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Musical preference but not familiarity influences subjective ratings and psychophysiological correlates of music-induced emotions

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ABSTRACT

Listening to music prompts strong emotional reactions in the listeners but relatively little research has focused on individual differences. This study addresses the role of musical preference and familiarity on emotions induced through music. A sample of 50 healthy participants (25 women) listened to 42 excerpts from the FMMS during 8 s while their autonomic and facial EMG responses were continuously recorded. Then, affective dimensions (hedonic valence, tension arousal, and energy arousal) and musical preference were rated using a 9-point scale, as well as familiarity using a 3-point scale. It was hypothesized that preferred and familiar music would be evaluated as more pleasant, energetic and less tense, and would prompt an increase of autonomic and zygomatic responses, and a decrease of corrugator activity. Results partially confirmed our hypothesis showing a strong effect of musical preference but not familiarity on emotion correlates. Specifically, musical preference predicted valence ratings, as well as HR acceleration and facial EMG activity. Overall, current findings suggested a great influence of musical preference on music-induced emotions, particularly modulating hedonic valence correlates. Our findings add evidence about the role of individual differences in the emotional processing through music and suggest the importance of considering those variables in future studies.

1. Introduction

Music is a powerful stimulus capable of conveying and inducing emotional reactions that can be measured at central and peripheral levels (Juslin & Västfjäll, 2008). Previous studies have shown that music listening activates brain regions involved in emotion and reward, such as the amygdala, striatum, orbitofrontal cortex, anterior cingulate cortex and the insula (Koelsch, Siebel, & Fritz, 2010), as well as other areas typically involved in the processing of information such as the auditory cortex (Koelsch, 2020). At a peripheral physiology level, music excerpts modulate autonomic correlates such as electrodermal activity (EDA) or Heart Rate (HR) (Bullack, Büdenbender, Roden, & Kreutz, 2018; Fuentes-Sánchez, Pastor, Escrig, Elipe-Miravet, & Pastor, 2021), as well as facial electromyographic (EMG) measures such as zygomatic or corrugator activity (Bullack et al., 2018; Roy, Mailhot, Gosselin, Paquette, & Peretz, 2009). Altogether, these results show that music is a powerful affective stimulus that can be used as a useful tool to investigate emotion processing in laboratory-controlled conditions. However, previous studies have also shown that emotion evocation through music can be affected by individual differences based on music reward sensitivity (Fuentes-Sánchez, Pastor, Eerola, & Pastor, 2021a), musical preference (Naser & Saha, 2021) or music familiarity (Pereira et al., 2011), which suggests the suitability to consider these factors in further experimental studies.

Musical preference refers to an individual's liking for a specific piece of music or genre of music (Schäfer & Sedlmeier, 2011). Prior research has suggested an influence of musical preference on subjective ratings, and brain and peripheral correlates of emotion (Aljanaki, Wiering, & Veltkamp, 2016; Schäfer & Sedlmeier, 2011). Previous findings indicate that preferred music is rated as more energetic (Hirokawa, 2004), less tense (Iwanaga & Moroki, 1999) and produces higher levels of relaxation, as well as lower levels of anxiety (Davis & Thaut, 1989; Thaut & Davis, 1993) in comparison to less preferred music. Listening to preferred music has also been linked to the activation of the default

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mode network and the hippocampus, regions involved in self-referential thought, empathy, self-awareness and memory (Wilkins, Hodges, Laurienti, Steen, & Burdette, 2014). Likewise, listening to preferred music (selected by the participants) has been associated with an increase in dopaminergic activity in the mesolimbic system, including the dorsal and ventral striatum (Salimpoor, Benovoy, Larcher, Dagher, & Zatorre, 2011). Previous studies (De Jong, van Mourik, & Schellekens, 1973; Lynar, Cvejic, Schubert, & Vollmer-Conna, 2017) have also demonstrated that HR, EDA and respiration rate are positively correlated with liking music ratings, as well as negatively with blood pressure (Davis & Thaut, 1989).

