CHAPTER

The impact of visual art and emotional sounds in specific musical anhedonia

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Abstract

A small percentage of healthy individuals do not find music pleasurable, a condition known as specific musical anhedonia. These individuals have no impairment in music perception which might account for their anhedonia; their sensitivity to primary and secondary rewards is also preserved, and they do not show generalized depression. However, it is still unclear whether this condition is entirely specific to music, or rather reflects a more general deficit in experiencing pleasure, either from aesthetic rewards in general, or in response to other types of emotional sounds. The aim of this study is to determine whether individuals with specific musical anhedonia also show blunted emotional responses from other aesthetic rewards or emotional acoustic stimuli different than music. In two tasks designed to assess sensitivity to visual art and emotional sounds, we tested 13 individuals previously identified as specific musical anhedonics, together with two more groups with average (musical hedonic, HDN) and high (musical hyperhedonics, HHDN) sensitivity to experience reward from music. Differences among groups in skin conductance response and behavioral measures in response to pleasantness were analyzed in both tasks. Notably, specific musical anhedonics showed similar hedonic reactions, both behaviorally and physiologically, as the HDN control group in both tasks. These findings suggest that music hedonic sensitivity might be distinct from other human abstract reward processing and from an individual's ability to experience emotion from emotional sounds. The present results highlight the possible existence of specific neural pathways involved in the capacity to experience reward in music-related activities.

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Highlights

- Two specific tasks were designed to assess sensitivity to visual art and emotional sounds.
- Specific musical anhedonics together with two groups with average and high sensitivity to music were tested with these two tasks.
- Results indicate that specific musical anhedonia is not driven by difficulties in experiencing emotion from visual aesthetic stimuli nor from emotional acoustic stimuli.

Keywords

Musical anhedonia, Aesthetics, Emotional sounds, IADS, Art, Reward, Pleasure

1 INTRODUCTION

Since prehistoric times, music has been around in all human cultures (Conard et al., 2009) although, like any other abstract, aesthetic stimulus, is not associated with any apparent biological advantage, as are primary rewards such as food or sex, nor does it possess utility value such as money. Despite this lack of direct advantage, people rank music as one of the highest sources of pleasure (Dubé and Le Bel, 2003). In accordance with this concept, previous studies have demonstrated that music can effectively elicit highly pleasurable emotional responses (Salimpoor et al., 2009) and previous neuroimaging and noninvasive brain stimulation studies have implicated emotion and reward circuits of the brain during pleasurable music listening (Blood and Zatorre, 2001; Koelsch, 2014; Koelsch et al., 2006; Martínez-Molina et al., 2016; Mas-Herrero et al., 2018; Salimpoor et al., 2011, 2013; Trost et al., 2012). Indeed, in human cultures and societies, music plays an important part in people's lives in manifold ways, and this idea underlies a general assumption that all human beings are able to experience pleasure from music of some kind. This conception has recently changed.

Within the last two decades, four case studies (Griffiths et al., 2004; Mazzoni et al., 1993; Satoh et al., 2011, 2016) reporting individuals for whom music in particular was not pleasurable were published. This condition was termed specific musical anhedonia since the patients did preserve hedonic responses to other kind of rewards, suggesting the existence of specific musical reward pathways. More recently, our group has identified a population of healthy individuals with this condition (Martínez-Molina et al., 2016; Mas-Herrero et al., 2014). This group of individuals, who were screened to exclude those with depression or generalized anhedonia, showed reduced behavioral pleasure ratings and no physiological or neural responses to pleasurable music, despite having normal musical perception capacities, and not even any impairment in recognizing emotions from music. In addition, these individuals showed preserved behavioral, physiological, and neural responses to monetary reward, indicating that the low sensitivity to music is not due to a global dysfunction of the reward network (Martínez-Molina et al., 2016; Mas-Herrero et al., 2014).

