Misophonia is associated with heightened emotion evocation by music

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Abstract

Misophonia is a disorder commonly characterized by negative emotional responses to "trigger" sounds, such as chewing or tapping. It has been linked to conditions like hyperacusis and PTSD; however, the relationship between misophonia and musical processing remains underexplored. Under the framework that misophonia stems from altered connectivity between auditory and limbic systems, we predicted that individuals with greater misophonia severity would also show stronger emotional responses to music. From a large initial screening study (n = 300), a subset of participants (low misophonia: n = 58, high misophonia: n = 40) were asked about several musical and non-musical traits. Participants in the high misophonia group scored higher than the low misophonia group on several musical measures, including active engagement with music and emotion evocation from music. Participants in the high misophonia group also scored higher than the low misophonia group on hyperacusis and PTSD tendencies, replicating prior work. The present study supports conceptualizing misophonia in terms of enhanced auditory-emotional responses, to both negative ("trigger") and positive stimuli, such as music. These findings fit within a small but growing body of research highlighting the positive emotional implications of misophonia, particularly in musical contexts.

Keywords: misophonia, auditory processing, music perception, emotion

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You hear your friend sniffling next to you and are instantly enraged. Your coworker is tapping their pen on the table during a meeting, and your physiological stress response is activated. You avoid eating dinner with your family, so you don't have to hear them chewing. In human auditory processing, the response to everyday sounds, such as chewing, breathing, or keyboard tapping typically garners little attention. But for some individuals with *misophonia*, these everyday sounds can turn into a cacophonous nightmare, invoking a visceral and uncontrollable negative response.

Misophonia is a condition where individuals experience an exceptionally strong negative emotional response (e.g., anger, anxiety) to specific "trigger" sounds or stimuli associated with such sounds (for review see Brout et al., 2018; Potgieter et al., 2019). These negative responses do not seem to be elicited by general psychoacoustic features of a sound (e.g., loudness, roughness), but rather by the specific meaning to an individual (Swedo et al., 2022). Trigger sounds tend to be repetitive and generated by the body (e.g., orofacial sounds); however, any sound in principle could serve as a trigger for someone with misophonia. Although the mechanisms underlying misophonia are still debated (e.g., see Palumbo et al., 2018), one possibility is that affective brain networks are in a heightened state of excitation in response to auditory input among individuals with misophonia (Møller, 2011). In support of this framework, Kumar et al. (2017) found heightened activity and altered functional connectivity of the anterior insular cortex – a core component of the salience network - among individuals with misophonia when listening to trigger sounds.

Misophonia is distinct from other auditory processing conditions, such as hyperacusis, which is characterized by physical discomfort or pain upon hearing sounds at a level of loudness

that would be tolerable for most people (Henry et al., 2022). Unlike misophonia, hyperacusis is not confined to specific trigger sounds but encompasses a wide array of everyday noises, often rendering even moderate decibel sounds unbearably loud and uncomfortable for those experiencing it. While auditory disorders, including hyperacusis, are often comorbid with misophonia (Jastreboff & Jastreboff, 2014), it is worth noting that the field of audiology generally classifies misophonia as a subtype of hyperacusis, rather than a distinct disorder (Tyler et al., 2014). The potential link between experiencing misophonia and hyperacusis remains unclear. It is theorized that distressing hyperacusis might amplify anxiety and depression, heightening an individual's likelihood of developing a strong reaction to trigger sounds, as seen in misophonia (Aazh et al., 2022). Alternatively, hyperacusis could potentially divert an individuals' attention, preventing them from attending to potentially bothersome misophonic trigger sounds (Aazh et al., 2022). The relationship between misophonia and hyperacusis thus remains uncertain. There is no clear indication of whether the likelihood of experiencing misophonia is associated with hyperacusis. It is important to note that previous studies have not thoroughly examined the relationship between the impact of hyperacusis and the presence of misophonia. However, a study by Aazh et al. (2022) identified that among a population seeking assistance from an audiology clinic for tinnitus (a perceived ringing or buzzing sound that does not have an external source) and/or hyperacusis, 23% were classified as also having misophonia.

Initially, misophonia was not thought to be associated with psychopathology (Jastreboff & Jastreboff, 2014). However, accumulating research shows that the condition is associated with elevated anxiety and stress-related symptoms, as well as increased co-occurrence with anxiety disorders, post-traumatic stress disorder (PTSD), autism spectrum disorder (ASD), mood disorders, and attention deficit hyperactivity disorder (Abramovitch et al., 2024; Erfanian et al.,

2019; Potgieter et al., 2019). Research has even found genetic correlations between misophonia and psychiatric personalities/disorders including major depression disorder, PTSD, generalized anxiety disorder, and neuroticism (Smit et al., 2023). Neuroticism is the tendency to experience frequent and intense negative emotions in response to various sources of stress. The responses include anxiety, irritability, anger, and the experience of anxious or depressive moods (Barlow et al., 2014). Anger and anxiety are common emotional responses to misophonic triggers (McKay et al., 2018), suggesting that neuroticism could be useful in understanding misophonia. It has been suggested that neuroticism may be a potential vulnerability factor for misophonia, as neurotic individuals may be prone to developing misophonic reactions to sounds they find aversive (Cassiello-Robbins et al., 2020).

