of the variables. Specifically, no significant effects were observed for EDA amplitude, $F < 1$, any of the HR maximum and minimum change scores across the three time intervals, $F(2, 216) = 2.149$ ($p = .119$, $\eta^2_p = .020$ for the 0–3 s interval), $F < 1$ for the maximum 3–5.5 s, and $F < 1$ for the 5.5–8 s interval, nor for averaged EMG corrugator activity, $F(1, 216) = 1.212$ ($p =.273$, $\eta^2_p = .011$).

Subjective ratings

Affective dimensions

ANOVA revealed a significant effect of the music category on ratings for hedonic valence, $F(2, 108) = 735.278$ ($p < .001$, $\eta^2_p = .872$), energy arousal, $F(2, 108) = 528.285$ ($p < .001$, $\eta^2_p = .830$), and tension arousal, $F(2, 108) = 241.384$ ($p < .001$, $\eta^2_p = .691$). Specifically, pleasant music was rated as more positive and energetic compared to neutral (corrected *ps* < .001), and unpleasant music (corrected *ps* < .001). Furthermore, unpleasant music was rated as more tense than both neutral and pleasant music (corrected *ps* < .001) (see Table 2).

INSERT TABLE 2 ABOUT HERE

No significant main effect of gender was found on ratings along the affective dimensions of hedonic valence, energy arousal or tension arousal, *F*s < 1. Additionally, no significant interactions between music category and gender were observed for any measure, $F < 1$ for hedonic valence and energy arousal, and $F(2, 216) = 1.112$ ($p = .331$, $\eta^2_p = .010$) for tension arousal.

Discrete emotions

ANOVA revealed significant main effects of music category on ratings for all the emotions: happiness, $F(2, 108) = 1614.610$ ($p < .001$, $\eta^2_p = .937$), anger; $F(2, 108) = 417.199$ ($p < .001$, $\eta^2_p = .794$), fear, $F(2, 108) = 1073.199$ ($p < .001$, $\eta^2_p = .909$), tenderness, $F(2, 108) = 195.219$ ($p < .001$, $\eta^2_p = .644$), and sadness, $F(2, 108) = 500.498$ ($p < .001$, $\eta^2_p = .823$). Specifically, pleasant music was rated happier than unpleasant (corrected *ps* < .001) and neutral music (corrected *p* < .001). Pleasant music was also rated as more tender than unpleasant (corrected *p* < .001) but not neutral music (*p* > .05). Unpleasant music was rated angrier and more fearful than neutral (corrected *ps* < .001) and pleasant music (corrected *ps* < .001). Finally, neutral music was evaluated as more sad than pleasant and unpleasant music (corrected *ps* < .001) (see Table 2). No significant main effect of gender was observed for any of the emotions [$F < 1$ for happiness, anger, fear, and sadness and $F(1, 108) = 1.224$ ($p = .271$; $\eta^2_p = .011$ for tenderness), nor were there any significant interactions between music category and gender, all $Fs < 1$.

Musical preference and familiarity

ANOVA revealed a significant main effect of music category for musical preference, $F(2, 108) = 222.519$ ($p < .001$, $\eta^2_p = .673$), and familiarity, $F(2, 216) = 113.090$ ($p < .001$, $\eta^2_p = .512$). Post-hoc analyses showed that pleasant music was rated as more preferred and familiar than unpleasant (corrected $ps < .001$) and neutral music (corrected $ps < .001$), but no significant main effect of gender was found for preference, $F(1, 108) = 1.129$ ($p = .290$, $\eta^2_p = .010$) or familiarity, $F(1, 108) = 1.444$ ($p = .232$, $\eta^2_p = .013$). There was, however, a significant main interaction between music category and gender for preference, $F(2, 216) = 3.221$ ($p = .029$, $\eta^2_p = .032$), but not familiarity, $F(2, 216) = 1.444$ ($p = .232$, $\eta^2_p = .013$). Post-hoc comparisons showed that women rated unpleasant music as less preferred than men, according to our predictions (corrected $p = .036$) (see Table 2).

Questionnaires

T-tests revealed significant differences between women's and men's trait anxiety, $t(109) = –2.375$ ($p = .009$, $d = .456$) such that, as predicted, women scored higher than men on the STAI-T (see Table 3). Their scores were not significantly different, however, for positive or negative affect, $t(109) = 1.818$ ($p > .05$, $d = .346$) and $t < 1$, respectively.