These findings raise intriguing questions. First, although specific musical anhedonics preserved hedonic responses to primary and secondary rewards, do these individuals have low reward sensitivity to other type of abstract stimuli (such as visual aesthetic stimuli), as well? Findings in either the music or the visual art domain are usually generalized to all other aesthetic experiences (Chatterjee, 2011; Leder et al., 2004; Nadal et al., 2008; Tiihonen et al., 2017). Pleasure derived from different aesthetics experiences is thus thought to act as a "common currency" in the brain (Cabanac, 1992; Montague and Berns, 2002). In this regard, previous studies have shown that similar to music, emotional responses to pleasant paintings activate regions implicated in reward processing such as the orbitofrontal cortex (OFC), the anterior cingulate cortex (ACC), and the striatum (Cupchik et al., 2009; Kawabata and Zeki, 2004; Vartanian and Goel, 2004). However, although aesthetic experiences may share a common abstract reward value representation within this circuitry, how perceptual and sensory information access this reward network may account for individual preference for different types of aesthetic experiences. For instance, recent fMRI and DTI studies have shown that musical pleasure may not rely only on the engagement of these common structures but also on their communication with regions involved in auditory perception (Loui et al., 2017; Martínez-Molina et al., 2016; Sachs et al., 2016; Salimpoor et al., 2013). Nevertheless, it is still unclear whether a uniform abstract aesthetic reward network, including musical and visual aesthetics, exists; and if so, if specific musical anhedonia reflect a dysfunction of this network.

A second question to address is whether music is in some way a specific form of abstract aesthetic stimulus that specific musical anhedonic individuals are unable to experience emotion with, or is it just that they do not experience emotion with any sound conveying emotional information. Previous fMRI studies have shown that simple emotional sounds engage overlapping regions related to musical reward such as the auditory cortex, the inferior frontal gyrus (IFG), and the amygdala (Frühholz et al., 2016; Viinikainen et al., 2012). Indeed, previous studies have postulated that music may somehow reflect our ability to transmit and receive basic emotional sounds, suggesting that the emotional responses evoked by music are a sophistication of this more primitive and intrinsic communication system (Panksepp and Bernatzky, 2002). If this is the case, specific musical anhedonia might reflect low sensitivity to emotional sounds, either musical or not. That would indicate that this condition is not specific to abstract sounds as music, but also applicable to more primitive sound responses.

The questions therefore that remain to be solved are whether specific musical anhedonia could be driven by (1) difficulties in experiencing emotion from abstract aesthetic stimuli in general or (2) difficulties experiencing emotion from any acoustic stimuli, not just music. In order to answer these two questions, we tested 13 individuals previously identified as specific musical anhedonics (ANH, Martínez-Molina et al., 2016; Mas-Herrero et al., 2014) together with two groups with average (musical hedonics, HDN) and high sensitivity (musical hyperhedonics, HHDN) to music reward. We designed two specific tasks to test sensitivity to aesthetics and emotional sounds in which participants had to evaluate the degree of pleasure they experienced with (1) visual art and (2) a set of emotional sounds, respectively. In addition to subjective behavioral measures, we also recorded skin conductance response (SCR), which is considered a good objective measure of emotion–reward-related signals (Bechara et al., 1997; Lole et al., 2014; Mas-Herrero et al., 2014; Ripollés et al., 2016). We predicted that if specific musical anhedonia is a general condition, reflecting either a lack of emotional responses to abstract aesthetic type of rewards or a deficit in response to any emotional sound, differences among groups should be present in response to visual art or emotional sounds, respectively, and similar to those previously reported in response to music (Martínez-Molina et al., 2016; Mas-Herrero et al., 2014). In contrast, if it is indeed specific to music, people with this condition would respond normally to nonmusical stimuli, and hence no differences among groups would be observed in either task.

2 RESULTS

2.1 AESTHETIC TASK

Different sets of information were obtained from the participants during the performance of the aesthetic task. Behaviorally, we compared among groups subjective ratings of pleasure, arousal, and familiarity and the time spent watching the paintings (e.g., amount of time participants freely spent appreciating the painting before pressing a keyboard button in order to begin the judgment of the painting) (Fig. 1).

One-way ANOVA revealed significant differences among group in subjective reports of pleasure ($F(2,36)=7.40$; $P=0.002$). Post hoc analysis revealed that HHDN individual reported higher liking rates than the ANH ($P=0.002$) and the HDN group

