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Separate Contribution of Striatum Volume and Pitch Discrimination to Individual Differences in Music Reward

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Abstract

Individual differences in the level of pleasure induced by music have been associated with the response of the striatum and differences in functional connectivity between the striatum and the auditory cortex. In this study, we tested whether individual differences in music reward are related to the structure of the striatum and the ability to discriminate pitch. We acquired a 3-D magnetization-prepared rapid-acquisition gradient-echo image for 32 musicians and 26 nonmusicians who completed a music-reward questionnaire and a test of pitch discrimination. The analysis of both groups together showed that sensitivity to music reward correlated negatively with the volume of both the caudate and nucleus accumbens and correlated positively with pitch-discrimination abilities. Moreover, musicianship, pitch discrimination, and caudate volume significantly predicted individual differences in music reward. These results are consistent with the proposal that individual differences in music reward depend on the interplay between auditory abilities and the reward network.

Keywords

individual differences, music perception, music reward, voxel-based morphometry, striatum

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Music can evoke a wide variety of strong emotions, including pleasure and joy. This emotional response has been studied using specific pieces of music that generate “thrills” or “chills” (Goldstein, 1980). Neuroimaging studies have revealed that the experience of these chills is associated with enhanced brain activity in reward-related areas (Blood & Zatorre, 2001), in addition to psychophysiological responses in the form of increased heart rate or skin conductance. Using a combination of positron emission tomography and functional MRI, Salimpoor, Benovoy, Larcher, Dagher, and Zatorre (2011) showed that participants' striatal dopamine levels increased while they listened to pleasurable song excerpts that were familiar to them: Seconds before the most pleasurable moment, dopamine activity increased in the dorsal striatum (caudate),

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whereas ventral striatum (nucleus accumbens, or NAcc) dopamine levels peaked at the moment of maximum pleasure. The authors proposed that the caudate and NAcc were involved in the anticipation and direct processing of music reward, respectively. In another study, Salimpoor et al. (2013) explored the effects of listening to unfamiliar musical stimuli. The results showed greater activation of the NAcc and increased functional connectivity of this area with the auditory cortex, the amygdala, and the ventromedial prefrontal cortex associated with the experience of listening to more pleasant music excerpts. The increase in functional connectivity between participants' NAcc and auditory cortex while they listened to pleasant music suggests a possible connection between music-perception skills and music reward.

With the aim of measuring individual differences in sensitivity to music reward, Mas-Herrero, Marco-Pallares, Lorenzo-Seva, Zatorre, and Rodriguez-Fornells (2013) developed the Barcelona Music Reward Questionnaire (BMRQ). This questionnaire divides music reward into five factors that make up the global BMRQ score: (a) music seeking, or how an individual pursues activities related to music (e.g., attending concerts) and seeks information related to the music to which he or she listens (e.g., singers, bands); (b) emotion evocation, or the emotional impact that music has on an individual; (c) mood regulation, or an individual's capacity to modulate his or her emotions through music, as in releasing stress or finding comfort; (d) sensory-motor behavior, or the degree to which music automatically induces motor movements synchronized with a rhythm's beat; and (e) social reward, or the social bonding that an individual may achieve through music. On the basis of that study's findings, the authors proposed that individual differences in music reward are stable and can be related to brain structure and function.

