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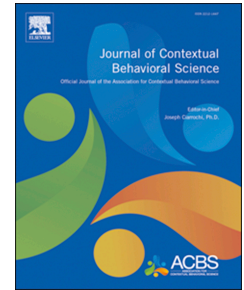
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Running Head: PEDIATRIC MISOPHONIA

Mindfulness and cognitive emotion regulation in pediatric misophonia

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Nicholas Murphy. Data used in analyses in the present study is available upon reasonable request.

Abstract

Misophonia is characterized by decreased tolerance of ordinary human-generated trigger sounds and associated visual stimuli (e.g., chewing, sniffing, lip smacking), coupled with intense affective reactions. The disorder often begins during childhood or adolescence and is associated with impairment and distress in numerous life domains. Research has begun to examine the underlying psychological mechanisms of misophonia in adults, but studies in youth are limited. Trait mindfulness (i.e., nonjudgmental and nonavoidant present-moment awareness) and cognitive emotion regulation (i.e., cognitive processing, or responding to, emotionally arousing situations) are two proposed mechanisms that may underpin pediatric misophonia and associated functional impairment. In the present exploratory cross-sectional study, we examined trait mindfulness and cognitive emotion regulation and their relations with misophonia features and adaptive functioning in 102 youth with misophonia ($M_{age} = 13.7$; $SD = 2.5$; range = 8 – 17). More severe misophonia was significantly associated with decreased levels of trait mindfulness and adaptive functioning across domains, in addition to deficits in certain facets of cognitive emotion regulation, particularly self-blame. Neither trait mindfulness nor facets of cognitive emotion regulation moderated the association between misophonia severity and adaptive functioning across domains, with the notable exception that difficulties with adaptive functioning in peer relationships was attenuated in those high in mindfulness. Findings suggest that trait mindfulness— and to a lesser extent cognitive emotion regulation— may be potentially relevant processes in pediatric misophonia. However, more research is needed to uncover the precise nature of these processes to aid future characterization and intervention efforts, especially in light of equivocal findings in the present study.

Keywords. Misophonia; youth; mindfulness; cognitive emotion regulation; misophonia assessment questionnaire (MAQ).

Mindfulness and cognitive emotion regulation in pediatric misophonia

Misophonia is characterized by decreased tolerance of ordinary human-generated sounds and associated visual stimuli (e.g., chewing, sniffing, lip smacking), coupled with intense affective reactions to triggers ranging from annoyance and frustration to heightened anger (Swedo et al., 2022). Misophonia often begins during childhood or adolescence and is associated with significant impairment and distress in numerous life domains, including associations with elevated internalizing and externalizing disorders (Guzick et al., 2023; Remmert et al., 2022), reduced life satisfaction (Rinaldi et al., 2022), and diminished quality of life (Jager et al., 2020; Möllmann et al., 2023; Williams et al., 2022). Although literature on the characterization of misophonia is growing, research has only just begun to examine the underlying psychological mechanisms of the condition in adults (Brout et al., 2018; Cowan et al., 2022), with corresponding studies in youth remaining relatively limited. A more precise understanding of potential misophonia mechanisms during childhood and adolescence could offer valuable insights into its etiology and prognostic factors. Furthermore, identifying psychological factors underpinning misophonia, including attentional, cognitive, and affective processes, is especially likely to aid the development of psychosocial interventions that specifically target candidate mechanisms.

Mindfulness

Mindfulness is a construct that may potentially be relevant for understanding pediatric misophonia, particularly in regard to attentional and cognitive components of the condition. While conceptualizations of mindfulness are historically diverse (Chiesa, 2013), within the behavioral health literature, mindfulness is most frequently defined as either a phenomenological state, dispositional trait (i.e., generalized tendency), or a set of skills to be targeted/instantiated

(Bishop et al., 2017; Brown & Ryan, 2003; Van Dam et al., 2018). A trait-based conceptualization of mindfulness is commonly used in clinical science research and has been shown to be amenable to development of psychometrically sound self-report measures of the construct (Baer, 2019).

From this perspective, mindfulness is defined as a multifaceted construct involving flexible noticing of present-moment experiences, acting with awareness of one's current behavior, and embracing a non-reactive and non-judgmental stance to internal and external phenomena (Baer et al., 2006, 2008). Particularly relevant to the present study, this definition of mindfulness has been adapted for youth in the context of psychometric development of the Child and Adolescent Mindfulness Measure (CAMM; Greco et al., 2011). Here, Greco et al. concluded that mindfulness may be best conceptualized in youth as a unidimensional construct, due to a data-driven argument that the multiple facets of mindfulness described above are less distinct and not fully developed in youth compared to adults.

