Music Empathizing and Music Systemizing are Associated with Music Listening Reward

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Music empathizing (ME) and music systemizing (MS) are constructs representing cognitive styles that address different facets of interest in music listening. Here we investigate whether ME and MS are positively associated with feelings of reward in response to music listening (MR). We conducted an online-survey in which $n = 202$ (127 identifying as female) participants, $M_{\text{age}} = 26.06$ years, $SD_{\text{age}} = 8.66$ years, filled out the Music-Empathizing-Music-Systemizing (MEMS) Inventory, the Barcelona Questionnaire of Music Reward (BMRQ), further music-related inventories, and ad hoc items representing general interest and investment in music listening. Results from a conditional inference tree analysis confirm our hypothesis by showing ME followed by MS were the most important predictors of MR. In addition, subscription to music streaming services and investing free time into music listening were also associated with higher MR. These results suggest that perceiving reward through music listening is a function of both music empathizing and music systemizing. The nonsignificant contributions of music sophistication and music style preferences deny a larger role of these factors in MR. Further research is needed to investigate the interrelationships of musical cognitive styles and MR to refine our understanding of the affective value of music listening.

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Billions of people around the globe listen to music regularly in their free time (Park et al., 2019). Evolutionary theories of music explain such inclinations as culturally and biologically grounded (Savage et al., 2020). However, there are profound individual differences in both motivation and interest in listening to music. To explain such differences, both the so-called cognitive styles (Greenberg, Baron-Cohen, et al., 2015), as well as in the ability to perceive reward in response to music listening (Holm et al., 2020) have been suggested as significant sources of variation in listening behaviors. Here we explored how these traits are related and whether individual approaches to music listening can predict the reward associated with music listening. Baron-Cohen theorized on the existence of two distinct cognitive styles: Empathizing and systemizing (Baron-Cohen, 2002). Empathizing is thought to represent the cognitive capacity to perceive and understand other individual's affective state and feelings. Systemizing is thought to represent the cognitive capacity to understand rule-based systems (Lawson et al., 2004). Based on this theory, two avenues of research on the implications of these constructs to music-related phenomena have been suggested.

The first has been to combine the original empathizing and systemizing scales with music related inventories such as preferences and performance. For example, Greenberg, Rentfrow, & Baron-Cohen (2015) found that the theory provided a solid framework to investigate how music could increase empathy in the general population and in individuals with autistic spectrum conditions. In fact, the interrelatedness of music listening and empathy has been investigated at behavioral (Eerola et al., 2016) and neural levels (Wallmark et al., 2018) to suggest that music listing might evoke networks in the brain that are associated with the processing of social valence.

The second route to gain better insight into cognitive styles and music-related behavior has led to the development of the music empathizing and music systemizing (MEMS) inventory (Kreutz et al., 2008). These authors conducted two online surveys, which confirmed and specified the E-S traits for the music domain. In particular, they observed that music empathizing (ME; i.e., the interest in social-emotional aspects of music production and performance) was more pronounced in females than males, whereas music systemizing

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(MS; i.e., the interest in technical aspects of music production and performance) was more pronounced in males. This mirrors findings of Wakabayashi et al. (2006), who found similar sex differences with a general empathizing and systemizing questionnaire.

Kreutz et al. (2008) found that musical expertise showed a positive correlation with levels of MS. Linnemann et al. (2018) extended these findings by showing that music systemizers and music empathizers differ in their music preferences, preferred listening contexts, and motivations for listening to music. Recently, the ME construct was further tested on Chinese participants (Zhao et al., 2021). The authors observed no sex differences for ME. Instead, music expertise and general measures of empathy were identified as important predictors, which suggests that cultural influences could play a role for music empathizing.

Empathizing and systemizing are related to emotional responses to music listening and thus may represent useful constructs in studying individual differences in such responses. For example, Kantor-Martynuska and Horabik (2015) found that ME and MS were both related to emotional responses to music listening. This means that despite the inherent differences in these dimensions their roles in music-induced emotions could be rather similar. In other words, emotional responses to music do not necessarily rely on high levels of empathizing, the trait that is more associated with the processing of affective states. Instead, high levels of either or both traits could be predictors in this relationship.