Less is known about misophonia as it relates to musicianship and music processing, although there is some evidence that active musicians experience higher noise sensitivity than non-musicians (Franěk, 2009; Jansen et al., 2009). Although there are anecdotal accounts of musicians who experience misophonia (Kuehn, 2015), few studies have directly examined whether musicians are more likely than non-musicians to experience misophonia. It is evident that musicians differ from non-musicians in their response to both musical and non-musical sounds, particularly affective sounds. There is overwhelming evidence that musicians process fundamental musical components such as pitch, melody, timbre, chords, and musical rhythm more efficiently than non-musicians (Franěk et al., 1991; Matthews et al., 2016; Rammsayer et al., 2012; Repp, 2010). Musicians also outperform non-musicians in recognizing emotion conveyed through music, and they have more consistent, rapid, and intense experiences with both positive and negative musical emotion (Akkermans et al., 2019; Castro & Lima, 2014; Park et al., 2014; Steinbeis et al., 2006). Musicians have been shown to have stronger emotional

responses than non-musicians, with specific neural activations linked to their musical training. For example, musicians rate sadness and fear as significantly more arousing than non-musicians, and musical training has been linked to specific neural activations in response to these emotions expressed in music (Park et al., 2014). In summary, musicians differ from non-musicians in their emotional responses to both musical and non-musical sounds; thus, if individuals higher in misophonia symptomology are also more likely to be musicians, this could be one potential explanation for why individuals with misophonia might experience heightened emotional responses to music.

Even if misophonia is not associated with greater amounts of musical training, there are other reasons to expect that misophonia might relate to the emotional processing of music. If misophonia is characterized by altered auditory-limbic connections, as has been suggested (e.g., Jastreboff & Jastreboff, 2023), then individuals experiencing misophonia might demonstrate altered (heightened) affective responses to positive sounds, such as music. In support of this idea, recent work has found a positive correlation between video-induced misophonic experiences and frisson reactions to music ("chills" or "goosebumps"), indicating that listeners who experience greater misophonic reactions also have increased physiological reactions associated with emotion processing in the context of music (Mednicoff et al., 2023). These authors also find positive associations between misophonic experiences and autonomous sensory meridian response (ASMR), which is commonly described as a pleasant tingling sensation across the head or back of the neck in response to certain auditory stimuli (Rouw & Erfanian, 2018). These studies suggest that individuals with more severe misophonia symptoms may experience overall heightened associations between sounds and affect, regardless of positive or negative valence.

The current study uses a quasi-experimental design to assess how misophonia relates to facets of auditory and emotional processing, with a specific emphasis on musical processing. A large sample of participants initially completed the Amsterdam Misophonia Scale (A-MISO-S) as part of a pre-screening study. Two groups of participants, matched on demographic variables (e.g., age, gender, education, race/ethnicity) but differing in misophonia severity, were then invited to complete the main study, which assessed participants' musicality, emotional responses to music, general auditory sensitivity and preference, and dispositional factors (e.g., anxiety, PTSD). Based on prior research, we predicted that individuals in the high misophonia group would display higher levels of anxiety, PTSD, autism traits, and hyperacusis compared to individuals in the low misophonia group. Additionally, based on the notion that misophonia represents altered connectivity between auditory and limbic pathways, we predicted that individuals in the high misophonia group would show higher levels of musicianship, and would also show stronger emotional responses to music relative to individuals in the low misophonia group.

Method

Participants

We recruited 300 participants for the initial misophonia screening. Participant eligibility for the main study was determined based on responses to the Amsterdam Misophonia Scale (A-MISO-S), in addition to data quality assessments (see *Participant Inclusion* for details). From this initial screening, 111 participants (low misophonia: $n = 67$; high misophonia: $n = 44$) were invited to complete the main study, with 98 participants (low misophonia: $n = 58$; high misophonia: $n = 40$) ultimately completing the study. Participants across groups were well

matched in terms of demographic variables (age, gender, education, and race/ethnicity), but differed as expected on reported misophonia (Table 1). All participants were recruited from Amazon Mechanical Turk via CloudResearch (Litman, 2017), with all participants successfully passing internally administered attention checks from CloudResearch. Participants were treated in accordance with the Declaration of Helsinki, and the study protocol was approved by the Huron University Research Ethics Board.

[[Table 1 about here]]

Materials

Screening

Self-reported misophonia was assessed via the A-MISO-S (Schröder et al., 2013). The A-MISO-S consists of six questions (e.g., "How much of your time is occupied by misophonia triggers?") that are answered on a Likert-type scale of 0 (e.g., *None*) to 4 (e.g., *Extreme: Greater than 8 hrs/day or near constant (thoughts about) triggers*), with higher values representing greater severity of misophonia. The final question of the A-MISO-S is a free response item, in which individuals are asked to state what would be the worst thing to happen to them if they were unable to avoid the misophonia triggers. Prior to completing the A-MISO-S, participants were provided with a definition of misophonia and were asked (1) whether they experience misophonia on a scale from 1 (*Definitely no*) to 5 (*Definitely yes*) and (2) whether they had heard of misophonia prior to participating in the study (*Yes*, *No*). In the present study, the six Likert-type questions of the A-MISO-S displayed excellent reliability, $\alpha = .94$, and the summed score from the six items significantly correlated with the single-item self-reported experience of misophonia, $r(96) = .55$, $p < .001$, providing convergent validity. The final free response item from the A-MISO-S was not specifically considered in terms of misophonia severity, but rather

was used as a data quality assessment (see *Participant Inclusion* for details). Prior to answering questions about their experiences with misophonia, participants completed a short demographic questionnaire, in which they provided age (in years), gender, level of education, employment status, proficiency with English, and race/ethnicity. The screening assessment was administered in Qualtrics (Provo, UT).