INSERT TABLE 3 ABOUT HERE

Discussion

In this study we aimed to investigate the effect of gender on music-evoked emotions. We therefore measured participants' autonomic reactivity (EDA and HR) and facial EMG (corrugator) while they were listening to pleasant, neutral, and unpleasant musical excerpts selected from the FMSS dataset (Eerola & Vuoskoski, 2011; Fuentes-Sánchez et al., 2021a), and analyzed their self-reports.

Our findings revealed some differences between women's and men's responses to the stimuli, which varied depending on the specific measurements. In terms of autonomic and facial EMG activity, we found that pleasant music elicited enhanced EDA, greater HR acceleration, and lower corrugator amplitude in comparison to neutral and unpleasant music. This suggests that the excerpts successfully evoked pleasant and unpleasant emotions in the listeners (Fuentes-Sánchez et al., 2021a), confirming previous findings from studies on emotion induction in laboratory settings (Codispoti et al., 2008; Lundqvist et al., 2009). Importantly, there were no significant differences between women and men in EDA and corrugator reactivity, regardless of whether they were listening to pleasant, unpleasant, or neutral music.

However, in line with previous research using different types of affective stimulus (Bianchin & Angrilli, 2012; Bradley et al., 2001a; Fernández et al., 2012), women exhibited greater HR deceleration while listening to pleasant music during the first deceleration period, and across all categories of music during the second deceleration period. Enhanced HR deceleration has traditionally been explained as an indicator of increased orientation to motivationally relevant stimuli (Bradley et al., 2001a). Women's increased orientation to emotion-eliciting, particularly unpleasant music, may reflect greater activation of the defensive system (Bradley et al., 2001a; Lang et al., 1997). This tendency to attend to and detect unpleasant emotional stimuli might underlie the greater likelihood of women to develop attentional negativity biases, which are linked to emotional pathologies (Koster et al., 2009; Lichtenstein-Vidne et al., 2017).

We found few differences between women's and men's subjective ratings of the excerpts. All the participants rated pleasant music as more pleasant, energetic, happy, and tender than unpleasant music, which in turn was rated more tense, angry, and fearful. This finding does not align with our prediction, which was based on previous studies of emotion induction that observed gender differences (Bianchin & Angrilli, 2012; Bradley et al., 2001a; Codispoti et al., 2008), specifically in relation to discrete emotions (Deng et al., 2016; Nolan & Ryan, 2000), such that women rated non-music stimuli as more arousing, unpleasant, and fearful when they elicited fear, horror, and disgust. An important difference between these studies and ours, however, was that our stimuli consisted of music excerpts, which could explain the divergence between their findings and ours. After all, previous researchers who used music as stimuli reported that women and men rated them in similar ways for both emotional arousal (Nater et al., 2006) and specific discrete emotions (Lundqvist et al., 2009).

We also found no differences between women and men's familiarity with the stimuli, which may have lessened the impact of factors such as participants' associations between the music and memories of past events on the results. Despite the unfamiliarity of music to participants, it was still capable of inducing powerful emotions, as noted by Fuentes-Sánchez et al. (2022). However, differences emerged in musical preferences, with women rating unpleasant music as less preferred compared to men. Musical preference is often linked to the hedonic valence of the stimulus (Fuentes-Sánchez et al., 2022). It may be possible that women's and men's ratings of hedonic valence did not differ because both groups viewed this as an objective judgment (*what the music expresses*), while their ratings of musical preference differed because they saw it as a subjective judgment (*how much I like the music*).

If so, women may have had a stronger emotional reaction to the music than men but responded similarly to men when assessing the emotions expressed by the music.