Völker (2021) also included the MEMS scales in her study on psychological mechanisms and individual differences in emotional responses to music listening. This author observed a number of correlations between both traits and variables related to the activation of emotional responses. Finally, Greenberg, Baron-Cohen and colleagues (2015) found that empathizers were more interested in low arousal music, whereas systemizers showed greater preferences for high arousal music.

Recently, a further construct has been developed which is thought to address affective value of music listening, namely music reward. To this end, the Barcelona Music Reward Questionnaire (BMRQ) was designed to "explain the variance observed in how people experience reward associated with music" (Mas-Herrero et al., 2013). The authors decompose this music listening reward into five factors called Music Seeking, Emotion Evocation, Mood Regulation, Social Reward, and Sensory Motor. In light of substantial correlations between these factors, an overall Music Reward (MR) scale was established to capture the overall concept.

Mas-Herrero et al. (2013) observed similarities and differences to other psychological constructs of reward/anhedonia including the Physical Anhedonia Scale (PAS) and related constructs. This means, for example, that lack of MR might partially originate from a more general impairment of reward experiences. However, in a subsequent study, it was shown that MR was behaviorally and neurologically distinct from monetary reward experiences (Mas-Herrero et al., 2014). A further study of this group suggested that MR (and music anhedonia, respectively) is also independent from experiencing emotion from visual stimuli and from emotional acoustic stimuli (Mas-Herrero et al., 2018).

CURRENT STUDY AND HYPOTHESIS

Cognitive styles of music listening and music listening reward both address an affective dimension of music appreciation. However, we lack understanding regarding the extent to which these cognitive styles predict feelings of reward in response to music listening. Our current study aims to address this gap in knowledge with the use of the association between music-related cognitive styles and music reward using recently developed psychometric instruments. A positive association might indicate a common affective dimension of music appreciation. A subsidiary goal was to investigate the influence of music style preferences and music sophistication as moderating factors in the cognitive style-reward association. We hypothesize that there is a positive association between cognitive styles and music reward with higher levels of music empathizing and/or high levels of systemizing predicting higher levels of reward.

Method

The study protocol was assessed and cleared by the ethics committee of the Carl von Ossietzky Universität Oldenburg.

PARTICIPANTS

A total of $n = 276$ participants responded to the online survey hosted via LimeSurvey and recruited via email at different faculties. All participants confirmed fluency in German. After excluding incomplete or invalid data a total of $n = 202$ participants, $M_{age} = 26.06$ years, $SD_{age} = 8.66$ years, $min_{age} = 18$ years, $max_{age} = 73$ years, remained. Of these participants, 127 identified as female, 70 identified as male, and 2 identified as non-binary. The entire questionnaire took roughly

15 minutes. Participants had the option of entering a lottery for five 20€ vouchers.

Responses were considered incomplete ($n = 62$ participants) if the last page of the questionnaire was not reached. Responses were considered invalid ($n = 13$) if an attention check question embedded in the questionnaire was answered incorrectly. Data collection started in October 2021. To estimate the number of participants needed, we conducted a power analysis using G*Power for four main predictors, $\alpha = 0.05$, $1\text{-}\beta = 0.80$, $F^2 = 0.15$. The required sample size was $n = 85$. We concluded data collection after the number of complete responses exceeded 2.5 times this sample size to power additional exploratory data analyses in December 2021.

INSTRUMENTS

We employed a number of validated instruments as well as a few ad hoc items to assess behavioral and cognitive predictors of musical reward. Our main independent variable, musical reward, was assessed using the Barcelona Music Reward Questionnaire (BMRQ, Mas-Herrero et al., 2013). Our main predictors, music empathizing (ME) and music systemizing (MS), were assessed using the Music-Empathizing-Music-Systemizing (MEMS) Inventory (Linnemann et al., 2018). Further, participants completed the Short Test Of Music Preferences (STOMP, Rentfrow & Gosling, 2003) and items from the Goldsmiths Musical Sophistication Index (GMSI, Schaal et al., 2014).