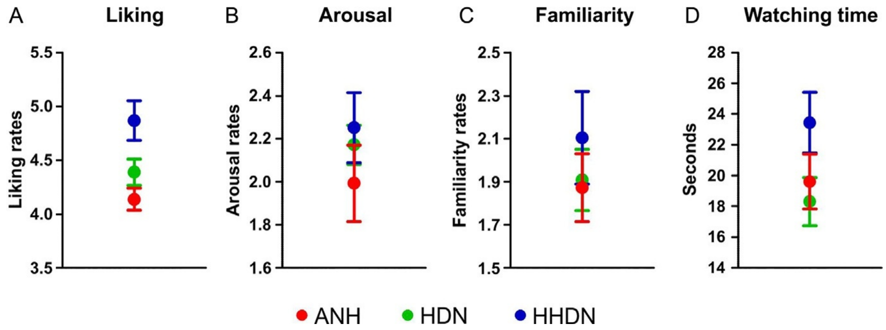

FIG. 1

Behavioral results in the aesthetic task. Average (A) liking, (B) arousal, (C) familiarity rates, and (D) the average time spent appreciating the paintings. *ANH*, anhedonic group; *HDN*, musical hedonic group; *HHDN*, musical hyperhedonics group.

($P = 0.038$) but no differences were found between the ANH and the HDN ($P = 0.46$). No statistically significant differences among groups were found either in arousal and familiarity ratings nor in the time spent watching the paintings (all Ps > 0.1).

In addition, in order to assess physiological differences among groups in responses to pleasant visual artwork, the painting that participants reported to like (ratings ≥ 5, from "I like it" to "I like it a lot") and those that they did not like (ratings ≤ 4, from "nor like/nor dislike" to "I found it unpleasant") were grouped in two conditions, pleasant and nonpleasant paintings.

Fig. 2 shows the SCR to pleasant and nonpleasant paintings across all participants. As shown in the figure, pleasant painting evoked greater SCR responses than nonpleasant paintings. The maximal difference between both conditions was observed 4 s after painting presentation. We then analyzed differences among groups around this maximal effect (averaging the amplitude of the signal from 2 to 6 s) with a Repeated Measures ANOVA. The analysis revealed that pleasant paintings evoked more SCR amplitude among all participants (condition effect, $F(1,36) = 14.12$, $P < 0.001$) and that this effect was independent of their music reward sensitivity (condition × group: $F(2,36) = 0.23$, $P = 0.795$, group effect: $F(2,36) = 0.77$, $P = 0.468$). Thus, although HHDN individuals reported to experience greater pleasure watching the painting than the other two groups; at the physiological level, no differences among groups were found.

2.2 EMOTIONAL SOUNDS TASK

In the emotional sounds task participants had to evaluate the pleasure and arousal experienced with 30 different emotional sounds. There were no statistically significant differences among group means as determined by one-way ANOVA, neither in liking ($F(2,36) = 1.67$; $P = 0.203$) nor in arousal ratings ($F(2,36) = 2.03$; $P = 0.147$) (Fig. 3).

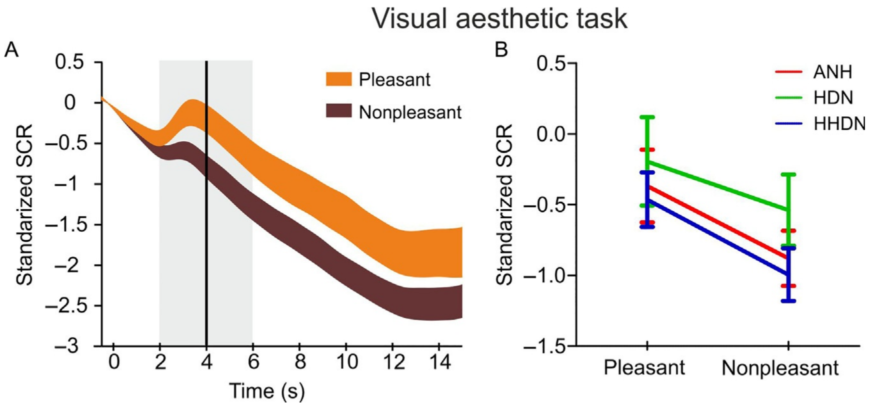

FIG. 2

(A) Standardized SCR to pleasant and nonpleasant paintings and (B) differences among the three groups in the peak time window from 10 to 14 s following pleasant and nonpleasant sounds.