Music familiarity has also been reported as an important factor in modulating emotional responses to music (Pereira et al., 2011). Prior research has shown that familiar music activates different brain regions in comparison to unfamiliar music; listening to familiar music was associated with the activation of the reward system, the superior frontal gyri, the ventral lateral nucleus of the left thalamus and the left medial surface of the superior frontal gyrus (Castro et al., 2020; Freitas et al., 2018), areas typically involved in emotion, memory and movement. In contrast, unfamiliar music activated brain regions associated with the recognition of music or the novelty detection, such as the insular cortex, the anterior cingulate cortex or the cingulate gyrus (Freitas et al., 2018). Additionally, previous studies have demonstrated that familiarity influences subjective and autonomic responses to music. For example, familiar music was rated with higher scores in preference (or liking) and pleasure (McLachlan, Marco, & Wilson, 2013; Peretz, Gaudreau, & Bonnel, 1998; Schellenberg, Peretz, & Vieillard, 2008) and prompted higher EDA responses (van den Bosch, Salimpoor, & Zatorre, 2013).

In sum, a literature review suggests a clear relationship between musical preference, familiarity and emotion processing. Previous studies, however, have tended to not consider other variables that could potentially influence their results. Most past research have not control the effects of valence and arousal of the selected music excerpts (Iwanaga & Moroki, 1999; Naser & Saha, 2021), which seems very important since these affective properties play an important role on emotional responses (Witvliet & Vrana, 2007). Also, many previous studies have used music pieces selected by the participants (Blood & Zatorre, 2001; Thaut & Davis, 1993), which could certainly influence the results due to familiarity effects. Finally, most past empirical works in this field have mainly focused on subjective ratings or autonomic measures such as EDA or HR (Iwanaga & Moroki, 1999; Ladining & Schellenberg, 2012; van den Bosch et al., 2013) but they do not usually combine classical measures with additional peripheral correlates, such as facial EMG activity.

In order to improve the key methodological limitations found in the previous literature, the present study aimed to investigate the influence of *musical preference* and *familiarity* on the emotional responses prompted by music using the standardized music dataset Film Music Stimulus Set (FMSS; Eerola & Vuoskoski, 2011). The FMSS provides normative ratings in both affective dimensions –hedonic valence, energy and tension– and discrete emotions –happiness, sadness, tenderness, anger and fear–, which allows to select the stimulation attending to different affective properties. Recently, the FMSS has been adapted to the Spanish population, increasing its experimental validity (Fuentes-Sánchez, Pastor, Eerola, & Pastor, 2021b). In the present study, we investigated the effect of preference and familiarity on subjective ratings (valence, energy, tension) and peripheral physiology (EDA, HR, zygomatic, corrugator) during the listening of pleasant, unpleasant, and neutral music excerpts. Regarding the *subjective ratings*, we hypothesized to find higher valence and energy arousal ratings, as well as lower tension ratings for music excerpts rated as more preferred and familiar. Regarding the *peripheral measures*, enhanced responses in EDA, HR, and zygomatic EMG were expected for the most preferred and most familiar music excerpts. By contrast, greater corrugator EMG amplitude was expected to be exhibited during the less preferred and less familiar music excerpts.

2. Method

2.1. Participants

The sample comprised 50 undergraduate students (25 females) from Universitat Jaume I (Spain) between 18 and 41 years ($M = 22.58$, $SD = 4.35$). One participant was removed due to technical difficulties during data acquisition, specifically for the recording of zygomatic EMG activity. The data were originally collected as part of a prior study that intended to investigate emotional reactions prompted by brief music stimuli (Fuentes-Sánchez, Pastor, Escrig, Elipe-Miravet, Pastor, 2021c), but did not explore the specific effects of musical preference and familiarity on subjective and peripheral correlates of music-induced emotions. Ethical approval from the Deontological Commission at Universitat Jaume I was obtained, and the study was conducted in accordance with the Declaration of Helsinki.

2.2. Stimuli and design

42 musical excerpts (14 unpleasant, 14 pleasant and 14 neutral) were selected from the *Film Music Stimulus Set* (FMSS: Eerola & Vuoskoski, 2011), based on the Spanish normative values for affective valence and energy arousal (Fuentes-Sánchez, Pastor, Eerola, Pastor, 2021b)[1]. Music excerpts were distributed into seven blocks with six excerpts each one (2 unpleasant, 2 neutral, and 2 pleasant). Each film musical excerpt was presented during 8 s, with no more than two consecutive trials of the same emotional category. Then, participants rated the affective dimensions of valence, energy arousal, and tension arousal using a 9-point scale[2]. Each extreme of the scale was composed of three adjectives taken from Eerola and Vuoskoski (2011). For valence, the adjectives 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]. Afterward, participants rated the musical preference (i.e., how much they liked the music) using a 9-point scale (0 = *nothing*, 9 = *a lot*), followed by the music familiarity using a 3-point scale (0 = *unfamiliar*, 1 = *somewhat familiar*, 2 = *very familiar*). Finally, each trial ended with an inter-stimulus interval (ITI), varying randomly between 8 and 10s (see Fig. 1).