One of the additional objectives of the BMRQ was to detect individuals with music anhedonia, that is, an incapacity to enjoy listening to music. Mas-Herrero, Zatorre, Rodriguez-Fornells, and Marco-Pallarés (2014) and Martínez-Molina, Mas-Herrero, Rodríguez-Fornells, Zatorre, and Marco-Pallarés (2016) selected individuals with music anhedonia who experienced very low music-specific pleasure but whose behavioral and neurophysiological responses to monetary reward or to other types of reward remained intact. In particular, music anhedonia was characterized by reduced music-induced electrodermal activity as well as lower striatal response. Moreover, specific music anhedonia was associated with lower functional connectivity between the NAcc and the primary auditory cortex (Martínez-Molina et al., 2016). By contrast, experiencing chills in response to pleasurable music was associated with stronger connectivity between these structures. Individual differences in experiencing pleasure when listening to music may therefore be associated with NAcc signaling and its connectivity to the auditory cortex. These results were consistent with previous structural data showing that individuals who perceived chills frequently and consistently had increased structural connectivity between brain areas involved in reward processing (medial prefrontal lobe and insula) and the superior temporal lobe (Sachs, Ellis, Schlaug, & Loui, 2016) and that a patient with music anhedonia had a lower connectivity of superior temporal gyrus and the striatum (Loui et al., 2017). Overall, these data suggest an involvement of both the reward and the auditory systems in mediating individual differences in music-induced pleasure.

It has been well established that the striatum plays a prominent role in determining individual differences in reward processing across different types of stimuli, including music (Martinez-Molina et al., 2016; Pickering & Gray, 2001). The ventral striatum seems to be at the core of neural networks that process reward value, whereas the dorsal striatum has been related to decision making, action selection and initiation, and the establishment of response–outcome contingencies in instrumental appetitive conditioning (Robbins & Everitt, 1992). Both responses in the ventral and the dorsal striatum have been shown to be stronger in individuals with high reward sensitivity (Costumero et al., 2013; Costumero et al., 2016). An important factor for the present study is that individual differences in reward sensitivity in healthy subjects have also been associated with lower volume in the striatum (Barrós-Loscertales et al., 2006). Patients with disinhibitory disorders such as attention-deficit/hyperactivity disorder and cocaine addiction also showed a reduced striatum volume when compared with matched control subjects (Barrós-Loscertales et al., 2011; Shaw et al., 2014; the exception is psychopathy, in which the volume is shown to increase; Glenn, Raine, Yaralian, & Yang, 2010). Thus, we hypothesized that individual differences in music-reward sensitivity could also be associated with reduced volume in the striatum. In the present study, we explored whether individual differences in music reward, as measured using the BMRQ, are associated with variation in striatal volume.

As we mentioned earlier, recent results by Martínez-Molina et al. (2016) indicated that increased music-induced reward is associated with enhanced functional connectivity between the auditory cortex and the NAcc. Music expertise has been linked to increased discrimination and sensitivity in different aspects of music analysis as well as to altered functional connectivity during audio-visual integration (Paraskevopoulos et al., 2014) and enhanced brain cortical activity during evaluation of music irregularities (Habibi, Cahn, Damasio, & Damasio, 2016). Musicians are often able to identify deviations of pitch more accurately and rapidly than are nonmusicians (Micheyl, Delhommeau, Perrot, & Oxenham, 2006). This pattern may indicate that musicianship is a factor associated with music-perception skills. However, previous research has also shown that both pitch discrimination and the anatomic structure of the auditory cortex seem to be genetically determined to a large extent (Drayna, Manichaikul, De Lange, Snieder, & Spector, 2001), which suggests that musicians may have brains somehow predisposed to music before training.

Given that previous research has shown that musicians obtain higher scores in music reward (Mas-Herrero et al., 2013), have greater pitch discrimination (Anderson & Kraus, 2011), and exhibit higher auditory cortex volume (Palomar-García, Zatorre, Ventura-Campos, Bueichekú, & Ávila, 2017), we used musicians and nonmusicians in this study to obtain a wider range of scores, with the aim of investigating whether the contributions of individual differences in striatum volume and pitch discrimination (based on musicianship) share the same source of variance as music reward. We hypothesized that each factor would contribute separately to explaining the individual differences in engaging in activities oriented toward obtaining pleasure from music.