Four ad hoc items were meant to assess whether general interest and disinterest in activities might influence participants' music listening reward. We asked participants to report whether they were currently being treated for psychological problems, whether they had received treatment for psychological problems in the past, and whether they frequently feel dejected. Further, they were asked to indicate whether they generally find joy in activities.

Additional ad hoc items queried general interest and investment in music listening: Participants were asked to list their three most preferred free time activities, whether they collect physical media of music, e.g., CDs or LPs, and whether they subscribe to music streaming services. Participants further reported the number of hours in a week they typically spend listening to music and how many of these hours they typically spend listening to music actively and passively (in the background, during another activity). Lastly, participants reported via six items whether they believe that others like or dislike their singing and music tastes.

DATA PROCESSING AND ANALYSIS

Summary measures were calculated for the BMRQ, MEMS, STOMP, and GMSI as described by the respective authors. From the list of three most preferred free time activities a binary variable reflecting whether music listening was listed among the three most preferred free time activities was calculated. The six items related to others' like or dislike for our participants' singing and music tastes were averaged, such that there was a separate average for items querying others' like or dislike for our participants' singing and for items querying others' like or dislike for our participants' music tastes.

The processed data were analyzed using a conditional inference tree analysis, with the BMRQ summary measure as the dependent variable, and all other variables along with sex and age entered as predictors. Conditional inference trees are a statistical approach to recursive binary partitioning (Hothorn et al., 2006), which is embedded into the theory of permutation tests (Strasser & Weber, 1999). The embedding guards against overfitting and binary partitioning guards against bias towards predictors with multiple splits, both of which are problems frequently encountered in other recursive partitioning algorithms (Mingers, 1987). As such, conditional inference tree analyses do not need to meet distributional assumptions and are able to handle larger numbers of predictors. The calculation and graphical representation of our conditional inference tree was conducted using the software package *partykit* (Hothorn & Zeileis, 2015) implemented in the free software environment *R* (R Core Team, 2013).

To interpret the conditional tree, one reads from top to bottom: The root node is the most important significant predictor, binary splits either lead to a terminal node indicating that no additional predictors are significant, or to intermediary nodes, which present less important significant predictors, from which further binary splits can either lead to a terminal node or additional intermediary nodes. Any predictors that were included in the analysis but do not form nodes are considered unimportant predictors.

Root and intermediary nodes are also called inner nodes. The higher the nodes the more important the predictor. End nodes are characterized by the distribution of values found for the dependent variable. Corresponding p values were extracted using the software package *strucchange* for each inner node (Zeileis et al., 2002), which assesses associations between variables with asymptotic permutations of Pearson correlation tests when both variables are numeric, and ANOVAs when one variable is numeric and the other categorical. All p values were Bonferonni adjusted where appropriate.

Results

This study's data is open accessible here https://bit.ly/3Oo4jSD. Table 1 presents the descriptive statistics of the standardized and nonstandardized measures, which were entered into the conditional tree analysis along with age and sex. The BMRQ, MEMS, and GMSI scores were within the range of the respective original studies. Cut-off values from Linnemann et al. (2018) were used to identify extreme empathizers, balanced individuals, and extreme systemizers. Females showed higher values in ME as compared to males, Welch's t-test; $t(141.23) = -1.96$, $p = .026$, whereas males showed higher values in MS as compared to females, Welch's t-test; $t(160.11) = 3.30$, $p < .001$.

TABLE 1. *Means and Standard Deviations of Variables Entered Into the Conditional Inference Tree Analysis*

Variable	M	*SD*	Counts
BMRQ	51.72	11.43	
Music Empathizing	3.55	0.72	
Music Systemizing	3.41	0.90	
ME-MS	0.14	0.90	
Extreme Music Systemizer			$n = 9$
Music Systemizer			$n = 38$
Balanced			$n = 106$
Music Empathizer			$n = 30$
Extreme Music Empathizer			$n = 19$
STOMP			
Reflective & Complex	4.24	1.37	
Intense & Rebellious	4.40	1.53	
Upbeat & Conventional	4.46	1.06	
Energetic & Rhythmic	4.26	1.41	
GMSI	4.38	1.22	
Music listening in top three free time activities			$n = 132$
Collects physical media of music recordings			$n = 71$
Subscribes to music streaming service			$n = 149$
Weekly hours of music listening	18.80	17.31	
Passive music listening	13.07	12.91	
Active music listening	5.02	8.50	
Others dislike participant's singing	3.15	1.30	
Others dislike participant's music taste	2.65	0.88	
Currently receiving psychological treatment			19
Has received psychological treatment in the past			41
Frequently feels dejected			73
Finds joy in many things			173