Finally, our findings are consistent with previous studies (Burton & Nkwo, 2022; McLean et al., 2011), confirming that women scored higher for trait anxiety than men. Indeed, anxiety disorders are reported to be between 1.5 and 2 times more common among women (McLean et al., 2011). The higher prevalence of depressive as well as anxiety disorders is thought to be a consequence of problems in affective processing and emotion regulation. In our study we found that women's HR deceleration was greater than men's, which we interpret as increased orientation to emotional stimuli. Given that women preferred the unpleasant excerpts less than men, we wonder if women and men respond to affective stimuli in different ways. Yet such responses are part of a basic and broader psychological process that encompasses not only emotional reactions to affective stimuli but also the regulation of these emotions. Previous research has shown some differences between women's and men's use of emotion regulation strategies, which could be related to the development and maintenance of some disorders (Nolen-Hoeksema & Aldao, 2011). It would be worth investigating this further, particularly in relation to gender differences in the use of particular emotion-regulation strategies such as cognitive reappraisal (Fuentes-Sánchez et al., 2019), using music to induce emotions, or even as a regulatory strategy itself.

Some limitations of the study and directions for future research should be noted. First, we did not account for women's menstrual cycles, despite the known effects of estrogen and progesterone on emotional states (Li et al., 2022). Additionally, we did not assess participants' depression levels, which could influence how music is perceived (Dan et al., 2019; Falkenberg et al., 2012). Including a screening instrument such as the Beck Depression Inventory could have allowed us to exclude participants with depressive disorder or subclinical symptoms (Lasa et al., 2000). While anxiety has been related to high levels of negative emotion and high physical arousal, depression is associated with high levels of negative emotion and low levels of positive emotion and physical arousal (see Anderson & Hope, 2008 for a review). Although we aimed to recruit healthy individuals to participate in this study, further research could explore the effects of menstruation, anxiety and depression on music-evoked emotions.

Second, we did not assess participants' general musical preferences. Our stimuli were limited to standardized film music excerpts from the FMSS for the laboratory task. While we measured preference for each musical excerpt, following Fuentes-Sánchez et al. (2022) and Iwanaga (1999), we did not include stimuli from other genres such as jazz, pop, and classical music. As a result, we were unable to evaluate the potential impact of preference for these genres.

Third, we did not consider participants' views on gender-role stereotypes or inquire about their gender identity. Future research should address these issues, as gender-related display rules have been shown to influence emotional processing (Brody & Hall, 2008; Chaplin, 2015). For instance, in Western cultures, women are often expected to express emotions such as happiness, fear, anxiety, and guilt in line with traditional gender roles and stereotypes. Understanding participants' perspectives on these topics could provide valuable insights into our findings. Additionally, exploring gender differences in cross-cultural contexts would be beneficial for a more comprehensive understanding of emotional processing.

Fourth, we confined ourselves to the use of scales, particularly for measuring responses along the affective dimensions, that had been used in previous research (Eerola & Vuoskoski, 2011; Fuentes-Sánchez et al., 2020). In future studies, other scales, such as the

Self-Assessment Manikin (SAM; Bradley & Lang, 1994), which does not rely on language, could be considered.

Fifth, future studies should integrate both discrete and dimensional models of emotions to provide a more comprehensive understanding of emotion processing (Fuentes-Sánchez et al., 2021a) and facilitate more meaningful comparisons across studies. Finally, future research should include standardized musical excerpts that evoke a broader range of discrete emotions, such as tenderness or sadness, as these emotions have been highlighted as significant in previous research (Bradley et al., 2001a; Deng et al., 2016).

In summary, our study's findings align with previous research demonstrating the effectiveness of music in inducing strong pleasant and unpleasant emotions. We also found that gender plays a role in emotional processing, suggested by HR changes that indicate women have an increased orientation to emotional music. Additionally, women rated unpleasant music as less preferred. This heightened sensitivity to emotional stimuli, particularly unpleasant music, might be related to women's higher trait anxiety scores, as observed in both our study and previous research (e.g., McLean & Anderson, 2009; El-Zahhar & Hocevar, 1991). Understanding the mechanisms underlying gender differences in emotional responses to music could inform the development of targeted interventions for clinical pathologies with different prevalence based on gender.

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TABLES

Table 1. Normative values: mean values and standard deviations (*SDs*) for affective ratings in each music category for the overall sample and each gender separately.