Method

Participants

An a priori power analysis was conducted using G*Power software (Version 3.1.92; Faul, Erdfelder, Buchner, & Lang, 2009) on the basis of the effect size observed in our previous study relating striatum volume to reward sensitivity (Barrós-Loscertales et al., 2006). This analysis yielded an R^2 of .35 (f^2 = .53) with an alpha of .05 and a power value (1 – β) of .90, resulting in a minimum sample size of 37 participants. Given the uncertainty of this estimated effect size—mainly because it was obtained from a single prior study—we set out to collect a larger sample. The increase in the sample size, however, was determined by funding (we were able to include 21 more participants). We did not analyze the data until we completed data collection. Therefore, the final sample size was 58 participants: 32 musicians (10 women; age: M = 20.13 years, SD = 2.1, range = 18–26) and 26 nonmusicians (10 women; age: M = 20.7 years, SD = 2.22, range = 18–27). The two groups did not differ in age or gender distribution. Musicians had completed formal music studies (conservatory, private schools) lasting at least 9 years and were active musicians: 75% of musicians played wind instruments, 16% played string instruments, 6% played percussion instruments, and 3% were singers; 47% of them had started official music studies at 6 years of age, 3% at 8 years, and 50% at 9 years, and the total duration of their studies was 10.32 years on average (SD = 1.32, range = 9–13). Nonmusicians had received only mandatory music instruction at school. None of the participants reported any neurological or psychiatric disorders, nor did they report any history of head injury with loss of consciousness. Written informed consent was obtained from all participants, following a protocol approved by the Universitat Jaume I. Participants received monetary compensation for their participation.

Measures

Music reward: BMRQ (Mas-Herrero et al., 2013). The BMRQ evaluates how people experience rewards associated with music. The questionnaire divides music reward into five factors: music seeking, emotion evocation, mood regulation, sensory-motor behavior, and social reward. Each factor contains 4 items, yielding a total of 20 items rated on a 5-point Likert-type scale (*completely disagree* to *completely agree*). Mas-Herrero et al. (2013) performed a psychometric analysis with a total of 1,661 subjects to determine the influence of each item on each factor and obtain factor scores. The sum of the scores obtained for each of the five factors determines the global index of sensitivity to music reward (higher scores indicate greater pleasure derived from music). This global index was the variable used in this study.

Jake Mandell Tonedeaf Test (JMTT). This test consists of 36 trials. Across trials, brief paired musical phrases are performed in a variety of timbres and musical styles; each matched pair shares the same melodic contour, rhythm, and timbre. Half of the pairs (18/36) differ by the pitch of a single note; of these 18 pairs, 9 contain a divergent note outside the key of the melody and 9 pairs contain a divergent note in the melody's key. The pitch difference of the single modified note can vary between the initial phrase and the repeated phrase by up to 11 semitones; variations greater than one octave are not used.

In each trial, the participant was successively presented with two short melodies and indicated whether they were the same (by pushing a green button) or different (by pushing a red button). The 36 pairs of melodies were presented to all participants in a fixed random order. This test is available at http://jakemandell.com/tonedeaf/.

The JMTT, which measures pitch-discrimination ability, was developed by Jake Mandell, whose aim was to create a brief test to evaluate tone deafness (congenital amusia). The test was designed to be challenging even for people with musical training to prevent clustering of high scores by trained individuals. According to the author, the JMTT is useful for measuring the average capacity for pitch perception, and it has been verified with a statistical analysis of 61,036 participants. This capacity for pitch perception is indexed with each subject's percentage of total correct answers.

MRI acquisition and voxel-based morphometry

We used a 3T Achieva scanner (Philips Medical Systems, Best, The Netherlands) to acquire high-resolution 3-D magnetization-prepared rapid-acquisition gradient-echo T1 images of all participants (repetition time = 8.4 ms, echo time = 3.8 ms, matrix = 224 × 269, voxel size = 0.90 mm × 0.89 mm × 0.80 mm). Voxel-based morphometry was performed with the CAT12 toolbox (Gaser & Dahnke, 2019) for the SPM12 package (Wellcome Centre for Human Neuroimaging, 2014). The following preprocessing steps were conducted following the standard default procedure suggested in the manual: (a) segmenting the images into gray matter, white matter, and cerebrospinal fluid; (b) registering the images to a standard template provided by the International Consortium of Brain Mapping; (c) normalizing the gray-matter segments in the DARTEL toolbox using the Montreal Neurological Institute template; (d) modulating the normalized data; (e) checking data quality (in which no outliers or incorrectly aligned cases were detected); and (f) smoothing with an 8-mm Gaussian kernel. Note that this procedure does not include any correction for global head size (e.g., total intracranial volume, or TIV, correction).