2.3. Psychophysiological data acquisition and reduction

Raw signals were recorded using a Biopac MP36 system. Acqknowledge 4.4 software was used for data acquisition, as well as for online rate calculation, rectification, integration, and smoothing of the

[1] 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. Excerpts numbers 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.

[2] Pleasant, neutral, and unpleasant excerpts were rated accordingly. A repeated measures ANOVA showed a significant main effect of the music type for hedonic valence, energy arousal and tension arousal, all $ps < 0.0001$, $\eta_p^2 = 0.89$, $\eta_p^2 = 0.82$, and $\eta_p^2 = 0.67$, respectively.

[3] The adjectives were translated from English to Spanish using a back translation (see Fuentes-Sánchez et al., 2021a). The Spanish adjectives were as follows: for 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".

Fig. 1. Trial structure of music listening task.

physiological data.

EDA was recorded through a Biopac SS57LA transductor with disposable snap electrodes, placed on the hypothenar eminence of the left palm. Electrodes were attached 10 min before beginning the experiment to ensure the stability of the recording. Previously, 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 to 6 s time window following music excerpt onset, and amplitude was computed as the maximum electrodermal change score with respect to a baseline of 1 s prior to the music excerpt onset applying Matlab version 22a subroutines. Logarithms of raw scores (log (SCR +1)) were calculated to normalize the data (Bradley, Codispoti, Cuthbert, & Lang, 2001).

Electrocardiogram was recorded at lead II using Ag/AgCl electrodes with electrolyte paste. A band-pass filter of 0.5–35 Hz and a sampling rate of 1000 Hz were used. HR was obtained online from the ECG, which measured the time interval between consecutive R waves (cardiac period). Based on the visual inspection of HR waveforms and prior research focused on emotion induction (see Bradley et al., 2001; Fuentes-Sánchez, Pastor, Escrig, et al., 2021), different HR parameters were calculated for statistical analyses purposes by applying subroutines elaborated with Matlab version 22a. More specifically, HR parameters 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 5.5 s to the end of the trial. In addition, change scores were calculated for each HR parameter as the difference from baseline (1 s prior to excerpt onset).

Facial EMG activity was recorded from corrugator supercilii and zygomaticus major muscle, placed directly over the left eye and the left cheek, respectively, with two Ag/AgCl electrodes (4 mm diameter). The EMG was continuously sampled at 1000 Hz, and filtered online with a high-pass (30 Hz) and low pass (500 Hz). The signal was integrated and rectified online using rectify integration with a time constant of 500 ms. For analysis purposes, facial EMG was averaged over the 8-s music presentation interval, and change scores were calculated from a 1-s baseline period before the excerpt onset using subroutines analyses elaborated with Matlab version 22a.

2.4. Procedure

Each participant enrolled in one laboratory session (1 h). Participants read an overview of the task and completed a written consent form followed by a survey to collect socio-demographic variables. Afterward, sensors were attached while participants reclined in a comfortable armchair and a training phase was carried out. Thus, participants were instructed that a series of musical excerpts would be presented, and they had to listen carefully the entire time that each music excerpt was presented. Then, the different scales (affective dimensions, musical preference, and familiarity) were explained to participants, and two examples were presented before the task began to ensure they understood the procedure. Thereupon, the main task started and lasted approximately 30 min.

2.5. Data analyses

Pairwise correlations and multiple regressions analyses were conducted with the aim of exploring the relationship between musical preference, familiarity and the subjective and objective emotion correlates measured in this study during listening to standardized music stimuli selected from FMSS. Regarding the multiple regressions, we carried out separate analyses for each dependent variable (subjective ratings for valence, energy and tension; physiological changes in EDA, HR, zygomatic and corrugator), with subjective evaluations for music preference and familiarity as independent variables. Bonferroni correction was applied for both analyses[4].

Statistical analyses were carried out using SPSS IBM Statistics version 26, and G*Power.