As mindfulness is predicated on the process of paying attention to one's environment in a particular way (i.e., nonjudgmental, curious, and flexible; Kabat-Zinn, 1990), the literature on attentional processes in misophonia further support the argument that mindfulness is a relevant process in pediatric misophonia. Conceptual models of misophonia posit that heightened sensitivity to particular sounds results in behavioral avoidance of potentially triggering situations, along with hypervigilance and attentional fixation toward triggers (Brout et al., 2018; Jastreboff & Jastreboff, 2014). Neurophysiological research also indicates that individuals with misophonia possess alterations in generalized (i.e., trait-like) attentional processes irrespective of exposure to trigger situations (Frank et al., 2020; Schröder et al., 2014). Of particular note are recent findings which suggest that individuals with misophonia tend to exhibit more rigid and

inflexible attentional and cognitive processes compared to controls (Eijsker et al., 2021; Simner et al., 2021). While mindfulness has been specifically discussed in the context of a case study articulating an acceptance- and mindfulness-based intervention for an adolescent with misophonia (Schneider & Arch, 2017), to date we are unaware of any research that examines trait mindfulness and its associations with other constructs relevant to pediatric misophonia in a larger sample. Such research could be especially helpful for furthering our understanding of misophonia and informing treatment development efforts.

Emotion Regulation

From a behavioral perspective, longstanding patterns of negatively reinforced avoidance behaviors in response to misophonia triggers necessarily mean that afflicted individuals are deprived of opportunities to learn and practice adaptive strategies for regulating emotions in response to such triggers (Cowan et al., 2022; Frank & McKay, 2019). Indeed, recent cross-sectional research in adults reveals that difficulties in emotion regulation are associated with misophonia symptom severity (Cassiello-Robbins et al., 2020) and intensity of reactions to misophonia triggers (Guetta et al., 2022). Further evidence of the relevance of emotion regulation for understanding misophonia is provided from uncontrolled case study research describing psychological treatments for the condition, which often promote emotion regulation skills for youth with misophonia (Dover & McGuire, 2023; Lewin et al., 2022; Zarotti et al., 2022).

Certain maladaptive *cognitive* emotion regulation strategies may also directly impact the development and maintenance of misophonia (e.g., a pattern of hostile attributions such as blaming others for making trigger noises could plausibly maintain anger responses). However, most of the research to date on emotion regulation in misophonia has focused on behavioral

affective regulation processes (e.g., Guetta et al., 2022), and relatively less so on cognitive aspects. Cognitive emotion regulation may be especially germane to study in misophonia, as reactions to misophonia triggers have been shown to be mediated by higher-order interpretations of a particular sound in a given context (e.g., a family member chewing loudly), rather than by the acoustical properties of the sound, *per se* (Neacsiu et al., 2022)

Similar to the complexities described above related to diverse conceptualizations of mindfulness, emotion regulation has been extensively studied using a range of frameworks (Braunstein et al., 2017; McRae & Gross, 2020). Consensus seems to have emerged, however, concerning the multifaceted nature of emotion regulation (Grazt & Roemer, 2004). Despite some developmental considerations, emotion regulation—broadly considered—has been similarly conceptualized as a multifaceted construct in youth (Silvers, 2022).

Relevant to the present study, cognitive emotion regulation in youth has been conceptualized via the framework of a set of distinct adaptive and maladaptive processes (Garnefski et al., 2005). When measured this way, deficits in cognitive emotion regulation strategies have demonstrated associations with greater psychopathology (Mayer et al., 2022; van den Heuvel et al., 2020) and decreased adaptive functioning (Mihalca & Tarnavska, 2013) in youth. While relatively less studied in pediatric misophonia compared to other conditions, it is tenable that such cognitive emotion regulation deficits are also pervasive in misophonia and may contribute to impairment in adaptive functioning across numerous life domains (Möllmann et al., 2023; Williams et al., 2022). Furthermore, since childhood and adolescence is a critical period for development of emotion regulation abilities (Silver, 2022), and also coincides with the most common onset of misophonia (Guzick et al., 2023), emotion regulation represents an important process to examine within pediatric misophonia.