Main Study

Questionnaires. Musicality was assessed via two measures: the Goldsmiths Musical Sophistication Index (Gold-MSI; Müllensiefen et al., 2014) and the Barcelona Musical Reward Questionnaire (BRMQ; Mas-Herrero et al., 2013). The Gold-MSI assesses a variety of musical skills (e.g., "I can sing or play music from memory") and general musical behaviors (e.g., "I enjoy writing about music, for example on blogs and forums"). Participants rated 38 statements on a scale from 1 (e.g., *Completely disagree*) to 7 (e.g., *Completely agree*) in terms of how well each statement described themselves. The final two questions (assessing which instrument participants play best and which musical genre participants prefer) were not included in the present analyses. The Gold-MSI has five subscales: (1) Active Engagement, (2) Perceptual Abilities, (3) Musical Training, (4) Singing Abilities, and (5) Emotions. The reliability of the Gold-MSI for this sample was excellent, $\alpha = .94$, with each subscale exhibiting good reliability (range from $\alpha = .71$ to .88). Mean scores were calculated for the overall Gold-MSI, as well as for each factor. The BRMQ assesses the extent to which individuals find music rewarding along five factors: (1) Music Seeking, (2) Emotion Evocation, (3) Mood Regulation, (4) Social Reward, and (5) Sensory Motor. Participants rated 20 statements (e.g., "I can become tearful or cry when I listen to a melody I like very music)" on a scale from 1 (*Completely disagree*) to 5 (*Completely agree*). Two items were reverse scored. The reliability of the BMRQ for this sample was

excellent, α = .92, with each factor of the BRMQ exhibiting good reliability (range from α = .70 to .82). Summed scores were calculated for the overall scale, as well as for each factor.

Broader emotional responses to stimuli were assessed via two measures, a modified version of the ASMR-Experience Questionnaire (AEQ; Swart et al., 2022) and a word aversion questionnaire (WAQ) modelled on Thibodeau (2016). The modified AEQ provided participants with a definition of ASMR and asked if they were capable of experiencing ASMR using a Likert-type scale ranging from 1 (*Definitely yes*) to 5 (*Definitely no*). The WAQ presented participants with a total of six words: three words (*milk*, *chew*, *meal*) broadly associated with eating and predicted to be aversive to participants with misophonia, and three minimal pair control words (*silk*, *new*, *teal*). Participants answered six questions related to each word: (1) How often they use the word in both speaking and writing, (2) How often they hear the word in everyday use, (3) How aversive the word is to them, (4) How positive versus negative the word is, (5) How exciting or attention-grabbing the word is, and (6) How easily the word brings an image to mind. Each response was made on a 100-point slider scale. Separate mean scores for the suspected misophonic trigger words and control words were calculated for each question. In the present study, only the questions related to emotional valence (Questions 3, 4, and 5) were analyzed.

General sensitivity to sound was assessed via the Hyperacusis Handicap Questionnaire (HHQ; Prabhu & Nagaraj, 2020). The HHQ consists of 21 questions (e.g., “How often do you avoid doing a certain task or going out because you have to be in a noisy place/situation?”) which participants rated on a Likert-type scale ranging from 0 (*Never*) to 4 (*Always*). The HHQ is evenly divided into (1) functional, (2) social, and (3) emotional subscales of hyperacusis. The HHQ for this sample displayed good overall reliability, α = .87, with each subscale additionally

exhibiting adequate reliability (range from α = .63 to .82). Mean scores were calculated for each subscale.

Personality was assessed via the Ten Item Personality Inventory (TIPI; Gosling et al., 2003). Each item of the TIPI consists of two descriptors (e.g., "Anxious, easily upset"), with participants rating how well *both* descriptors described themselves on a Likert-type scale ranging from 1 (*Not at all*) to 5 (*Extremely*). There were two items for each of the five personality factors (Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism). One item per factor was reverse scored. Although the TIPI is not expected to have strong reliability given that only two items compose each factor, the present administration found good reliability for two factors (Extraversion: α = .79; Neuroticism: α = .70), adequate reliability for Conscientiousness (α = .59), and inadequate reliability for Agreeableness (α = .41) and Openness (α = .41). Mean scores were calculated for each subscale.