3. Results

Firstly, pairwise correlation analysis revealed a positive relationship between the ratings of musical preference and familiarity with both the subjective and objective correlates of emotion responses prompted by music excerpts. Particularly, scores in *musical preference* were significantly associated with subjective ratings of valence, as well as with HR acceleration, zygomatic and corrugator activity, being all positive associations except for the negative relationship with corrugator activity (see Table 1). As regards subjective evaluation for *music familiarity*, a significant positive correlation was found with valence ratings, as well as with facial EMG reactivity (see Table 1). Additionally, pairwise correlations showed a significant positive relationship between musical preference and familiarity, $r(40) = 0.71$, $p < .0001$.

Secondly, to explore the combined contributions of musical preference and familiarity, multiple regressions were performed. Regarding *affective ratings* of the FMSS excerpts, analyses showed that the global model was significant for predicting valence and tension, being the musical preference the most important predictor for both variables (see Table 2).

With regard to *peripheral physiology*, the global model was significant to predict HR acceleration, as well as zygomatic and corrugator activity (see Fig. 2). Interestingly, for those psychophysiological measures, scores in musical preference were also the most important predictor ($p < .001$ for HR acceleration, $p = .02$ for zygomatic, and $p = .002$ for corrugator).

[4] Further analyses were performed to explore gender differences. ANOVAs revealed a lack of statistical significance for main effects or interactions, which could be explained by the small sample size. For EDA responses, analyses revealed a significant main effect of music type ($p < .0001$), but no significant effects neither for gender ($p = .07$) nor interaction of gender with music type ($F < 1$). For HR acceleration a main effect of music type ($p = .0009$) and gender ($p = .03$) was found, but not significant interaction of gender with music type ($F < 1$). In the same vein, a main effect was found for both corrugator and zygomatic EMG activity, $p = .0004$ and $p < .0001$, respectively. However, there was no significant main effect for gender ($F < 1$) nor interaction of gender with music type ($F < 1$) for both EMG measures.

Table 1
Pairwise correlations between musical preference, music familiarity, subjective ratings, and peripheral correlates of emotion reactions prompted by music excerpts.*,**,***

	Subjective Ratings			Peripheral Physiology					
	Hedonic Valence	Energy	Tension	EDA	HR			Zygomatic	Corrugator
					Deceleration (0.5–3)	Acceleration (3–5.5)	Deceleration (5.5–8)		
Preference	0.95***	0.19	−0.37	0.31	0.24	0.49***	0.21	0.61***	−0.64***
Familiarity	0.67***	0.37	−0.01	0.26	0.03	0.17	0.15	0.58***	−0.50***

Bonferroni corrections were applied ($p = .05 / 18 = 0.0027$).
* $p < .05$.
** $p < .01$.
*** $p < .001$.

Table 2
Multiple regression analysis for subjective ratings and peripheral physiology; adjusted R^2 the general model and the Beta coefficient (β) for each independent variable (musical preference and familiarity).

	Subjective Ratings			Peripheral Physiology					
	Valence	Energy	Tension	EDA	HR deceleration (0.5–3)	HR acceleration (3–5.5)	HR deceleration (5.5–8)	Zygomatic	Corrugator
Model (Adjusted R^2)	0.90***	0.11	0.23**	0.06	0.10	0.27***	−0.003	0.38***	0.41***
Preference (β)	0.96***	−0.16	−0.74***	0.26	0.44*	0.75***	0.22	0.39*	−0.56**
Familiarity (β)	−0.02	0.49*	0.51*	0.07	−0.28	−0.36	−0.004	0.30	−0.10

Bonferroni corrections were applied for the global model ($p = .05 / 2 = 0.025$).
* $p < .05$.
** $p < .01$.
*** $p < .001$.