Mindfulness and Emotion Regulation

The constructs of mindfulness and emotion regulation also share some degree of conceptual overlap and distinction that bear mention. More specifically, mindfulness and emotion regulation have been shown to have differential statistical associations with relevant psychosocial outcomes, with such relations often manifesting at the facet level for mindfulness (Baer et al., 2008; Iani et al., 2019; Stevenson et al., 2019). In the realm of clinical intervention, mindfulness has been conceptualized as an adaptive process of regulating attention and emotions (Chambers et al., 2009; Kabat-Zinn, 1990), further suggesting the interrelated nature of these two constructs. However, due to challenges in extrapolating findings from the adult literature in these areas to children and adolescents (e.g., mindfulness defined as a unidimensional construct in youth; Greco et al., 2011), along with the paucity of research to date concerning mindfulness and emotion regulation in pediatric misophonia, in the present study we chose to examine the unique (i.e., distinct) associations between trait mindfulness and cognitive emotion regulation facets, respectively, and misophonia.

Current Study

The foregoing literature review reveals that mindfulness and cognitive emotion regulation are worthwhile processes to investigate within the context of pediatric misophonia. While some research in this area exists for adults, the extent to which these processes are associated with pediatric misophonia has yet to be examined. The present exploratory cross-sectional study seeks to address this gap in the literature.

First, statistical associations among trait mindfulness, cognitive emotion regulation facets, domains of adaptive functioning, and misophonia features were examined. Based on past cross-sectional (Cassiello-Robbins et al., 2020; Guetta et al., 2022) and intervention (Lewin et

al., 2022; Schneider & Arch, 2017) research suggesting the relevance of attentional, cognitive, and affective processes within misophonia and the salutary nature of mindfulness and emotion regulation, we hypothesized that trait mindfulness and adaptive cognitive emotion regulation facets would generally demonstrate inverse associations with misophonia features. Due to a lack of extant literature on the subject, no formal hypotheses were proffered regarding the differential magnitude of specific associations among trait mindfulness, cognitive emotion regulation facets, and misophonia features; in that regard, these analyses were considered exploratory in nature.

Subsequently, we explored whether trait mindfulness and adaptive cognitive emotion regulation facets moderated the association between misophonia severity and diminished adaptive functioning across domains. Aligned with past literature suggesting the salience of mindfulness and emotion regulation as transdiagnostic mechanisms underlying psychopathology in youth (Trosper et al., 2009; Zack et al., 2014), we generally predicted that trait mindfulness and adaptive cognitive emotion regulation facets would function to attenuate (i.e., moderate) inverse psychopathological associations between elevated misophonia features and diminished adaptive functioning across domains. Again, due to the paucity of extant literature on the topic, no precise hypotheses were offered regarding the specificity of moderation for trait mindfulness and cognitive emotion regulation facets, and such moderation analyses were also considered exploratory in nature.

Method

Participants

Data utilized in the present study were gathered as part of a larger project conducted at a private university hospital in the southern U.S.A. pursuing an in-depth phenotypic characterization of pediatric misophonia (see Guzick et al., 2023 for more details regarding study

procedures and characterization of the sample used for the present study). Potential participants were recruited via a multimedia advertising campaign that included mainstream (e.g., flyers, TV interviews, community presentations) and electronic (e.g., Listserves, social media) media, referrals from allied healthcare professionals, and public service announcements. Inclusion criteria were: between 8 to 17 years old, and experiencing clinically significant misophonia symptoms defined as a score ≥ 10 on the Amsterdam Misophonia Scale (A-MISO-S; Schröder et al., 2013), which corresponds with clinically significant symptoms. Clinically significant misophonia in participants was further confirmed through the use of a semi-structured misophonia diagnostic interview (Misophonia Assessment Interview; Lewin et al., 2022) and through consultation with licensed psychologists involved with the study. Exclusion criteria were: lifetime diagnosis of schizophrenia, other psychotic disorder, organic brain syndrome, or cognitive impairment; suicidality in need of immediate clinical attention; or inability to speak English. As depicted in Table 1, the average age of the 102 participants in the sample was 13.7 years old ($SD = 2.5$; range = 8 – 17), and the majority identified their gender as female (67.6%) and race as White (87.3%). Of the 79% of participants who met diagnostic criteria for a comorbid psychiatric disorder, 45% experienced a current anxiety or obsessive-compulsive disorder, and 47% experienced a past or current major depressive episode. As shown in Table 1, other common comorbidities included attention-deficit/hyperactivity disorder and chronic tic disorders. The most common primary (non-misophonia) psychiatric diagnoses were major depressive disorder (29.4%), generalized anxiety disorder (16.7%), and attention deficit hyperactivity disorder (9.8%).