Posttraumatic stress, anxiety, and depression were assessed via three measures: the National Stressful Events Survey PTSD Short Scale (NSESSS-PTSD; LeBeau et al., 2014), the Short Form State Anxiety Inventory (SF-SAI; Zsido et al., 2020), and the Patient Health Questionnaire (PHQ-9; Kroenke et al., 2011), respectively. The NSESSS-PTSD consists of nine questions that assess how bothered participants are by problems over the past seven days, triggered by an extremely stressful event or experience (e.g., "Trying to avoid thoughts, feelings, or physical sensations that reminded you of a stressful experience?"). Participants respond on a Likert-type scale ranging from 0 (*Not at all*) to 4 (*Extremely*), and mean scores were calculated as an indicator of current PTSD symptoms. The NSESSS-PTSD for this sample displayed excellent reliability (α = .95). The SF-SAI consists of 5 items (e.g., "I feel that difficulties are piling up so that I cannot overcome them."), which participants rate on a Likert-type scale

ranging from 1 (*Not at all*) to 4 (*Very much so*). The SF-SAI for this sample displayed excellent reliability (α = .92), and mean scores were calculated as an indicator of current anxiety. The PHQ-9 consists of nine personal descriptors (e.g., "Feeling tired or having little energy"), which participants rate on a Likert-type scale ranging from 0 (*Not at all*) to 3 (*Nearly every day*) in terms of how often participants have felt this way over the past two weeks. The PHQ-9 for this sample displayed excellent reliability (α = .92), and mean scores were calculated as an indicator of current feelings of depression.

Behaviors associated with ASD were assessed via the 10-item Autism Spectrum Quotient (AQ-10; Allison et al., 2012). The AQ-10 consists of statements (e.g., "I know how to tell if someone listening to me is getting bored."), which participants rate on a Likert-type scale ranging from 1 (*Definitely agree*) to 4 (*Definitely disagree*). Six items are reverse scored (i.e., disagreeing is consistent with ASD traits). For each item, if the response is consistent with ASD traits (e.g., responding with a "3" or "4" to the example prompt), participants receive a "1"; otherwise, they receive a "0". Scores are then summed (ranging from 0-10), with scores above 6 taken to indicate potentially clinical ASD. The AQ-10 for this sample displayed adequate reliability (α = .67).

Sound Rating Task. Participants rated a total of 80 short (5-second) sounds on a scale from 1 (*Extremely unpleasant*) to 5 (*Extremely pleasant*). Sounds were presented in three total forms: unaltered (n = 20), time-domain scrambled (n = 30), and noise vocoded (n = 30). The unaltered sounds consisted of 10 recordings from nature (e.g., birdsong, crashing waves) and 10 recordings from urban environments (e.g., background chatter, traffic) used in prior work (e.g., Van Hedger et al., 2019). The time-domain scrambled and noise-vocoded sounds consisted of the same 20 nature and urban sounds, plus an additional 10 sounds widely considered to be

misophonic triggers (e.g., chewing, breathing, knuckle cracking, lip smacking). We did not present these misophonic trigger sounds in their unaltered forms, as we did not want to cause undue distress in the high misophonia group. Time-domain scrambling was selected to preserve the long-term spectral profiles of each sound, while disrupting the temporal transitions critical for sound object identification (Van Hedger, Nusbaum, Heald, et al., 2019). Noise vocoding was selected to preserve the temporal profiles of each sound, while disrupting the spectral profiles (e.g., see Shannon et al., 1995). Both time-domain scrambling and noise vocoding were done through Matlab (MathWorks: Natick, MA). Scrambled sounds were chopped into a set of short (25 ms) windows with 50% overlap, tapered with a raised cosine window. The 25 ms windows were then shuffled and re-overlapped within a 250 ms radius. Noise vocoded sounds used 4 frequency bands (120 to 498 Hz, 498 to 1378 Hz, 1378 to 3426 Hz, and 3426 to 8192 Hz). Within each band, the amplitude envelope was extracted and modelled with white noise. All sounds were normalized to -25 dB Full Spectrum. Mean rating scores were calculated for each sound type (unaltered nature, unaltered urban, scrambled nature, scrambled urban, scrambled misophonia, vocoded nature, vocoded urban, vocoded misophonia). The sound rating task was programmed in jsPsych (de Leeuw, 2015).

Procedure

Screening

After providing informed consent, participants answered demographic questions and an attention check, in which they were given a scale and were instructed to select a specific response option. Following the initial attention check, participants completed the A-MISO-S. There was a second attention check embedded within the A-MISO-S (following the Likert-type responses and preceding the free response question), similar in nature to the first attention check.

Following the A-MISO-S, participants were given a unique completion code and compensated with $1.25 USD.

Main Study

Eligible participants were invited to complete the main study via a personalized email announcement, sent through CloudResearch. Eligible participants had 30 days to complete the main study from its launch, which occurred 4 days after the initial screening. After providing informed consent, participants completed the questionnaires (Gold-MSI, BMRQ, AEQ, WAQ, HHQ, TIPI, NSESSS-PTSD, SF-SAI, PHQ-9, AQ-10) in a randomized order. Following the questionnaires, participants were automatically redirected to the sound rating task and upon task completion participants were given a unique completion code and compensated with $10.00 USD.