	Global			**Men**			**Women**		
	Unpleasant	*Neutral*	*Pleasant*	*Unpleasant*	*Neutral*	*Pleasant*	*Unpleasant*	*Neutral*	*Pleasant*
Valence	2.86 (0.45)	5.02 (0.56)	7.01 (0.64)	3.17 (0.53)	5.40 (0.53)	6.90 (0.56)	2.75 (0.44)	4.88 (0.65)	7.05 (0.68)
Energy arousal	6.71 (0.61)	3.17 (0.48)	6.87 (0.52)	6.43 (0.64)	3.01 (0.36)	6.60 (0.55)	6.82 (0.64)	3.23 (0.61)	6.97 (0.53)
Tension arousal	7.45 (0.44)	3.46 (0.73)	5.36 (0.57)	7.42 (0.48)	3.39 (0.59)	5.05 (0.88)	7.46 (0.44)	3.50 (0.85)	5.47 (0.50)

Table 2. Means (*SDs*) and confidence intervals (*CI*) for the peripheral physiology measures and subjective ratings for each music category and each gender separately.

	Women								
	Unpleasant			Neutral			Pleasant		
		95% CI			95% CI			95% CI	
	M (SD)	Lower	Upper	M (SD)	Lower	Upper	M (SD)	Lower	Upper
Peripheral physiology									
EDA	0.02 (0.59)	.01	.04	.01 (.03)	-1.45×10^{-4})	0.02	0.04 (0.09)	0.02	0.06
HR deceleration (0.5–3)	-3.60 (1.97)	-4.11	-3.09	-3.25 (1.72)	-3.69	-2.81	-3.41 (2.31)	-4.01	-2.82
HR acceleration (3–5.5)	2.01 (2.80)	1.28	2.73	2.46 (2.86)	1.72	3.19	3.25 (2.78)	2.53	3.97
HR deceleration (5.5–8)	-5.58 (2.98)	-6.35	-4.82	-5.13 (2.67)	-5.82	-4.44	-4.28 (2.44)	-4.91	-3.65
Corrugator	2.07×10^{-4} (4.79×10^{-4})	8.27×10^{-5}	3.30×10^{-4}	4.32×10^{-5} (2.12×10^{-4})	-1.16×10^{-5}	9.82×10^{-5}	-1.82×10^{-5} (5.35×10^{-4})	-1.56×10^{-4}	1.19×10^{-4}
Subjective ratings									
Affective dimensions									
Valence	2.66 (0.81)	2.45	2.87	5.24 (1.09)	4.96	5.52	7.40 (0.74)	7.20	7.59
Energy arousal	6.61 (1.24)	6.29	6.93	3.68 (0.90)	3.44	3.91	7.47 (0.77)	7.27	7.67
Tension arousal	7.11 (1.17)	6.81	7.42	3.78 (0.95)	3.54	4.03	5.96 (1.39)	5.60	6.32
Discrete emotions									
Happiness	1.61 (0.62)	1.45	1.77	2.86 (0.99)	2.60	3.11	7.11 (0.84)	6.89	7.33
Anger	4.78 (1.50)	4.39	5.17	2.00 (0.91)	1.77	2.24	1.61 (0.64)	1.44	1.77
Fear	6.59 (1.28)	6.26	6.92	3.10 (1.15)	2.80	3.39	1.45 (0.58)	1.30	1.59
Tenderness	1.23 (0.33)	1.14	1.31	3.48 (1.38)	3.12	3.83	3.56 (1.44)	3.18	3.93
Sadness	2.90 (1.40)	2.54	3.26	5.40 (1.21)	5.09	5.71	1.48 (0.56)	1.33	1.62
Preference & Familiarity									
Preference	3.17 (1.42)	2.81	3.54	4.85 (1.49)	4.47	5.24	6.20 (1.16)	5.90	6.51
Familiarity	0.30 (0.28)	0.22	.37	0.40 (0.31)	0.32	0.48	0.67 (0.37)	0.57	0.77