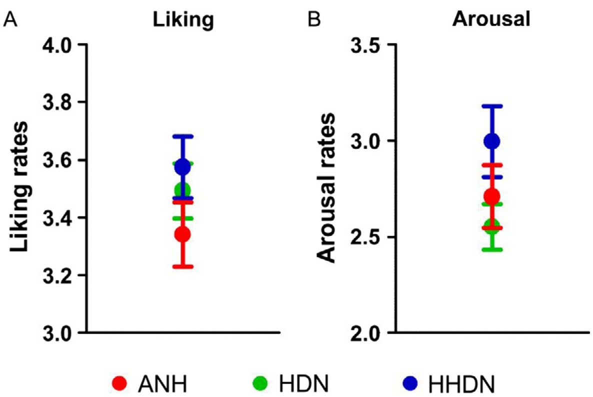

FIG. 3

Behavioral results in the emotional sound task. Average (A) liking and (B) arousal rates. *ANH*, anhedonic group; *HDN*, musical hedonic group; *HHDN*, musical hyperhedonics group.

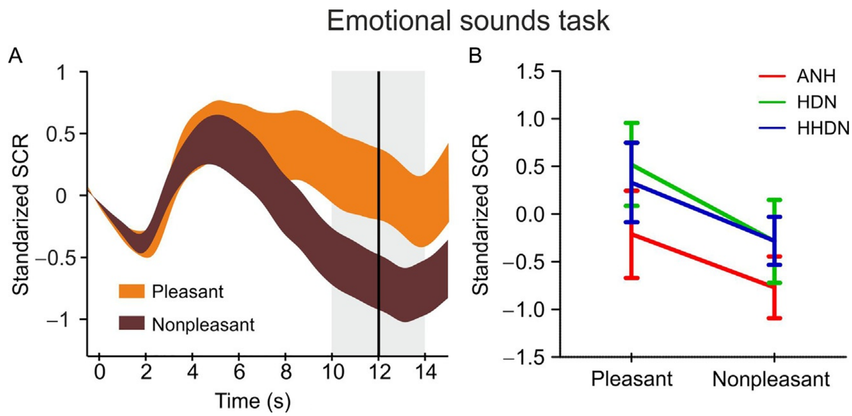

FIG. 4

(A) Standardized SCR to pleasant and nonpleasant emotional sounds and (B) differences among the three groups in the peak time window from 2 to 6 s following pleasant and nonpleasant sounds.

In order to explore physiological differences among groups in response to pleasant sound, they were classified as pleasant (ratings $\geq$5) and nonpleasant (ratings $\leq$4); following the same procedure used in the aesthetic task. Fig. 4 shows the SCR to pleasant and nonpleasant emotional sounds across all participants. As shown in the figure, both pleasant and nonpleasant sounds evoked similar SCR immediately after the sound presentation, but the effect was sustained following pleasant sounds. The maximum difference between both conditions was found around 12 s. The SCR in a timeframe window, going from 10 to 14 s, was analyzed to assess differences among groups. Pleasant emotional sounds evoked greater SCR among the participants ($F(1,36)=7.67$, $P=0.009$), but this effect did not interact with the group variable ($F(2,36)=0.0.1$, $P=0.915$). The main effect of group was not significant either ($F(2,36)=1.61$, $P=0.213$).

3 DISCUSSION

The aim of this study was to investigate whether specific musical anhedonia is really specific to music, or instead could be driven by difficulties in experiencing pleasure from any kind of aesthetic reward (e.g., visual art) or any emotional acoustic stimuli. With this aim in mind, behavioral and SCR measures were analyzed in three groups of participants—specific musical anhedonics (ANH), musical hedonics (HDN), and musical hyperhedonics (HHDN)—while performing two tasks designed to assess hedonic responses to art and emotional sounds.

Pleasantness ratings collected from the two tasks showed that specific musical anhedonics responded similarly to the HDN control group (Figs. 1 and 3). In addition, SCR measurements in both tasks indicated higher physiological responses in all three groups with pleasant paintings and sounds compared to nonpleasant. This response indicates that skin conductance is a sensitive and valid measure of the affective value associated with these stimuli. However, there were no differences among the groups, indicating that the three groups of participants experienced similar emotional reactions to either paintings or emotional sounds (Figs. 2 and 4). Hence, both behavioral and physiological results are consistent with the null hypothesis, that is, that no differences exist in response to nonmusical pleasant stimuli between ANH and the HDN control group. This negative result is unlikely to reflect a lack of statistical power, given that we observed a clear behavioral effect between the HHDN and the other two groups in the visual aesthetic task. Additionally, we have shown in two previous studies that the specific musical anhedonics tested here had significant lower behavioral, physiological, and neural responses to music than the other two groups using similar samples size and procedures than the used in this study. These findings thus indicate that specific musical anhedonia is not driven by difficulties in experiencing pleasure from any kind of aesthetic reward nor from any emotional acoustic stimuli. These observations have significant implications for two issues.