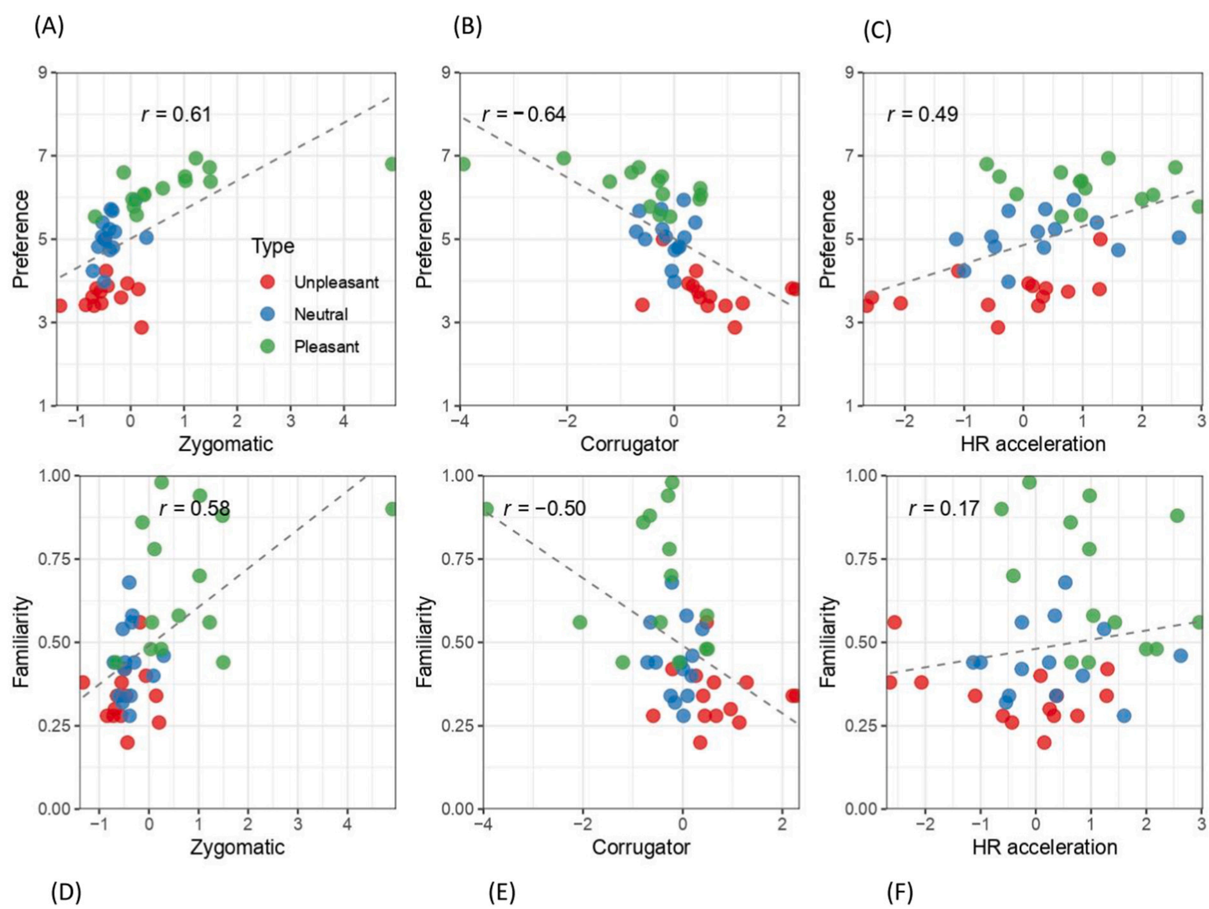

Fig. 2. Linear regressions between Preference and (A) Zygomatic, (B) Corrugator, (C) Heart Rate Acceleration; as well as linear regressions between Familiarity and (D) Zygomatic, (E) Corrugator and (F) HR Acceleration.

4. Discussion

Most people listen to music for its ability to convey and induce emotions (Juslin & Sloboda, 2001). In fact, previous research has demonstrated a strong influence of music listening on both subjective and objective correlates of emotion (Fuentes-Sánchez, Pastor, Escrig, et al., 2021). As a result, it is important to understand the underlying mechanisms related to emotion induction through music (Fuentes-Sánchez, Pastor, Escrig, et al., 2021) and how some individual differences could influence such processing. Nevertheless, there are relatively few studies investigating the influence of individual variables on music-induced emotions. The current research aimed to investigate the influence of musical preference and familiarity on emotional responses to music. To that end, subjective ratings and peripheral physiological responses were measured while participants listened to film music excerpts selected from the FMSS dataset (Eerola & Vuoskoski, 2011; Fuentes-Sánchez, Pastor, Eerola, Pastor, 2021b).

According to our hypotheses, current findings revealed that musical preference and familiarity influence subjective and objective correlates of emotion, suggesting that both factors should be considered in future studies that seek to understand the processing of emotions through music. Particularly, multiple regression analysis showed that the global model with musical preference and familiarity predicted valence and tension ratings, as well as HR acceleration and EMG activity. Interestingly, those analyses showed that musical preference, and not familiarity, was the most important variable in modulating emotional responses, which was not in line with our expectations and did not replicate other studies (Pereira et al., 2011; van den Bosch et al., 2013). These findings suggest that it might not be necessary listening to familiar music in order to elicit emotions in the listeners, which has potential clinical implications specially for patients with memory impairments, such as those affected by Alzheimer's disease (Arroyo-Anlló, Dauphin, Fargeau, Ingrand, & Gil, 2019).