Procedure

The present study received approval from the Institutional Review Board at the authors' affiliated university. Potential participants (and their caregiver/legal guardian) were prescreened via telephone. Informed consent was obtained from caregiver/legal guardians (along with assent from youth) of all interested potential participants who met eligibility requirements. Youth and caregivers then completed a synchronous virtual assessment session with a research assistant via a secure telehealth platform and completed child- and caregiver-report measures via a secure Internet platform (see subsections of the Measures section for details of which measures were child- and caregiver-report). Participants received \$100 compensation (\$50 parent and \$50 child) for participation.

Measures

Demographic information. Participants completed a demographic form that contained questions regarding gender, age, and race. Gender categories included male, female, and other. Race categories included black/African-American, Asian, White, or Other. The Mini International Neuropsychiatric Interview for Children and Adolescents (MINI-KID; Sheehan et al., 2010) was administered to participants by a trained research assistant and was used to assess for the presence of psychiatric disorders among study participants. For the purposes of the present study, only primary psychiatric diagnoses were reported.

Misophonia features. Misophonia was assessed with two related, yet distinct, youth-completed self-report questionnaires. The *Amsterdam Misophonia Scale (A-MISO-S; Schröder et al., 2013)* is a six-item instrument utilizing a 5-point Likert scale designed to assess misophonia severity and impairment. Scores are summed, and higher scores indicate greater misophonia symptom severity. Item 4 of the A-MISO-S ("How much effort do you make to resist thoughts about the misophonic triggers?") was not included in the calculation of sum scores in the present

study, as this item has demonstrated sub-optimal psychometric properties in past research (XXX-MASKED, under review). The A-MISO-S has demonstrated preliminary evidence of adequate psychometric properties in previous research (Naylor et al., 2021). Cronbach's alpha in the present study was $\alpha = .76$.

The *Misophonia Assessment Questionnaire (MAQ; Johnson, 2014)* is a 21-item instrument utilizing a 4-point Likert scale that is designed to assess various aspects of misophonia, including distress, recognition of difficulties, and interference. Scores are summed, and higher scores indicate greater misophonia acuity (1-21 = mild, 22-42 = moderate, 43-64 = severe; Dozier, 2015). Although the MAQ was originally developed within the context of clinical practice rather than via a rigorous empirical process, it has recently been psychometrically evaluated. More specifically, the MAQ preliminarily demonstrated evidence of acceptable psychometric properties in a youth sample, including construct validity pertaining to four sub-factors (pessimism, distress, interference, and non-recognition) with one higher-order factor (XXX-MASKED, under review). Cronbach's alpha for the higher-order factor in the present study was $\alpha = .94$.

Mindfulness. The *Child and Adolescent Mindfulness Measure (CAMM; Greco et al., 2011)* is a 10-item youth-report questionnaire utilizing a 5-point Likert scale that is designed to capture the construct of trait mindfulness based on the tenets of mindfulness-based stress reduction (MBSR; Kabat-Zinn, 1990) and dialectical behavior therapy (DBT; Linehan, 1993), as adapted to be developmentally appropriate for youth. For the CAMM in particular, unidimensional mindfulness is conceptualized with a focus on present-moment awareness, along with non-judgmental and non-avoidant responses to feelings and thoughts. Items are reverse-scored and summed, such that higher scores indicate greater trait mindfulness. The CAMM has

demonstrated excellent psychometric properties in previous research (de Bruin et al., 2014; Greco et al.). Cronbach's alpha in the present study was $\alpha = .86$.