Participant Inclusion

There were five primary considerations for participants who completed the initial screening to be invited to participate in the main study. First, participants had to pass both attention checks. Second, participants could not have completed the entire survey in under two minutes, as this represented a completion time that was over twice as fast as the average completion time of 4 minutes and 26 seconds, and was considered by the researchers to represent an insufficient amount of time to thoroughly read the prompts and response options of the A-MISO-S. The third consideration was that participants could not have skipped questions, as this either invalidated the calculation of their misophonia score or did not allow for proper demographic comparisons across the constructed misophonia groups. The fourth consideration was an inadequate or otherwise suspicious answer on the free response question of the A-MISO-S. Although we expected a large degree of variability in these free responses depending on one's

self-reported misophonic severity, some participants provided a definition of misophonia accessed from a search engine or answered the question in a way that was nonsensical given the prompt. Two authors (OB and SVH) independently rated the free response answers and then discussed discrepancies (1.7% of responses) until a determination was made as to whether the free response was acceptable for inclusion. Assuming participants satisfied the first four inclusion criteria, the fifth and final consideration was participants' scores on the A-MISO-S. To be invited to the low misophonia group, participants had to score under 4 (defined as *Subclinical* misophonia symptoms). To be invited to the high misophonia group, participants had to score above 10 (defined as *Moderate* misophonia symptoms).

Data Analysis

Data were analyzed in R 4.3.0 (R Core Team). A series of independent samples *t*-tests were used to assess group differences between the low and high misophonia participants. For each analysis, we additionally calculated effect sizes (Cohen's *d*) using the "effsize" package. Given the number of administered measures, we report both the uncorrected *p*-values and the False Discovery Rate (FDR) *q*-values (Benjamini & Hochberg, 1995), which provides a multiple comparison correction that limits the Type I Error (i.e., false discoveries) to our specified alpha cut-off of 5%.

Results

Musicality and Emotional Responses to Music

Participants in the high misophonia group scored overall higher on the Gold-MSI compared to participants in the low misophonia group, $t(96) = 2.72$, $p = .008$, $q = .018$, $d = 0.56$. For the subscales, high misophonia participants reported greater active engagement with music,

$t(96) = 3.27$, $p = .002$, $q = .004$, $d = 0.67$, as well as greater amounts of musical training, $t(96) = 3.01$, $p = .003$, $q = .009$, $d = 0.62$. No other subscale of the Gold-MSI differed across group (qs > .105). In terms of experiencing musical reward, there was no overall difference between high and low misophonia participants on the BMRQ, $t(96) = 1.53$, $p = .130$, $q = .244$, $d = 0.31$. However, participants in the high misophonia group scored higher on the emotion evocation subscale of the BMRQ compared to participants in the low misophonia group, $t(96) = 2.80$, $p = .006$, $q = .015$, $d = 0.57$. No other subscale was significant (all qs > .104). Figure 1 plots the group comparisons across all musical measures.

[[Figure 1 about here]]

Sound Sensitivity

Participants in the high misophonia group reported a greater degree of hyperacusis compared to participants in the low misophonia condition, as measured by the overall score on the HHQ, $t(96) = 7.87$, $p < .001$, $q < .001$, $d = 1.62$. The functional, social, and emotional handicaps of hyperacusis were additionally higher among the high misophonia participants (all ps and qs < .001), with each subscale showing a large effect size (functional: $d = 1.21$, social: $d = 1.40$, emotional: $d = 1.41$). Figure 2 plots the group comparisons across the HHQ subscales.

[[Figure 2 about here]]

Emotional Responses to Non-Musical Stimuli

For the WAQ, participants in the high misophonia group reported greater aversion to *both* the trigger words, $t(96) = 5.21$, $p < .001$, $q < .001$, $d = 1.07$, and the control words, $t(96) = 4.52$, $p < .001$, $q < .001$, $d = 0.93$, compared to participants in the low misophonia group. Participants in the high misophonia group also rated the trigger words, $t(96) = 4.62$, $p < .001$, $q < .001$, $d = 0.95$,

and the control words, $t(96) = 3.49$, $p < .001$, $q = .002$, $d = 0.72$, as more exciting and attention-grabbing. There were no group differences in terms of how positive or negative the trigger and control words were rated (qs > .682). For the sound rating task, we observed no differences across groups as a function of each sound category (all qs > .273). Participants in the high misophonia group nominally reported a lower capacity to experience ASMR; however, the group difference was not significant after false discovery rate correction, $t(96) = -2.05$, $p = .043$, $q = .095$, $d = 0.42$.

Personality and Autistic Traits

Participants in the high misophonia group scored significantly higher on neuroticism, $t(96) = 3.53$, $p < .001$, $q = .002$, $d = 0.73$, and significantly lower on conscientiousness, $t(96) = -4.32$, $p < .001$, $q < .001$, $d = 0.89$, compared to participants in the low misophonia group. The two groups did not differ on extraversion, openness, or agreeableness (all qs > .391). In terms of autism traits, consistent with our prediction, participants in the high misophonia group scored significantly higher on the AQ-10 compared to participants in the low misophonia group, $t(96) = 3.69$, $p < .001$, $q = .001$, $d = 0.76$.

PTSD, Anxiety, and Depression

Compared to participants in the low misophonia condition, participants in the high misophonia group reported significantly greater amounts of posttraumatic stress, $t(96) = 6.09$, $p < .001$, $q < .001$, $d = 1.25$, greater anxiety, $t(96) = 5.39$, $p < .001$, $q < .001$, $d = 1.11$, and greater depressive symptoms, $t(96) = 5.56$, $p < .001$, $q < .001$, $d = 1.14$.

Discussion

The field of misophonia research faces a pressing question: Does misophonia's scope expand beyond aversive reactions to "trigger sounds" and auditory sensitivity to include heightened emotional responses to a wider range of stimuli, including music? The present study finds several factors are associated with misophonia, including musicality, emotion evocation from music, sound sensitivity, language perception, personality, autism traits, and symptoms related to PTSD, anxiety, and depression. These findings support the conceptualization of misophonia as a multifaceted construct with both positive and negative associations.