Table 2 summarizes the coefficients of correlations between the psychometric measures of the current study. Significant correlations were found for nearly all measures. Correlations between measures of music reward and cognitive styles give a first indication of a statistical commonality in these measures as expected. Substantial correlations can also be seen for music sophistication.

Next, a conditional inference tree analysis was performed to establish which of the variables emerged as predictors of music reward. Figure 1, which is a graphical representation of the determined tree, reveals six inner nodes and seven terminal nodes. Note that the BMRQ was designed such that the overall population mean is expected to be $M = 50$ and the standard deviation is expected to be $SD = 10$ (Mas-Herrero et al., 2013), thus BMRQ values below 40 or over 60 can be considered low or high respectively. ME and MS values can range between 1 and 5, as do the ad hoc item averages on other's perception of participants' singing and music tastes. The difference between ME and MS values (ME-MS) was further coded using the age norms presented in Linnemann et al. (2018). GMSI values can range between 1 and 7.

The root node at the top of the conditional tree shown in Figure 1, and thus the most important predictor for the BMRQ value, encoded in the terminal nodes, is the ME value, $p < .001$. When the ME value is ≤ 2.86, the MS value becomes significant in predicting BMRQ values, $p = .025$, see the two terminal nodes furthest to the left. MS, and the other inner nodes of the conditional tree, can thus be considered a moderating variable of sorts, in that the value of the terminal node is different for different values of the inner node. However, inner nodes are not moderators in that they only predict differences in BMRQ for a split of participants as determined by the previous node.

We next consider the other branches of the conditional tree from left to right: When the ME value is > 2.86 one can further differentiate between those that are ≤ 3.56 or those that are > 3.56, $p < .001$. When the ME value is > 2.86 but ≤ 3.56, whether the participant subscribes to a music streaming service becomes a significant predictor of BMRQ values, $p = .015$. When the ME value is > 3.56, whether the participant lists music listening among their three most favored free time activities becomes a significant predictor of BMRQ values, $p = .012$. For those that do list music listening among their three most favored

TABLE 2. *Coefficients of Correlations Between Psychological Measures, Music Preferences, and Music Sophistication*

				STOMP			
	BMRQ	ME	MS	R&C	I&R	U&C	E&R
ME	.65***						
MS	.40***	.39***					
R&C	.28**	.24*	.57***				
I&R	.13*	.13*	.23***	.30***			
U&C	.32***	.28**	.25**	.44***	.05		
E&R	.30***	.11*	.19*	.23*	.17*	.18*	
GMSI	.45***	.38***	.68***	.57***	.16*	.31***	.15*

Note: (n = 202); BMRQ = Barcelona Music Reward Questionnaire; ME = music empathizing; MS = music systemizing; STOMP = Short Test of Music Preferences; R&C = Reflexive & Conventional; I&R = Intense & Rebellious; U&C = Upbeat & Conventional; E&R = Energetic & Rhythmic; *p < .05; **p < .01; ***p < .001 (Bonferroni corrected).