	Men								
	Unpleasant			Neutral			Pleasant		
		95% CI			95% CI			95% CI	
	M (SD)	Lower	Upper	M (SD)	Lower	Upper	M (SD)	Lower	Upper
Peripheral physiology									
EDA	0.03 (0.05)	0.02	0.05	0.02 (0.04)	0.01	0.03	0.06 (0.07)	0.04	0.08
HR deceleration (0.5–3)	-2.88 (2.21)	-3.51	-2.25	-2.53 (2.12)	-3.14	-1.93	-1.92 (1.97)	-2.48	-1.36
HR acceleration (3–5.5)	2.44 (2.67)	1.68	3.20	3.12 (3.22)	2.21	4.03	4.18 (3.58)	3.16	5.20
HR deceleration (5.5–8)	-3.35 (2.61)	-4.09	-2.60	-2.69 (3.06)	-3.56	-1.82	-2.33 (3.37)	-3.29	-1.38
Corrugator	1.01×10^{-4} (4.39×10^{-4})	-2.34×10^{-5}	2.26×10^{-4}	5.71×10^{-4} (1.82×10^{-4})	5.25×10^{-5}	1.09×10^{-4}	-1.04×10^{-5} (1.82×10^{-4})	-6.22×10^{-5}	4.15×10^{-5}
Subjective ratings									
Affective dimensions									
Valence	2.91 (1.07)	2.60	3.21	5.28 (1.30)	4.91	5.65	7.46 (0.88)	7.21	7.71
Energy arousal	6.62 (1.53)	6.18	7.05	3.64 (1.01)	3.35	3.92	7.32 (0.77)	7.11	7.54
Tension arousal	7.33 (1.15)	7.01	7.66	3.73 (0.89)	3.47	3.98	5.71 (1.36)	5.32	6.10
Discrete emotions									
Happiness	1.64 (0.74)	1.43	1.85	2.88 (1.09)	2.57	3.19	7.18 (0.79)	6.96	7.40
Anger	4.5 (1.71)	4.01	4.99	1.88 (0.92)	1.62	2.14	1.59 (0.68)	1.40	1.78
Fear	6.64 (1.31)	6.27	7.12	3.34 (1.38)	2.95	3.74	1.40 (0.56)	1.25	1.56
Tenderness	1.27 (0.49)	1.13	1.41	3.69 (1.51)	3.26	4.12	3.85 (1.53)	3.42	4.29
Sadness	2.99 (1.45)	2.58	3.40	5.18 (1.57)	4.74	5.63	1.49 (0.50)	1.35	1.63
Preference & Familiarity									
Preference	3.81 (1.73)	3.32	4.30	4.97 (1.50)	4.54	5.40	6.19 (1.34)	5.81	6.57
Familiarity	0.41 (.33)	0.31	0.50	0.48 (0.33)	0.39	0.58	0.69 (0.39)	0.58	0.80

Table 3. Means (*SDs*) and confidence intervals (*CI*) for the questionnaires for women and men separately.

	Women			**Men**		
		95% CI			95% CI	
	M (SD)	Lower	Upper	*M (SD)*	Lower	Upper
Positive affect	33.7 (4.67)	32.49	34.91	35.22 (4.09)	34.06	36.38
Negative affect	21.93 (6.81)	20.17	23.69	21.3 (6.39)	19.48	23.12
Trait anxiety	22.75 (8.89)	20.45	25.05	18.46 (9.86)	15.66	21.26

Endnotes

1. We selected 14 excerpts per music category to ensure a minimum number of trials to analyze the physiological correlates accurately, based on previous studies (Bradley et al., 2001b; Fuentes-Sánchez et al., 2019; 2021b; Pastor et al., 2008).
2. Unpleasant and pleasant excerpts were rated below 4 and above 6 in hedonic valence, respectively, whereas all stimuli in both categories were rated above 6 in energy arousal. Neutral excerpts were rated between 4 and 6 in hedonic valence, and below 4 in energy arousal. The numbers of the excerpts used in this experiment were: Unpleasant (098, 124, 157, 168, 170, 177, 215, 218, 219, 230, 234, 306, 309, 313); Neutral (032, 037, 273, 274, 276, 278, 280, 283, 288, 292, 293, 294, 295, 360); Pleasant (001, 003, 004, 011, 020, 022, 188, 192, 204, 246, 250, 260, 263, 269, 029, 039). Excerpts 029 and 039 were used as practice trials.
3. The adjectives were presented in Spanish (see Fuentes-Sánchez et al., 2021b). The Spanish adjectives were as follows: for hedonic valence scale were *desagradable–agradable*, *malo–bueno*, *negativo–positivo*; for energy arousal were *adormilado–despierto*, *somnoliento–alerta*, *cansado–desvelado*; and for tension arousal were *relajado–excitado*, *calmado–en tensión*, *tranquilo–nervioso*. The adjectives were taken from the original study (Eerola & Vuoskoski, 2011).

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