Cognitive Emotion Regulation. The *Cognitive Emotion Regulation Questionnaire, child version (CERQ-k; Garnefski et al., 2007)* is a 36-item youth-report questionnaire utilizing a 5-point Likert scale that is designed to assess nine separate adaptive and maladaptive facets of cognitive emotion regulation in response to particular stressful life events. Scores are summed within each individual subscale (4 items per subscale), and higher scores indicate either adaptive (i.e., positive refocusing, planning, positive reappraisal, putting into perspective) or maladaptive (i.e., acceptance, self-blame, rumination, catastrophizing, other-blame) cognitive emotion regulation. The CERQ has demonstrated robust psychometric properties in previous research (Betegon et al., 2022; Garnefski et al.). Cronbach's alpha across the nine subscales in the present study ranged from $\alpha = .70$ to $.94$.

Adaptive functioning. Selected subscales from the larger package of the *Patient Reported Outcomes Measurement Information System Pediatric Parent Proxy (PROMIS-P-P; Varni et al., 2012)* were utilized to assess youth adaptive functioning across three separate domains, including: (a) peer relationships (PROMIS-P-P-PR), (b) family relationships (PROMIS-P-P-FR), and (c) life satisfaction (PROMIS-P-P-LS). These 8-item (7 items for the PROMIS-P-P-PR) parent-report questionnaires utilize a 5-point Likert scale; scores are summed within each domain separately, and higher scores indicate greater adaptive functioning. The PROMIS parent proxy scales have demonstrated evidence of robust psychometric properties in previous research (Brandon et al., 2017; Varni et al.). Cronbach's alpha across the three subscales in the present study ranged from $\alpha = .88$ to $.95$.

Data Analytic Plan

Due to the largely exploratory nature of the present study and the moderate sample size, no family-wise error corrections were performed and an alpha of .05 was used as an indicator of statistical significance. Skewness and kurtosis values for all measures were ± 1 , suggesting adequate univariate normal distributions. Additionally, a lack of variance inflation factor (VIF) values greater than 5 among study variables suggested that concerns with multicollinearity were not present. Pairwise comparisons were utilized for all analyses, and missingness was negligible (i.e., ranged from 0-5 missing cases per variable).

To address study aims, we first examined zero-order correlations among all study variables. Second, based on these correlational findings, we ran two separate linear regression models to explore the unique associations between candidate processes (i.e., mindfulness and facets of emotion regulation) and misophonia features (separate models for MAQ and A-MISO-S as dependent variables). Age, gender (dummy coded as 1 = non-female, 2 = female), and primary comorbid psychiatric diagnosis (dummy coded as 1 = no diagnosis, 2 = any diagnosis) were entered as covariates. All candidate process variables demonstrating statistically significant correlations with misophonia features were entered as predictors in both regression models. This step was conducted to examine which variables had the clearest associations with misophonia. Findings from the two separate regression models were compared to determine which of the two misophonia measures demonstrated more robust findings for use in subsequent exploratory moderation analyses.

Third, candidate process variables that were uniquely associated with misophonia features in the aforementioned regression models were subsequently examined as potential moderators of the relations between misophonia severity and domains of adaptive functioning. To do so, Model 1 in PROCESS macro for SPSS (A. F. Hayes, 2022) was employed to test for

possible two-way interaction effects. PROCESS macro was used to estimate interaction effects for each model using a bootstrapping approach utilizing 5,000 samples (A. F. Hayes). With each of the three domains of adaptive functioning (i.e., PROMIS-P-P-PR, PROMIS-P-P-FR, PROMIS-P-P-LS) as the dependent variable, a series of six separate linear regression models were run with the best-performing misophonia measure as the independent variable, a given candidate process variable as the potential moderator, and age, gender, and psychiatric diagnosis status entered as covariates. Statistically significant interaction effects were further probed via examination of simple slopes of the conditional effect. This permitted estimation of the differential effect of a given moderator variable (i.e., $M \pm 1 SD$) on the relationship between misophonia severity and a given domain of adaptive functioning.

Results

Bivariate Associations

Correlations coefficients among study variables (see Table 2) indicated that the MAQ was significantly and positively correlated with all measured maladaptive facets of cognitive emotion regulation, including self-blame, acceptance, rumination, catastrophizing, and other-blame ($r_s = .22$ to $.62$); significant associations were less consistent with the A-MISO-S ($r_s = .06$ to $.22$). Misophonia features were generally not associated with adaptive cognitive emotion regulation facets. Misophonia features were also significantly inversely correlated with trait mindfulness ($r_s = -.24, -.60$) and all three domains of adaptive functioning ($r_s = -.18$ to $-.40$). Across all correlational analyses, the MAQ generally demonstrated relations in greater magnitude compared to the A-MISO-S, and thus was used as the primary dependent variable in subsequent multivariable analyses.