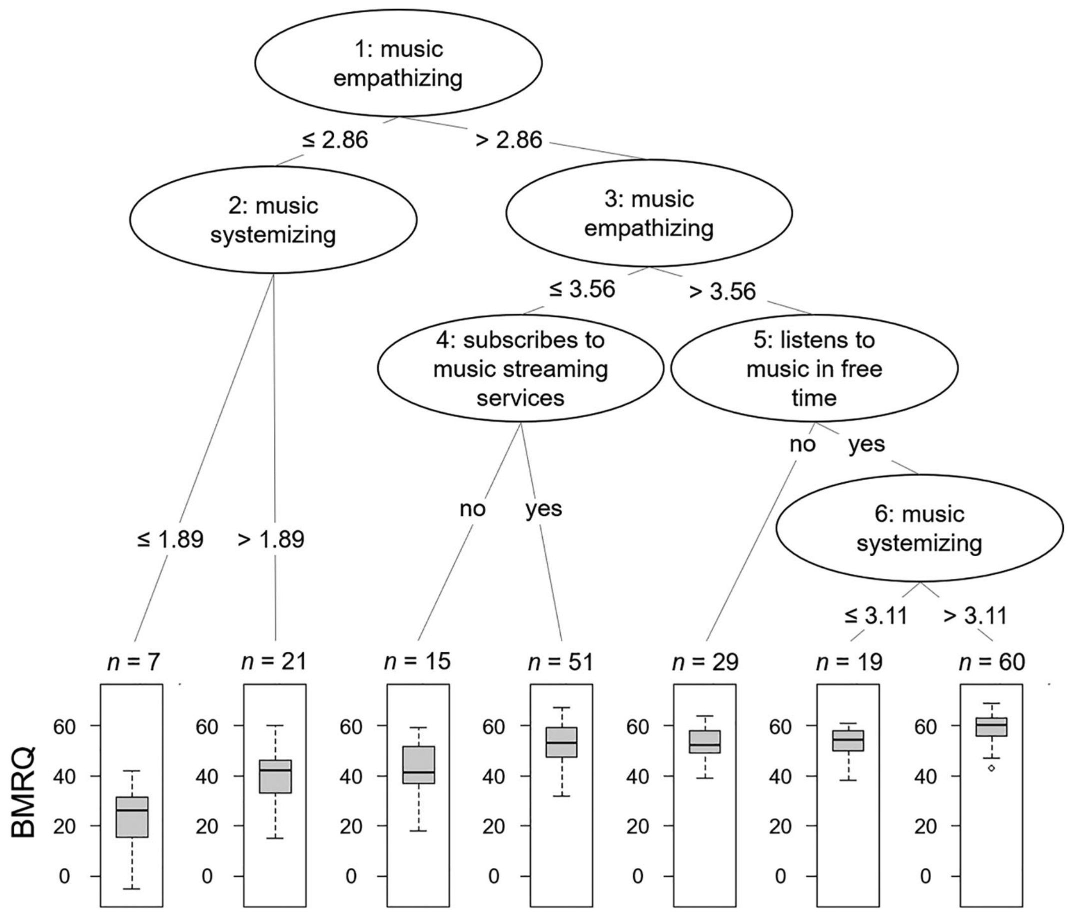

FIGURE 1. Conditional inference tree displaying six numbered inner nodes and seven terminal node boxplots. Terminal node boxplots visualize BMRQ values predicted by preceding nodes. Split criteria are displayed on the respective node branches.

free time activities, the MS value becomes a significant predictor of BMRQ, p = .029.

For all of these predictors, the association with the dependent variable BMRQ is positive, i.e., higher ME or MS values, and subscribing to a music streaming service and listening to music in free time are associated with higher BMRQ values. Figure 2 visualizes the association between the BMRQ and ME values, and BMRQ and MS values using a scatterplot. The proportion of explained variance for ME is $R^2 = 42.29\%$, $r(200) = .65$,