Statistical analysis

We applied a region-of-interest (ROI) analysis because this type of analysis is recommended when brain structures are too small to survive whole-brain analyses. CAT12 was used to obtain the gray-matter volumes of preselected ROIs—the bilateral caudate and NAcc—using the neuromorphometric atlas provided by CAT12. All of these volumes were estimated in native space before any spatial normalization. These volumes were exported to SPSS to test our hypotheses. First, we calculated descriptive statistics and group comparisons for each variable using *t* tests or analyses of covariance (using TIV and age as covariates). Because gender was highly correlated with TIV, biserial $r(58) = .58$, $p < .001$, we did not include it as a covariate to avoid collinearity. Second, we calculated partial correlations between the BMRQ score and the four striatum volumes. In these correlations, we used age, TIV, and musicianship as covariates. Results were considered at an alpha of .0125, based on Bonferroni correction for multiple comparisons, taking into account that there were four striatum volumes to be correlated with the BMRQ score (one for each volume; $p < .05$). Additionally, we applied a hierarchical regression analysis to investigate the separate contribution of different factors to BMRQ scores. We introduced musicianship (as a dichotomous variable), TIV, and age in the first step; JMTT in the second step; and the four volumes of the striatum in the third step. These volumes were introduced in the last step using a forward stepwise approach with a *p* value of less than .05 to introduce a variable in the model.

Results

The means, standard deviations, and results of *t* tests comparing the two groups on all measures are summarized in Table 1. As we expected, musicians obtained higher scores on the global BMRQ; this global difference between groups was mainly driven by musicians showing higher scores on the music-seeking, emotion-evocation, and social-reward scales. In addition, musicians obtained higher scores on the JMTT pitch-discrimination test. No between-groups differences were obtained in volumetric measures.

Partial correlations between BMRQ global scores and volumetric measures for each group and for the whole sample appear in Table 2. Age, TIV, and musicianship were used as covariates. The results showed that the BMRQ correlated negatively with the volume of the striatum (both caudates and left NAcc; see Fig. 1). Some of those correlations did not reach significance when we analyzed the two groups separately (musicians and nonmusicians). However, it is relevant that those correlations were significant overall, which means that the relation between the BMRQ scores and the volume of those three structures was not restricted to one of the groups.

To test for the possible influence of musical abilities on music reward, we calculated the partial correlation between the overall BMRQ and the JMTT and found it to be significant for the overall sample, $r(50) = .37$, 95% confidence interval (CI) = [.12, .57], $p = .007$ (age, musicianship, and TIV as covariates). The same partial correlation was significant for musicians, $r(27) = .55$, 95% CI = [.25, .75], $p = .002$, but not for nonmusicians, $r(20) = .20$, 95% CI = [–.20, .54], $p > .10$.