Specifically, regarding *musical preference*, our results partially replicate previous findings (Iwanaga & Moroki, 1999; Schäfer & Sedlmeier, 2011). In line with past research, preferred music was evaluated as more pleasant, and prompted enhanced HR acceleration and zygomatic EMG, whereas diminished corrugator EMG activity (de Jong et al., 1973), which suggests an influence of musical preference on correlates typically considered as indexes of affective valence (Fuentes-Sánchez, Pastor, Escrig, et al., 2021). By contrast, this individual factor did not influence arousal measures. Particularly, correlation analyses showed that musical preference was not significantly related to EDA, according to prior results (Schäfer & Sedlmeier, 2011; van den Bosch et al., 2013), nor to subjective ratings of energy or tension arousal, which are not in line with other evidences (e.g., Hirokawa, 2004; Iwanaga, Ikeda, & Iwaki, 1996; Iwanaga & Moroki, 1999). Altogether, our findings revealed a strong effect of musical preference on emotion processing, influencing objective correlates of emotion such as HR and facial EMG, and not only subjective ratings as prior research has claimed (Iwanaga et al., 1996). Particularly, musical preference modulated affective valence but not emotional arousal indexes (such as EDA or energy or tension arousal), which might suggest that listening to preferred music did not alter the level of activation. Regarding *music familiarity*, correlation analysis demonstrated that it was related to valence ratings, and EMG activity. Nevertheless, multiple regressions demonstrated that this variable did not predict physiological nor subjective responses, having very little weight in the global regression model.

Finally, our results revealed a positive relationship between musical preference and familiarity, replicating previous findings (Freitas et al., 2018; Witvliet & Vrana, 2007) and demonstrating that listening to familiar music increased the preference for them. This result is explained by the mere exposure effect (Peretz et al., 1998; Zajonc, 1968), which argues that preference to musical excerpts increases with the exposition to those excerpts. Nevertheless, the opposite effect can occur when the listener is exposed to those excerpts to a greater extent (Szpunar, Schellenberg, & Pliner, 2004).

In summary, our results demonstrated that musical preference was the main factor influencing both subjective ratings and peripheral physiological correlates of emotions induced by music, specifically those measures of hedonic valence. By contrast, familiarity did not have a significant effect on emotional correlates, which suggested that listening to unfamiliar music seems capable of inducing strong emotional responses.

To end, some limitations and future directions should be mentioned. Firstly, we have not investigated other individual differences that could influence emotional reactions to music, such as gender. In fact, prior research has been suggested that women and men might react differently when inducing emotions (Fuentes-Sánchez, Pastor, Eerola, Pastor, 2021a). To this extent, another limitation is that the phase of the menstrual cycle of the volunteers was not monitored in our study, which could also influence the results (Sudström & Gingnell, 2014). Furthermore, another limitation concerns the scales used in the experimental task implemented in this study, particularly related to the affective scales (valence, energy, and tension) and music familiarity. On the one hand, a 9-point Likert scale was used for the affective scales. However, future research might consider using other rating methods free of language effects such as the Self-Assessment Manikin (SAM; Bradley & Lang, 1994). On the other hand, the music familiarity scale only has a 3-point range, which could be inadequate or not sufficient to investigate this factor. Additionally, further research should consider including other psychophysiological measures such as the startle reflex –which is a better index of defensive or appetitive activation (Bradley et al., 2001), and therefore a more reliable objective correlate of hedonic valence–, or the respiration rate, which is another accurate index of emotional intensity.

CRediT authorship contribution statement

Nieves Fuentes-Sánchez: Conceptualization, Methodology, Software, Investigation, Formal analysis, Writing – original draft. **Raúl Pastor:** Conceptualization, Methodology, Writing – review & editing. **Tuomas Eerola:** Methodology, Formal analysis, Writing – review & editing. **M. A. Escrig:** Methodology, Investigation, Data curation, Software, Writing – review & editing. **M. Carmen Pastor:** Conceptualization, Methodology, Investigation, Resources, Writing – review & editing, Supervision, Project administration, Funding acquisition.

Data availability

Data will be made available on request.

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