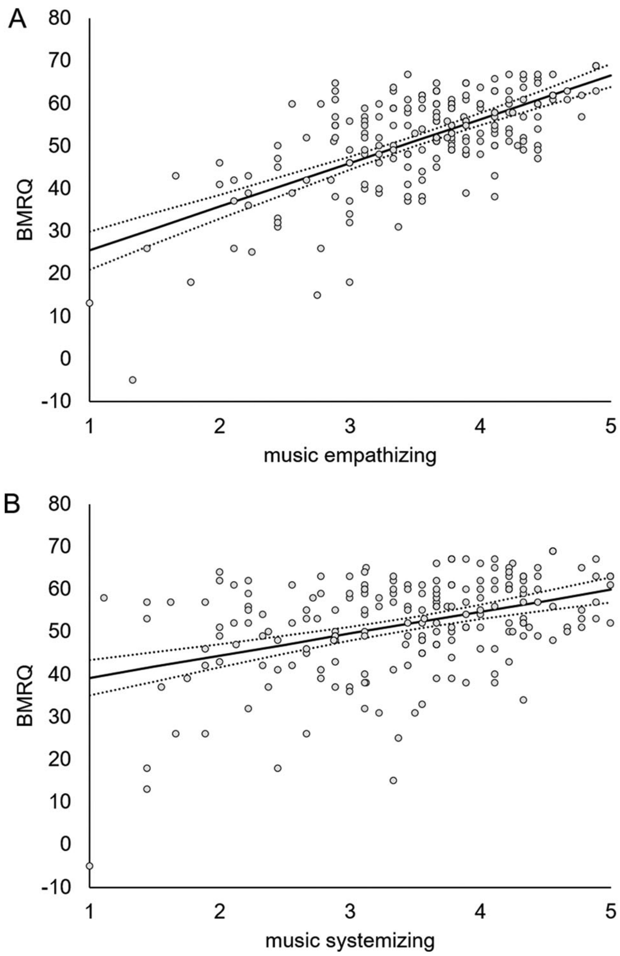

FIGURE 2. Scatterplots of music empathizing values from the MEMS Inventory and music listening reward as assessed using the BMRQ. Solid lines indicate the fitted regression line, dotted lines indicate their 95% confidence interval. Panel A shows the scatterplot for ME, Panel B shows the scatterplot for MS values.

$p < .001$; the proportion of explained variance for MS is $R^2 = 16.37\%$, $r(200) = .40$, $p < .001$.

The difference between ME and MS values, age-normed classifications based on the difference, GMSI, STOMP, ad hoc items on general disinterest, reported hours of music listening, the collection of physical music recordings, and participants' beliefs on others' perception of their singing and music taste, as well as age and sex did not contribute significantly to the prediction of BMRQ.

Discussion

We hypothesized that cognitive styles of music listening called music empathizing and music systemizing (MEMS) may predict the ability to perceive musical reward (MR). Our findings confirm this assumption by showing that ME and MS explained about 42 and 16 percent of the variance in MR. This means that high values of either or both cognitive styles scales were associated with high values in MR, and vice versa. However, lower levels of ME were more consistently associated with weaker feelings of MR as compared to low level MS, which was still associated with strong feelings of MR in some listeners, as shown also in the order of importance of these predictors in the conditional tree analysis. The overall confirmation of the hypothesis offers different interpretations as will be explicated below.

First, the MEMS scales represent music-related traits to reflect the fact that interest in music can arise equally from emotional and intellectual engagement. In other words, according to this theory reward in response to music listening might be predicted from high levels of ME (in the presence or absence of high levels of MS), and vice versa. Note that reward or pleasure in response to music listening does not necessarily depend on high ME as long as MS values indicate elevated interest in rule-based or technical aspects in the musical fabric. This notion is generally supported by the observation of significant positive correlations between both cognitive style measures and MR. However, MS shows a weaker correlation with MR and also appears as a secondary predictor as compared to ME.

There are at least two possible explanations of the above findings. First, it may be that high MS offers generally less musical reward than does high ME. In other words, technical aspects of music could stimulate interest and give enough reason for music engagement, but such interest may fall short of giving rise to strong emotional responses indicating high levels of pleasure and reward. Clearly, this interpretation appears not in line with the empathizing and systemizing theory as proposed by Baron-Cohen (2002).

A second explanation of a weaker MS-MR association as compared to the ME-MR might be that the BMRQ may contain a bias towards the music empathizing trait than the music systemizing trait. Indeed, in its present form, the BMRQ addresses emotional, social, and motor aspects, while neglecting the potentially rewarding nature of interest in music as a rule-based system. Therefore, it seems likely that the construct of MR may need to be revised and extended to fully capture the genuinely rewarding aspects of music listening.

Other music listening constructs of our analyses were found to also be significantly correlated with MEMS and MR. However, the conditional inference tree analysis showed that not all variables that were correlated with music reward were also acting as significant predictors. To the contrary, we found that neither music preferences nor music sophistication predicted higher or lower values of musical reward over and above the cognitive styles ME and MS. However, the latter observation stands in contrast with recent findings according to which the latter was positively associated with musical empathizing and systemizing traits (Dahary et al., 2020). Therefore, it seems important to further explore especially to what extent and how engagement in music is a function of motivation, interest, and reward in response to music listening.