As hypothesized, individuals with misophonia reported greater active engagement with music, greater amounts of musical training, and stronger emotion evocation from music. This suggests that individuals with misophonia might seek out and engage with music more compared to those without misophonia. This additionally supports the contention that misophonia can involve heightened affective responses to positive sounds, like music, in addition to negative trigger sounds. Further research could explore whether music serves as a distraction, or coping mechanism to modulate emotional arousal, in individuals with misophonia. The finding that individuals higher in misophonia scored higher on the emotion evocation subscale of the BMRQ conceptually supports recent work examining how misophonia relates to positive emotional responses to sounds, including musical frisson (Mednicoff et al., 2023) and is more broadly aligned with the framework that misophonia is characterized by altered auditory-limbic connections (cf. Jastreboff & Jastreboff, 2023).

However, Mednicoff et al. (2023) also found that misophonia was not related to musicality and was positively associated with ASMR. In the present study, we found that misophonia related to some facets of musicality (overall musicality scores, active engagement,

and musical training) and was (nominally) *negatively* associated with the capacity to experience ASMR. These differing results could be due to differences in study design as well as task construction. Although the musicality assessment (Gold-MSI) was the same in both studies, Mednicoff (2023) used a correlational design (i.e., examining variability in misophonia across the full range of responses) whereas we used a quasi-experimental design (constructing groups of individuals who have low and high misophonia experiences). If musicality is related to misophonia in a non-linear manner, this could potentially explain why we found associations between misophonia and musicality and Mednicoff et al. (2023) did not. With respect to ASMR, the present study differed from Mednicoff et al. (2023) by only assessing ASMR using a single item, self-report measure. In contrast, Mednicoff et al. (2023) played ASMR-inducing videos to individuals and examined self-reported emotional responses. Thus, it is possible that individuals high in misophonia might expect to dislike ASMR videos (particularly given that the source of the sounds can be orofacial, such as whispering) but ultimately derive emotional enjoyment from them when experiencing them. Nevertheless, these divergent findings highlight the need for further research to clarify the underlying mechanisms of misophonia, ASMR, and musical frisson given that there might be some overlap or interaction between the sensory processes involved in these phenomena.

Participants in the high misophonia group reported hypersensitivity to sound and greater aversion to specific words compared to participants in the low misophonia group. Specifically, functional, social, and emotional hyperacusis handicaps were significantly elevated in the high misophonia group. This suggests that individuals with misophonia experience not only heightened aversion to specific trigger sounds, but also significant impairments in daily functioning, social interactions, and emotional well-being due to their sensitivity to sound.

Additionally, participants in the high misophonia group reported greater aversion to *both* the trigger words and the control words presented on the WAQ, and also found these words to be more exciting and attention-grabbing. Engaging in thoughts or imaginings involving verbalization often conjures images of forming words, a process that inherently involves the orofacial region, potentially leading to negative associations for those with misophonia. For the trigger words, this suggests that the mere anticipation of encountering a trigger, can sometimes suffice to elicit a response on its own. This suggests that the anticipation of discomfort or aversion can itself serve as a trigger, underscoring the complex interplay between cognitive processes, sensory experiences, and emotional responses. In terms of the control words, an examination of discourse on Reddit (2022) revealed discussions among individuals with misophonia concerning specific letter sounds that evoke aversive responses. This discussion informed the use of non-food related words (*silk, teal, new*) as control words. Notably, letters such as "p," "k," and "s" emerged as salient triggers within these conversations. This observation underscores the nuanced nature of misophonia, indicating that the condition extends beyond conventional triggers such as chewing or sniffling. The identification of phonetic elements as triggers highlights the potential for misophonia to manifest in response to a broader range of stimuli, including linguistic components intrinsic to speech production. More research should be conducted into the linguistic elements of misophonia triggers.

Participants in the high misophonia group also scored significantly higher on neuroticism, indicating a predisposition to experience negative emotions such as anxiety, irritability, and distress. Additionally, they scored significantly lower on conscientiousness, reflecting lower levels of self-discipline, organization, and reliability. These personality traits may exacerbate the emotional and behavioral responses to misophonic triggers, contributing to the overall symptom

severity and impairment experienced by individuals with misophonia. Clinicians and researchers should recognize that individuals with misophonia may exhibit heightened emotional reactivity and lower self-discipline, which could influence responses to misophonic triggers and overall coping strategies. Interventions focusing on emotion regulation and coping skills may be particularly beneficial for individuals with misophonia characterized by high neuroticism and low conscientiousness.

Participants in the high misophonia group scored significantly higher on the AQ-10, indicating elevated levels of autism-related traits. This finding supports the hypothesis that there may be an overlap between misophonia and autism spectrum symptoms, characterized by difficulties in sensory processing, emotional reactivity, and repetitive behaviors. Both ASD and misophonia involve atypical sensory processing, characterized by heightened sensitivity to sensory stimuli. Individuals with ASD often experience sensory sensitivities across multiple modalities, including auditory, visual, tactile, and olfactory domains. Similarly, individuals with misophonia exhibit hypersensitivity to specific auditory, and at times visual and tactile, stimuli, which can evoke intense emotional and physiological responses. Moreover, in ASD, emotional regulation difficulties are a core feature, characterized by atypical emotional responses and difficulties in interpreting and regulating emotions. Individuals with misophonia can also experience intense emotional reactions, such as anger, anxiety, or distress, in response to trigger sounds. These shared features may explain the finding of overlap in ASD and misophonia. Further research is needed to explore the underlying mechanisms linking misophonia and autism traits in general population samples.