First, we conclude that the capacity to experience reward from music-related activities might differ to a certain extent from sensitivity to derive pleasure from other types of abstract aesthetic experiences. Both pleasant visual art and music engage overlapping structures, including the OFC, the ACC, and the striatum, which are also involved in the processing of primary and secondary rewards (Jacobsen et al., 2006; Kawabata and Zeki, 2004; Vartanian and Goel, 2004). However, the processing of music and visual art might engage different routes of access to this common reward circuitry. In music, the processing of time and sound is critical: listening to music engages high-order cortical structures including the auditory cortex (Peretz et al., 2009; Zatorre and Halpern, 2005), as well as the frontal regions to which it connects, such as the IFG, crucial for working memory and predictive coding (Albouy et al., 2015; Bastos et al., 2012; Tillmann et al., 2006). In contrast, appreciation of visual art requires the processing of early and intermediate visual properties (e.g., color, shape, and composition), which in turn engage attentional circuits mediated by frontoparietal neural network (Cela-Conde et al., 2011; Nadal et al., 2008). Critically, the interaction between these perceptual and attentional circuits and the reward centers of the brain are thought to be of prime importance in the experience of aesthetic pleasure (Koelsch et al., 2013; Loui et al., 2017; Marco-Pallarés and Mas-Herrero, 2015; Martínez-Molina et al., 2016; Sachs et al., 2016; Salimpoor et al., 2013). Indeed, we have shown that individuals with specific musical anhedonia showed reduced connectivity between the nucleus accumbens (Nacc), a key region in reward and affective processing, and the superior temporal gyrus (STG), crucial for music perception (Martínez-Molina et al., 2016). In addition, recent studies using probabilistic tractography indicate that individual differences in music reward sensitivity may be driven by structural differences in the paths connecting the STG and reward and emotion-related structures (Loui et al., 2017; Martínez-Molina et al., under review; Sachs et al., 2016). The intact sensitivity of specific musical anhedonics to artistic paintings may indicate that the communication between visual and attentional paths involved in visual art processing, on the one hand, and reward centers, on the other, is unaltered in these individuals, leading to typical hedonic reactions in response to visual aesthetic rewards.

In addition, our study revealed interesting findings related to musical hyperhedonics: the HHDN group reported higher ratings of pleasantness than the other two groups in the aesthetic task. However, this did not translate into differences in SCR responses. We found a similar effect in our previous study with music: HHDN participants reported greater emotional subjective experiences than the HDN individual, but objective measurements (SCR and heart rate) did not reflect these differences (Mas-Herrero et al., 2014). In that study, we suggested that musical hyperhedonics may evaluate the same hedonic experience driven by music as more valuable, leading to a greater "wanting" or desire to listen to music (Mas-Herrero et al., 2014). Results of this study partially reproduced this tendency in visual abstract aesthetics, suggesting it might not be solely specific to music. These results could indicate the existence of a common reward value representation across aesthetic experiences. Thus, while ANH participants have altered music-specific interactions between auditory cortices and reward-related structures—leading to a specific lack of sensitivity to music (but not other abstract aesthetic rewards)—HHDN participants may reflect a greater valuation of aesthetic experiences leading to a greater motivation and appreciation of abstract than nonabstracts rewards. Further studies with these individuals are required to better understand the neural mechanism underlying their specific high reward sensitivity in response to both music and visual aesthetic rewards.

Second, from the present findings we conclude that specific musical anhedonia does not impact an individual's ability to experience emotion from nonmusical emotional sounds (such as baby laughing and dog barking). Low musical sensitivity therefore does not imply low sensitivity to other emotional sounds. While some researchers (Panksepp and Bernatzky, 2002) have earlier raised the question of music's emotional basis on the existence of the intrinsic emotional sounds humans make, our results indicate that the pleasure experienced with simple or more complex sounds may, in part, rely on distinct circuits. Indeed, emotional reactions to nonverbal and nonmusical emotional sounds slightly differ from those to music. They are highly consistent across individuals and can be either innate responses (e.g., baby laughing) or may have been associated through experience with certain rewards (e.g., coins falling from a slot machine). In contrast, music's ability to generate pleasure in the listener is highly depending on cultural backgrounds and experience and is not only driven by its association with good memories or rewards, but by its temporal and structural regularities as well (Gebauer et al., 2012; Salimpoor et al., 2015; Vuust and Frith, 2008). A recent meta-analysis has shown that although simple and complex sounds (including both speech and music) may engage a "core" circuit, involving the amygdala, IFG, and insula among other, the affective processing of complex sounds, particularly music, involved an extended circuitry involving the OFC, the hippocampus, and the Nacc (Frühholz et al., 2016). Consistently, in our previous study we showed that specific musical anhedonics present reduced responses to music in the Nacc (Martínez-Molina et al., 2016), but not to monetary reward. Thus, the present findings indicate that the lack of emotional reaction to music of specific musical anhedonics is not driven by deficits in the functioning of the "core" circuit involved in sound processing, but rather, by specific musical paths (Martínez-Molina et al., under review).