Linear Regression Analyses

Two separate linear regression models were run with candidate process variables that correlated significantly with either the MAQ or A-MISO-S. As such, trait mindfulness and all five maladaptive facets of cognitive emotion regulation (i.e., self-blame, acceptance, rumination, catastrophizing, and other-blame) were entered as predictors, along with age, gender, and current psychiatric diagnosis entered as covariates. VIF values for variables within the regression model ranged from 1.02 – 2.49, suggesting that multicollinearity was not a concern.

Only the regression model with MAQ as the criterion variable was statistically significant. Within this model, which explained approximately 43% of the variance in MAQ scores, only trait mindfulness ($\beta = -.28, p = .02$), and cognitive emotion regulation-self-blame ($\beta = .32, p = .01$) were statistically significant predictors (see Table 3). Thus, both trait mindfulness and cognitive emotion regulation-self-blame were selected as potential moderator variables for subsequent moderation analyses.

Moderation Analyses

Six sets of linear regression analyses were conducted to explore whether trait mindfulness and cognitive emotion regulation-self-blame, respectively, moderated the relationship between misophonia symptomology (measured by the MAQ) and each of the three domains of adaptive functioning, respectively (see Table 4). Only one of the six models, with trait mindfulness as a moderator and adaptive functioning in peer relationships as a criterion, yielded a significant interaction term. Results revealed that this model accounted for 21% of the variance in peer relationship functioning, $F(6, 95) = 5.68, p < .001$. Within this model, the interaction between misophonia symptomology and trait mindfulness was significant, $B = 0.02, SE = .01, p = .001$, and explained 6.6% of unique variance above and beyond main effects in the model.

A visual depiction of the slope analyses for the interaction between misophonia symptomology and trait mindfulness on peer relationship functioning is provided in Figure 1. The conditional effects of misophonia symptomology on peer relationship functioning were $-.37$ ($SE = .07, t = -5.01, p < .001$) when the trait mindfulness score was 1 SD below the mean, $-.24$ ($SE = 0.05, t = -4.65, p < .001$) at the mean, and $-.11$ ($SE = .05, t = -1.98, p = .05$) 1 SD above the mean. A simple slope analysis also revealed that the strength of the effect of misophonia symptomology on peer relationship functioning was attenuated when the level of trait mindfulness was high. That is, a difference test between the simple slopes indicated a statistically significant difference between the slopes of the regression line at low and high levels of mindfulness ($t = 2.85, p = .004$). Thus, the degree of the negative relationship between misophonia symptomology and peer relationship functioning was attenuated when mindfulness levels were higher.

Discussion

Psychological processes underlying misophonia remain unclear, particularly in youth. The present exploratory cross-sectional study sought to address this by examining the relations among misophonia features, domains of adaptive functioning, and proposed process variables of trait mindfulness and cognitive emotion regulation facets in a well-characterized sample of youth with misophonia. Findings revealed that misophonia severity was generally positively associated with maladaptive facets of cognitive emotion regulation and negatively associated with trait mindfulness and domains of adaptive functioning. Of these relations, trait mindfulness and cognitive emotion regulation-self-blame were most robustly associated with misophonia severity measured by the MAQ. Furthermore, trait mindfulness moderated the inverse association between misophonia severity, measured by the MAQ, and adaptive functioning in peer

relationships, such that the aforementioned association was attenuated in participants high in trait mindfulness. However, none of the other proposed moderator models yielded significant interaction effects.

Findings concerning the roles of mindfulness and cognitive emotion regulation-self-blame are consistent with previous conceptualizations of misophonia, which highlight the salient roles of alerting/attentional processes and higher-order cognitive functioning (Brout et al., 2018; Neacsiu et al., 2022). At least in the context of the present study, it may be that rigid attentional fixation on misophonia triggers and a lack of nonjudgmental, flexible awareness of present-moment experiences (i.e., deficits in mindfulness), along with challenges in regulating emotions related to a negative or overly critical view of oneself (i.e., self-blame) function to maintain misophonia symptomology in youth. Moreover, our findings highlighting the role of trait-based attentional and cognitive processes in misophonia comport with recent neurophysiological and neuropsychological research in adult misophonia, which indicate that individuals with misophonia tend to possess detrimental alterations in attentional processes (Eijsker et al., 2021; Frank et al., 2020; Simner et al., 2021). While findings from the present study, along with preliminary inclusion of mindfulness and other attention-focused intervention kernels in treatments for youth with misophonia hold promise (Lewin et al., 2022; Schneider & Arch, 2017), more work is needed to mechanistically understand the role of mindfulness within misophonia. Fortunately, the framework of the above-mentioned neurophysiological studies on attention provides a useful model for such research.