We performed a hierarchical multiple regression analysis to examine whether each of the four striatum volumes and the JMTT independently contributed to explaining the variance in the BMRQ global score (our dependent variable). In the first step, TIV, age, and

Table 1. Means and Between-Groups Comparisons

Variable	Nonmusicians (n = 26)	Musicians (n = 32)	Comparison
Barcelona Music Reward Questionnaire score			
Overall	75.54 (9.55)	81.16 (6.51)	$t(56) = 2.65^{**}$
Music seeking	12.34 (2.63)	13.56 (1.75)	$t(56) = 2.10^{*}$
Emotion evocation	16.03 (2.84)	17.78 (1.82)	$t(56) = 2.83^{**}$
Mood regulation	16.92 (2.00)	17.34 (2.35)	$t(56) = 0.72$
Sensory-motor behavior	14.46 (1.53)	14.87 (1.00)	$t(56) = 1.23$
Social reward	15.76 (3.05)	17.59 (1.93)	$t(56) = 2.77^{**}$
Jake Mandell Tonedeaf Test score	68.88 (9.94)	76.56 (9.46)	$t(56) = 3.00^{**}$
Left caudate volume (cc)[a]	3.20 (0.39)	3.22 (0.30)	$F(1, 54) = 0.14$
Right caudate volume (cc)[a]	3.25 (0.39)	3.28 (0.33)	$F(1, 54) = 0.23$
Left nucleus accumbens volume (cc)[a]	0.44 (0.06)	0.45 (0.04)	$F(1, 54) = 0.05$
Right nucleus accumbens volume (cc)[a]	0.44 (0.05)	0.44 (0.04)	$F(1, 54) = 0.06$

Note: Values in parentheses are standard deviations.
[a]We controlled for age and total intracranial volume when analyzing this variable.
$^{*}p < .05$. $^{**}p < .01$.

musicianship were entered into the equation. In the second step, JMTT was entered in the model. In the third step, the four striatum volumes were included. Because the four volumes were strongly correlated, this last factor was entered using a forward stepwise approach. The results are summarized in Table 3. These results revealed significant effects for musicianship and TIV in Step 1, indicating that musicians and individuals with smaller TIVs had higher BMRQ scores. As we expected, the contribution of individual differences in pitch-discrimination abilities to explaining music reward was significant in Step 2. Moreover, the volume of the left caudate had the greater significant (negative) contribution among the striatum volumes to music reward in Step 3, explaining—along with musicianship and pitch-discrimination abilities—42% of the variance, $F(5, 49) = 8.81$, $p < .001$, in this final Model 3.

Finally, we performed three complementary hierarchical regression analyses. In each of them, we included one of the three striatum volumes other than the left caudate. These three separate regression analyses resulted in similar significant models in which striatum volumes were negatively correlated with BMRQ scores, explaining variances of 40%, 40%, and 37% for the right caudate, the left NAcc, and the right NAcc, respectively.

Discussion

In the present study, we investigated anatomical differences associated with music reward in a group of participants composed of both musicians and nonmusicians. The statistical analysis using ROIs showed a negative relationship between music reward and striatum volume (mainly the caudate nucleus but also the left NAcc) in both groups. This result is consistent with previous findings that general reward sensitivity may be related to striatum volume. However, the observed positive correlation between music-reward scores and the scores obtained in the pitch-discrimination task revealed that individual differences in music-reward sensitivity depend not only on the participation of reward-processing networks but also on auditory capacities.

The BMRQ scores obtained in the present study were similar to those reported in previous studies (Mas-Herrero

Table 2. Partial Correlations Between Brain Volumes and Scores on the Barcelona Music Reward Questionnaire for Each Group and for the Overall Sample

Group	Left caudate	Right caudate	Left nucleus accumbens	Right nucleus accumbens
Nonmusicians	−.55[a] [−.77, −.21]	−.50 [−.74, −.14]	−.31 [−.62, .09]	−.38 [−.67, .01]
Musicians	−.40 [−.66, −.06]	−.45[a] [−.69, −.12]	−.36 [−.63, −.01]	−.25 [−.55, .11]
All participants	−.45[a] [−.63, −.22]	−.43[a] [−.62, −.19]	−.36[a] [−.56, −.11]	−.28 [−.50, −.02]

Note: Values in brackets are 95% confidence intervals. Covariates were age and total intracranial volume (TIV) for individual groups and musicianship, age, and TIV for the overall sample.
[a]The alpha for this value was Bonferroni corrected from .05 to .012.