Finally, those with high misophonic symptoms also reported significantly more symptoms related to PTSD, anxiety, and depression compared to the low misophonia group.

These symptoms suggested altered emotion-related functioning within these individuals, and prior research has also identified associations between misophonia and altered functional connectivity among brain networks responsible for emotion processing and regulation (Kumar et al., 2017). Prior research also indicates that PTSD and depression, along with obsessive compulsive disorder and anorexia, are common psychiatric comorbidities of misophonia (Erfanian et al., 2019). Although participants in this study were not asked to report clinical diagnoses, the presence of a higher degree of psychiatric symptoms in participants high in misophonia indicates that misophonia might be more likely to co-occur with other affective disorders.

The present study has several notable limitations. First, all data were collected via self-report measures from an online sample of participants. While past research has shown that similar methodologies produce high quality data (Hauser et al., 2023), we cannot rule out the possibility that participants did not accurately complete the questionnaire measures used in this study. Furthermore, given the research question self-report measures are an important feature of the study design, as it is not possible to randomly assign participants to experience misophonia. Second, the data for this study are cross-sectional and associations between study variables cannot establish causality. It is not presently known whether musical training influences the subsequent development of misophonia symptoms or whether engagement with music represents a potential coping mechanism employed by those with misophonia to manage negative affective reactions. Further research on the development of misophonia is needed to begin addressing these questions.

Despite these limitations, the presents study provides initial findings exploring the relationship between misophonia and different facets of auditory and emotional processing.

Overall, we find that individuals high in misophonia also report greater engagement with music, more emotion evocation from music, and heightened sound sensitivity, as well as higher levels of neuroticism, autism traits, and symptoms related to PTSD, anxiety, and depression compared to individuals who do not experience misophonia in their daily lives. Importantly, the findings of this study suggest that individuals with misophonia might have heightened affective responses to positive auditory stimuli, and this represents a promising direction for future research.

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Disclosure of Interest

The authors report no conflict of interest.

Data Availability Statement

All data and analysis scripts are available through Open Science Framework (10.17605/OSF.IO/X2UDK)

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Tables and Figures

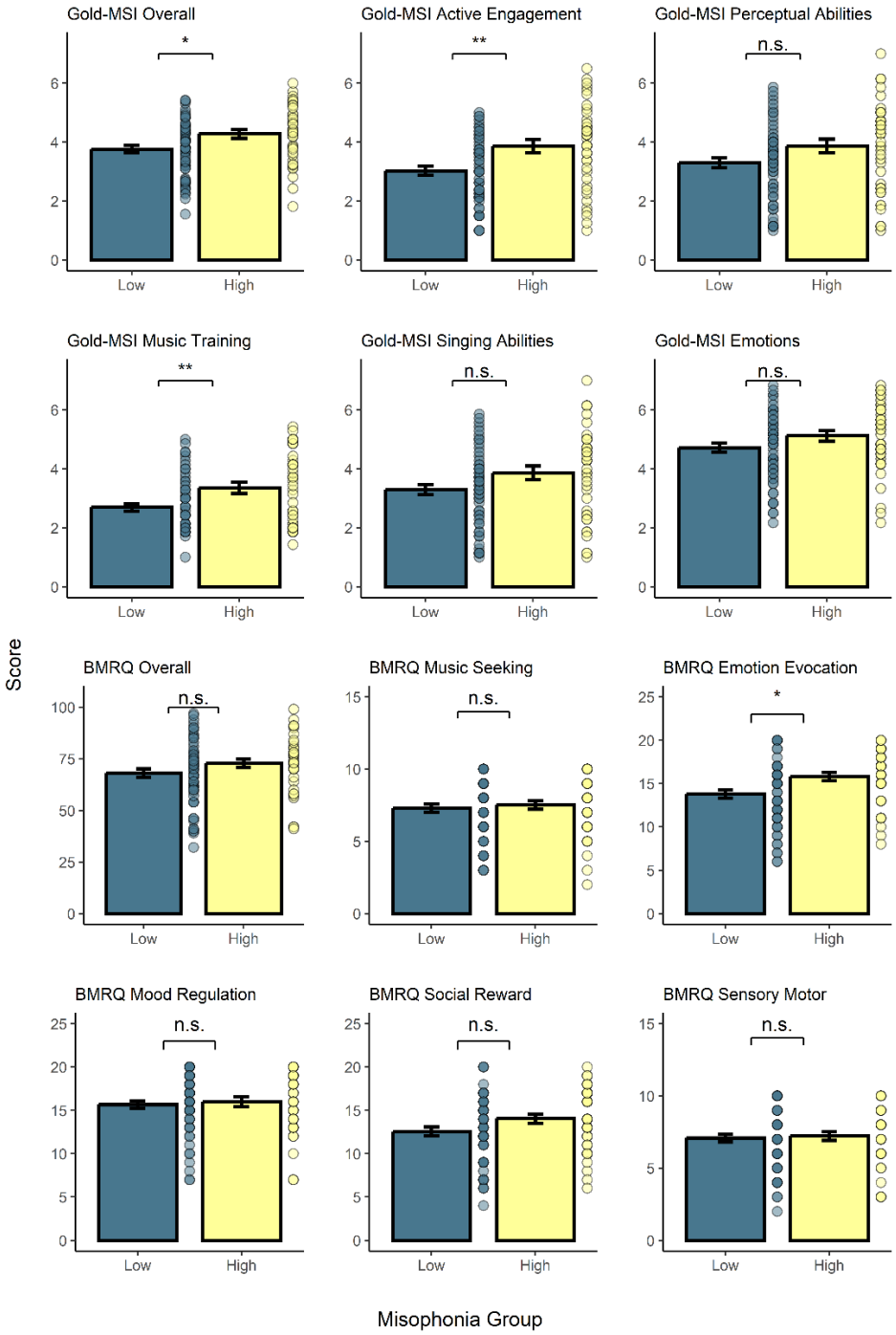
Table 1
Comparison of low and high misophonia groups on misophonia screening questionnaire (A-MISO-S) and demographic variables