Overall, our findings, from both tasks, indicate that specific musical anhedonia is indeed specific to music and it is not driven by a more general-domain deficit in eliciting reward from other abstract aesthetic experiences (e.g., visual art) or emotional sounds. However, the behavioral differences found between HHDN and the other two groups in the visual aesthetic task may indicate the existence of certain common circuitry involved in processing abstract aesthetic experiences or common brain regions involved in the processing of reward value associated to aesthetic experience. Further research might be needed in this direction to isolate common and divergent pathways involved in the processing of different aesthetic experiences.

4 MATERIALS AND METHODS

4.1 PARTICIPANTS

Thirty-nine healthy subjects were classified into three groups of 13 individuals according to their Barcelona Music Reward Questionnaire (BMRQ, Mas-Herrero et al., 2013) scores: specific musical anhedonics (ANH, BMRQ < 65), musical hedonics (HDN, $65 <$ BMRQ < 87), and musical hyperhedonic (HHDN, BMRQ > 87) (same criteria used in Mas-Herrero et al., 2014). The BMRQ is known to be a reliable indicator of interindividual variability in music-induced reward. All ANH individuals

Table 1 Psychometric Scores in BMRQ, PAS, VAS, MBEA, and SVAQ of the Three Groups

	Anhedonics	Hedonics	Hyperhedonics	*P* Value
N	13 (6)	13 (7)	13 (9)	
Age	22.1 (4.4)	21.1 (3.4)	22.15 (5.9)	0.81
BMRQ	53.8 (8.1)	76.4 (5.2)	88.0 (3.1)	0.000**
PAS	12.6 (5.7)	11.4 (5.7)	10.6 (5.7)	0.63

P *value indicates the significance of the group effect in a One-Way ANOVA. The* first row *indicates the number of participants for each group (number of females in parenthesis).* Second to fourth row *indicate the average age (standard deviation in parenthesis) and the average BMRQ and PAS scores.* BMRQ, *Barcelona Music Reward Questionnaire;* PAS, *Physical Anhedonia Scale.* **P $<$ *0.001.*

of the current experiment were identified as specific musical anhedonics in two previous studies (Martínez-Molina et al., 2016; Mas-Herrero et al., 2014). As shown in Table 1, the three groups of individuals clearly differed in BMRQ scores but presented similar scores in hedonism as measured by the Physical Anhedonia Scale (PAS, excluding those items referring to musical rewarding experiences to assess the hedonic impact of other activities or stimulus outside the music domain). In addition, the three groups were matched in sex and age. Order of tasks was counterbalanced across participants.

The ethical review board of the IDIBELL approved the study. We ensured the respect for rights and dignity of the participants, and they were free to stop the experiment whenever if so wished. The approved informed consent was given to the participants in the experiment situation. Subjects were paid 20 euros for their participation.

4.2 AESTHETIC TASK

For the aesthetic task, we used a variation of the task developed by Cattaneo et al. (2014) and Cela-Conde et al. (2004, 2009). In the task, participants were presented with a set of paintings. Each painting was presented during at least 10 s, after which participants were instructed to press a keyboard button when they felt ready to make a judgment about the picture. Ten seconds after, participants had to evaluate the amount of (1) pleasure (on a scale from 1—"I found it unpleasant" to 7—"I liked it a lot," where 4 was "I neither liked nor disliked it"), (2) arousal (on a scale from 1 to 5), and (3) familiarity (on a scale from 1 to 5) experienced with that painting.