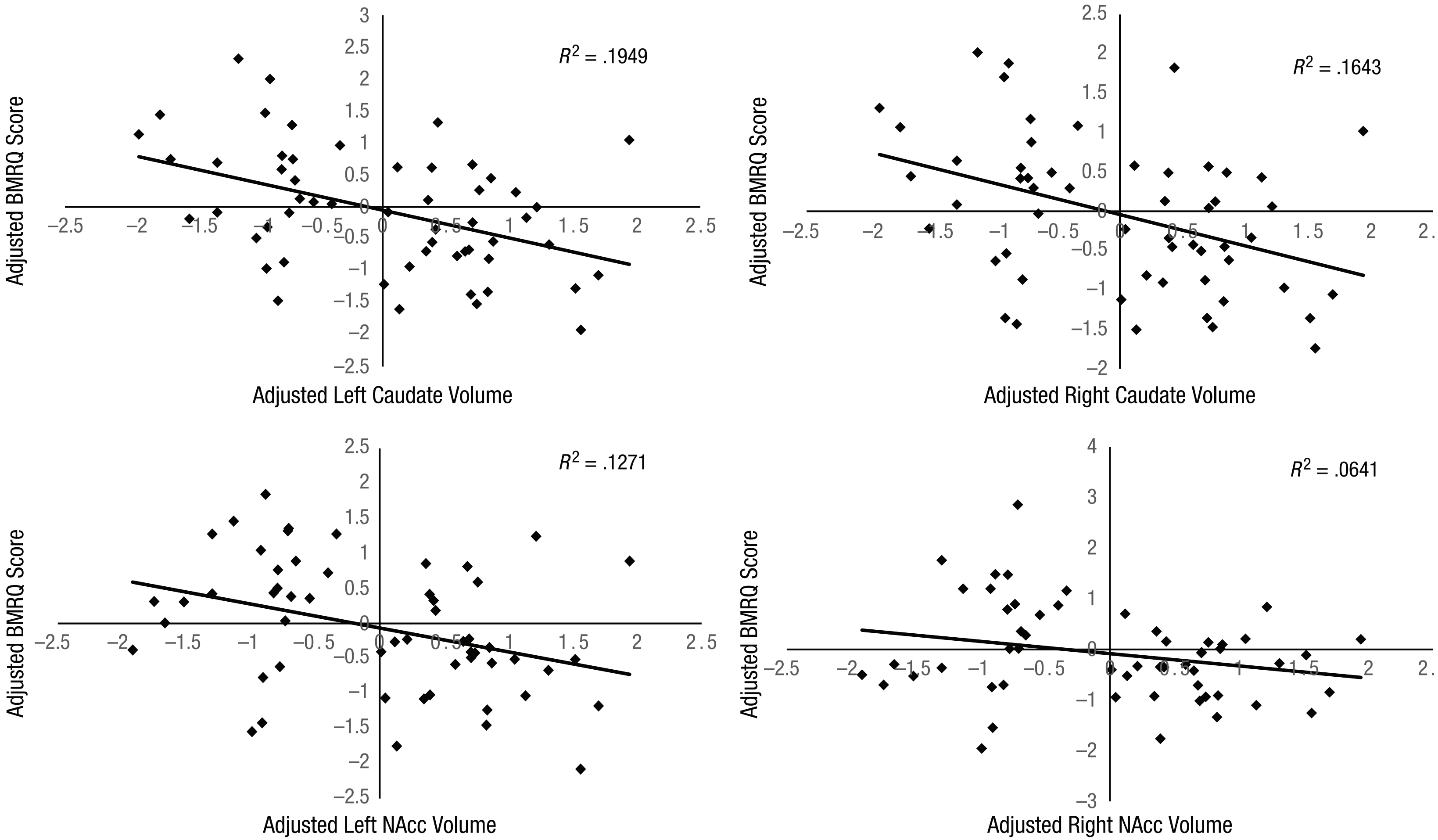

Fig. 1. Scatterplots (with best-fitting regression lines) representing the relationship between volume in each of four striatum regions and Barcelona Music Reward Questionnaire (BMRQ) scores (controlling for total intracranial volume, musicianship, and age). Volumes on the *x*-axes are standardized. NAcc = nucleus accumbens.