Two further variables provided information to explain variations in MR, namely whether or not participants subscribed to streaming services, and whether or not they allocated free time for listening to music. Both variables appear related to the Music Seeking factor that dominates the BMRQ (Mas-Herrero et al., 2013). In other words, to an extent, music reward mirrors the readiness for physical investment in terms of financial and time resources to accommodate a need for music listening. Although secondary to the cognitive style measures, reward does not arise without commitment, or rather the opportunity to commit.

Some authors have referred to lower levels of BMRQ as indicative of lack of musical reward and music-specific anhedonia (Mas-Herrero et al., 2013, 2018). The inability to feel pleasure or reward to music listening has been previously described as a neurological condition that affects specific cortical and subcortical pathways in auditory-affective processing (Holm et al., 2020).

Belfi and Loui (2020) argue that connectivity in cortical and subcortical brain structures that are specifically associated with predictive auditory processing and dopaminergic responses to music stimuli is critical with respect to the presence or absence of musical anhedonia (Belfi & Loui, 2020). The hypothesis that musical anhedonia is based on neural correlates that differ from other types of anhedonia is further corroborated by research which shows that individuals suffering from major depression and anhedonia may find benefit in music interventions as an adjunctive treatment to alleviate psychophysiological symptoms (Braun Janzen et al., 2019). Therefore, it is assumed that music-specific anhedonia may arise from brain injury or disease, or it may have congenital origins. The current study, however, does not address musical anhedonia per se. Moreover, we found that the ad hoc items with which we assessed potential for general anhedonia (see Table 1) did not offer predictive value to musical reward. For the time being we consider varying degrees of feelings of musical reward as a naturally occurring phenomenon that does not necessarily implicate a neurological condition. Future studies would require specific recruitment strategies in the context of planned study protocols to properly examine how low reward to music listening can be predicted and differentiated from neurologically grounded musical anhedonia.

In sum, the questions surrounding the variations in feelings of reward to music listening from individual to individual can be at least partially answered by turning to music-related cognitive style traits. We observed that music empathizing appears to have a greater explanatory value in predicting greater or lesser reward as compared to music systemizing. However, reflecting musical emotions or empathetic styles of listening are not necessarily prerequisites in experiences of reward and pleasure from listening to music for all individuals. Instead, interest and motivation to engage in music listening may arise from different routes that may or may not entail aspects of social valence.

LIMITATIONS

The study used a cross-sectional design that precludes a deeper understanding of the mechanisms and the causality that might link cognitive styles of music listening and music-listening reward. Although the constructs being employed were validated and subject to different lines of research, there remains uncertainty especially with respect to the BMRQ as to whether it fully captures the facets that are linked with strong feelings of music reward, and whether it is sensitive to differentiate clinical and subclinical anhedonia. These methodological issues may limit the interpretation of the present findings, especially as the set of constructs did not include validated measures of anhedonia, trait empathy, or empathizing and systemizing. Nevertheless, our preliminary observations substantiate the assumption of an intrinsic communality that underlies both varying interests in and reward in response to music listening.

A second limitation could arise from a self-selection bias in our sample. The simple reason for such a bias is the advertisement of the survey with a focus of interest (or lack of interest) in music. The key word “music” may have had a positive impact for those participants with greater affinity to music in some form. This may have led to an underrepresentation of individuals that lack in both interest and reward in music listening. In light of this potential bias, a positive shift of MR/MEMS could be assumed and, in consequence, an underestimation of the true distribution of these variables in the general population.

Conclusions

We found a positive relationship between music empathizing and music systemizing on the one hand, and music reward on the other. The scales that were used to assess this association were both previously validated and offer differential views on how music is processed and how music listening may elicit emotional responses. Our results suggest that the MEMS scales and BMRQ tap into the same or at the least a highly similar affective dimension of music listening. Further research is needed to ascertain this relationship and further explore the hypothesis that pleasure in music listening may be evoked by independent channels of processing, which may or may not be related to social valence measures including empathy or emotional expression.

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