Measure		Low Misophonia (n = 58)	High Misophonia (n = 40)
A-MISO-S		1.90 (1.55)	13.95 (3.87) ***
Age (Years)		37.31 (9.08)	37.25 (9.75)
Gender			
	Women	43%	45%
	Men	57%	55%
	Non-Binary	0%	0%
Education		4.33 (1.30)	4.42 (1.17)
Full-Time Employment		74%	75%
Race/Ethnicity			
	White	77%	72%
	Black	9%	10%
	Asian	14%	10%
	Hispanic	5%	5%
	Indigenous	0%	2%

Note. *** $p < .001$. Education was scored on a 9-point scale, with 1 corresponding to "some high school" and 9 corresponding to "doctorate or higher". Given this scale, the mean value for both groups was between an associate's degree (4) and a bachelor's degree (5). For race/ethnicity categories participants were given the option to select all that apply, so the reported percentages do not add to 100%.

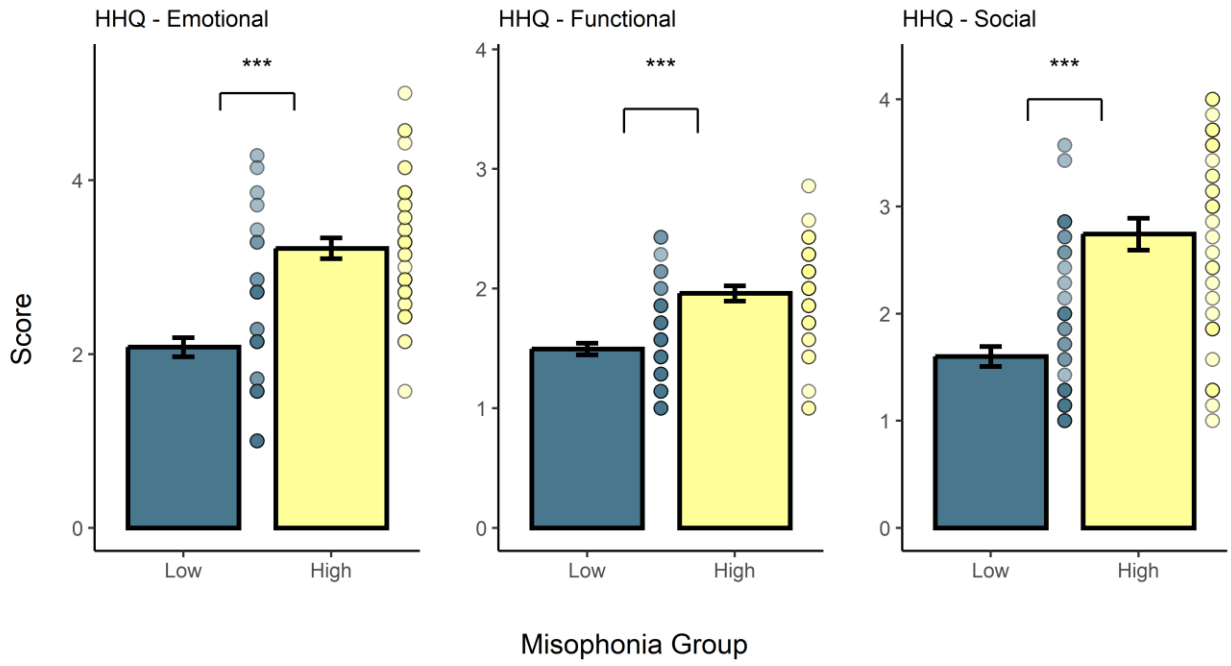
Figure 1

Responses from the Goldsmiths Musical Sophistication Inventory (Gold-MSI) and the Barcelona Musical Reward Questionnaire (BMRQ)



Note: Error bars represent plus or minus one standard error of the mean. Individual points represent individual participants. * $q < .05$ ** $q < .01$

Figure 2
Responses from the Hyperacusis Handicap Questionnaire (HHQ)



Note: Error bars represent plus or minus one standard error of the mean. Individual points represent individual participants. *** $q < .001$