Table 3. Results of the Hierarchical Regression Analysis on Barcelona Music Reward Questionnaire Scores

	Model 1 (Adjusted R^2 = .24***)		Model 2 (Adjusted R^2 = .33***; ΔR^2 = .09)		Model 3 (Adjusted R^2 = .42***; ΔR^2 = .09)	
Step and variable	Adjusted β	Partial *r*	Adjusted β	Partial *r*	Adjusted β	Partial *r*
Step 1						
Age	–0.12	–.13	–0.11	–.32	–0.12	–.18
Total intracranial volume	–0.29*	–.32	–0.35**	–.40	–0.16	–.16
Musicianship	0.42***	.44	0.29*	.27	0.35**	.40
Step 2						
Jake Mandell Tonedeaf Test			0.34**	.37	0.26*	.30
Step 3						
Left caudate volume					–0.36**	–.38

*$p < .05$. **$p < .01$. ***$p < .001$.

et al., 2013; Mas-Herrero et al., 2014). As we expected, these scores correlated with striatum volume, especially in the caudate nucleus. This correlation was observed for both groups, without any global differences between musicians and nonmusicians. The caudate nucleus is involved in decision making, behavior activation, and reward-related habit learning, whereas the NAcc is more involved in detecting reward-cue value (Robbins & Everitt, 1992). The BMRQ taps both aspects but may be more focused on behavior (Mas-Herrero et al., 2013). This result is consistent with those of recent studies describing that a smaller volume of striatal areas is related to high reward sensitivity (Barrós-Loscertales et al., 2006). This personality dimension is associated with individual differences in detecting and approaching cues linked to different kinds of rewards, such as sexual stimuli, monetary incentives, or social recognition (Pickering & Gray, 2001). Even though we did not measure reward sensitivity (which is a limitation in this study), the positive correlation between the BMRQ global score and reward sensitivity shown by Mas-Herrero et al. (2013) leads us to assume that music and nonmusic reward may share similar brain mechanisms in the striatum (Salimpoor et al., 2011). In this regard, recent evidence showed that lower striatum volume predisposes one to a greater desire for specific rewards, such as the pleasure some individuals experience with Facebook usage (Montag et al., 2017), pornography consumption (Kühn & Gallinat, 2014), immediate gains (Tschernegg et al., 2015), and substance abuse (Urošević et al., 2015). Also, this pattern of smaller volume in areas of the striatum has also been found in clinical studies with cocaine- and alcohol-dependent subjects (Barrós-Loscertales et al., 2011; Grodin & Momenan, 2017) as well as in patients with attention-deficit/hyperactivity disorder (Shaw et al., 2014).

Current neuroscience acknowledges the striatum as an interface between motivational and cognitive systems; the striatum organizes and selects behavior associated with biologically relevant stimuli, such as those involving reward, and establishes dominant reward-related responses (sometimes in the form of habits; Stocco, Yamasaki, Natalenko, & Prat, 2014). Together with the prefrontal cortex, the striatum appears to be involved in those neural mechanisms that give flexibility to behavior-selection and action-initiation processes (Aarts, van Holstein, & Cools, 2011). A lower striatum volume could therefore be associated with increased incentive salience and reward detection, which could in turn facilitate the activation of motivational resources to guide reward-oriented responses. In this regard, individuals with stronger reward sensitivity (or stronger music-reward sensitivity) show a stronger striatal response to rewards (Costumero et al., 2013; Martinez-Molina et al., 2016). Also, recent studies have shown that variations in the dopamine system or the function of frontostriatal circuits are directly related to the experience of music-induced reward (Mas-Herrero, Dagher, & Zatorre, 2018). Individual differences in striatal volume have also been associated with differential dopamine levels in these areas, which may imply that a lower striatal volume was associated with greater endogenous dopamine (Caravaggio et al., 2017). Lower striatal volume might be associated with reduced flexibility with respect to deciding how or when to make reward-related approach responses and a limit to the capacity for weighting potential reward values and potential negative consequences.