4.3 AESTHETIC STIMULI

Cela-Conde et al. (2009) used a set of artistic pictures that were homogenized on the bases of pictorial complexity, color spectrum, luminosity, and light reflection, including abstract (150), classic (50), impressionist (25), and postimpressionist art (25). In order to reduce this set to 100 pictures, we selected from the initial set 25 pictures of each art category (25 abstract, 25 impressionists, 25 postimpressionist, 25 realistic). Since most of the paintings from this set of stimuli were very unfamiliar, we added 35 popular or high familiarity paintings without clear facial expressions. These 135 paintings in total were evaluated for 100 university students in a first pilot study, to select the final set of paintings used for the aesthetic task. Using a Likert-scale from 1 to 7, 28 paintings (14 low familiar, 14 high familiar) with a mean liking rate above 5 (I like it), and 28 paintings (14 low familiar, 14 high familiar) with a mean liking rate between 3 (I do not like) and 5 (I like) were selected for the main study to ensure enough variability of ratings. The paintings obtained from Cela-Conde et al. (2009) were framed in a uniform scale (709 pixels for the width and 531 pixels for the height) giving the presented stimulus similar size. Since the famous art was in multiple sizes and their real-life dimensions varied (e.g., the breadth of "Guernica" by Pablo Picasso), we decided to keep their original aspect ratio for not altering the dimensions of the original art. While keeping in mind the optimal size offered by the earlier studies, we tried to adapt the famous art into that frame. Otherwise, we followed the limitations of the program and the screen, giving a maximum size for the width 1000 pixels and 630 pixels for the height. All participants were presented with the same selection of 56 paintings.

Visual stimuli were presented over a black background on a 19-in. computer monitor. Stimuli presentation was implemented using the Presentation software version (Neurobehavioral Systems) running on Windows XP (Microsoft). Participants were tested in an electrically isolated, dimly lighted, and sound-attenuated booth, and they were monitored through a camera over the entire session.

4.4 EMOTIONAL SOUNDS TASK

In the emotional sounds task, participants listened to 30 different sounds (such as baby laughing, dog barking, and audience cheering) selected from the International Affective Digitized Sounds (IADS-2, Bradley and Lang, 2007). The 30 sounds selected presented similar arousal ratings (from 5.5 to 6.5, in a scale from 1 to 8). As in the aesthetics task, to ensure enough variability of liking rates we selected sounds with pleasure rating from 3 to 7.5 (in a scale from 1 to 8). Emotional sounds task was carried out also in the same environment and with the same software and computer setup as used in the aesthetic task.

After listening to a specific sound stimulus of 6 s, a 10 s interval of silence followed, after which participants had to rate the degree of pleasure and arousal experienced with the same procedure as in the aesthetic task.

4.5 SKIN CONDUCTANCE RESPONSE

SCR was recorded during aesthetic and emotional sounds tasks using two AgAgCl electrodes using a BrainVision BrainAmp device. The electrodes were attached to the forefinger and the ring finger of the left hand. The level of SCR was determined by measuring the mean SCR amplitude after stimulus or response onset with respect to baseline (−500 ms). In both tasks, SCR amplitude was determined in the 0–15 s windows after the presentation of a painting or an emotional sound. Painting or emotional sounds rated ≥5 (in a 1–7 scale) in pleasantness were categorized as pleasant, those with ratings ≤5 were classified as nonpleasant. In order to compare different conditions, trials associated with each specific condition were averaged for each subject. Given the large interindividual variability in SCR sensitivity, in each task and for each participant, the resulting SCR was normalized across conditions: each time point was transformed into *z*-scores by subtracting the mean and dividing by the standard deviation of the two conditions (Ben-Shakhar, 1985; Martínez-Molina et al., 2016; Mas-Herrero et al., 2014; Ripollés et al., 2016). In both tasks, maximum peak difference in the SCR amplitude between the pleasant and nonpleasant conditions were determined at the group level ($N = 39$). SCR differences among groups were then analyzed by averaging the SCR amplitude in a time window located 2 s around that peak, for both pleasant and nonpleasant stimuli.

4.6 DATA ANALYSIS

The statistical analysis was made with SPSS Statistics 21. To explore behavioral differences among groups, One-Way ANOVA was carried out with post hoc test (Tukey). SCR differences between conditions (pleasant and nonpleasant) and groups (ANH, HDN, and HHDN) by performing a Repeated Measures ANOVA including pleasantness as a within-individuals factor and group as a between-individuals factor.

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