Prior research has shown that music-reward sensitivity may be partially dissociated from general reward sensitivity, even if they might share similar neuroanatomical mechanisms. Mas-Herrero et al. (2014) reported that individuals with music anhedonia who showed poor psychophysiological activation in response to music-induced chills showed normal sensitivity to different kinds of rewards, including food, sex, money, exercise, and drugs of abuse. What are the factors that may help explain the differences between music- and nonmusic-reward sensitivity? The results obtained in the present study are consistent with the idea that music-discrimination skills can influence music reward. We observed that music reward correlated with striatum volume but also with pitch-discrimination abilities. Our results show that scores on the JMTT correlated with music reward for the musicians and the overall sample, suggesting that individual differences in music reward are indeed related to the ability to perceive music. It is important to note that striatum volume and pitch discrimination contributed significantly to the explanation of individual differences in music-reward sensitivity.

Previous research in music processing has revealed the existence of an interaction between cognitive and emotional factors. Some of this evidence was obtained in individuals with amusia, a disorder characterized by severe impairment of music perception or production caused by abnormal brain development (congenital) or brain damage (acquired). Amusia was associated with reduced gray matter or lesions in the right superior temporal gyrus along with the striatum and inferior frontal gyrus (Sihvonen et al., 2016). In some cases, amusia was accompanied by music anhedonia (Hirel et al., 2014). Importantly, individuals with amusia show reduced sensitivity to consonance and harmony in chords, as reflected by pleasantness ratings (Cousineau, McDermott, & Peretz, 2012) and impaired recognition of emotions derived from pieces of music (Lévêque et al., 2018). Thus, the lower capacity of pitch discrimination in individuals with amusia was associated with a blunted emotional response to music. Individual differences in music reward have also been associated with a specific response in the striatum, accompanied by a different connectivity with the auditory cortex (Martínez-Molina et al., 2016). Thus, we suggest that emotional and cognitive factors contribute to explaining the individual differences in music reward.

The present results are relevant in characterizing the concept of reward sensitivity. The data obtained for music-reward sensitivity indicated that this concept should be characterized as multifactorial, adding the influence of a global predisposition in the striatum and a specific factor, in this case, related to music abilities. Martínez-Molina et al. (2016) demonstrated the relevance of the functional connectivity between the striatum and the auditory system in accounting for differences in music reward. Thus, the interplay between cognition and emotion should be considered in order to understand the individual differences in sensitivity to specific rewards. We acknowledge that a limitation of the present study is that the sample size may not be considered particularly large. In this regard, however, we have no reason to believe that the results cannot be generalized universally.

Action Editor

Philippe G. Schyns served as action editor for this article.

Author Contributions

M. Hernández, R. Pastor, C. Ávila, and M.-A. Parcet developed the concept of the study. All the authors contributed to the design of the study. M. Hernández, M.-Á. Palomar-García, G. Olcina-Sempere, and B. Nohales-Nieto performed testing and data collection. M. Hernández, M.-Á. Palomar-García, B. Nohales-Nieto, and E. Villar-Rodríguez analyzed and interpreted the data under the supervision of M.-A. Parcet and C. Ávila. R. Pastor, C. Ávila, and M.-A. Parcet provided critical revisions. All the authors approved the final manuscript for submission.

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Declaration of Conflicting Interests

The author(s) declared that there were no conflicts of interest with respect to the authorship or the publication of this article.

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Open Practices

Data and materials for this study have not been made publicly available, and the design and analysis plans were not preregistered.

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