Moderating Effect of Mindfulness

The present exploratory study found preliminary evidence of a moderating effect of trait mindfulness on the relation between misophonia severity and adaptive functioning in peer

relationships. More specifically, the interactive effect of trait mindfulness and misophonia severity on adaptive functioning in peer relationships was such that for participants high in trait mindfulness (i.e., 1 SD above the mean), the inverse association between misophonia severity and deficits in adaptive functioning in peer relationships was no longer statistically significant ($p = .05$). This suggests that mindfulness may serve as a protective, or buffering, factor in pediatric misophonia, such that when mindfulness is bolstered, youth may be better able to maintain adaptive functioning in peer relationships despite the presence of misophonia symptomology. Given that recent research suggests that approximately half of youth with misophonia report that this condition significantly interferes with their social relationships (Guzick et al., 2023), this finding highlights the potential critical role of mindfulness in this population.

Findings from the present study concerning the moderating effect of mindfulness in pediatric misophonia are consistent with the *decoupling effect* as a mechanism of change in mindfulness, in which mindfulness has been found to attenuate, or decouple, the link between mental health vulnerability factors and maladaptive behavioral outcomes (Levin et al., 2015). This suggests that mindfulness represents a promising technique for promoting adaptive functioning in the context of misophonia, where symptoms may be more intractable, less amenable to habituation via exposure, and thus complete remission less likely compared to other conditions (Frank & McKay, 2019). Specific aspects of mindfulness related to the nonjudgmental quality of attention and the ability to flexibly shift/direct attention (e.g., Kabat-Zinn, 1990; Masuda & Wilson, 2009) may be especially applicable to misophonia (Schneider & Arch, 2017), as hypervigilant, rigid fixation on triggers, along with maladaptive negative interpretations regarding trigger situations have been shown to perpetuate symptomology (Brout et al., 2018; Neacsiu et al., 2022).

Emotion Regulation in Misophonia

Intuitively, it might be expected that a propensity to blame *others* would be more strongly related to misophonia severity than a tendency to blame oneself, as youth with misophonia often react aggressively to others making trigger noises. Despite the frequency of verbal aggression in misophonia, however, the robust association with self-blame in the present study (rather than other-blame) appears to speak to a multifaceted and more internalizing (rather than externalizing) nature of misophonia psychopathology (Guzick et al., 2023). While our results concerning the role of cognitive emotion regulation facets in pediatric misophonia were notably equivocal, the limited findings that did emerge remain consistent with past research positing difficulties in emotion regulation as a key process within misophonia (Cassello-Robbins, 2020; Guetta et al., 2022).

As mentioned, of all the facets of cognitive emotion regulation examined in the present study, only self-blame emerged as a reliable statistical predictor of misophonia features measured by the MAQ; correlations between cognitive emotion regulation facets and misophonia features also varied widely. Additionally, this self-blame facet did not exert a moderating effect on any of the relationships between misophonia severity and impairment in adaptive functioning. While the design of the present study did not allow us to empirically examine reasons for these equivocal findings concerning cognitive emotion regulation, several possible explanations for such findings emerge that warrant further investigation. More specifically, the focus on cognitive emotion regulation over behavioral and affective components in the present study may have contributed to the lack of associations found. Past research on emotion regulation in adult misophonia populations that found more robust associations between misophonia symptomology and emotion regulation difficulties (Cassello-Robbins et al., 2020; Guetta et al., 2022) utilized

measures such as the Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004), which tap into the behavioral and affective components of emotion regulation. This raises the possibility that cognitive emotion regulation processes may be less relevant in pediatric misophonia than originally thought, which is consistent with the notable affective and internalizing responses often observed in response to misophonia triggers among youth (Guzick et al., 2023).

Furthermore, sub-optimal measurement of cognitive emotion regulation may have also contributed to our equivocal findings. More specifically, the CERQ-k asks youth to respond to items in consideration of when they are “experiencing strong threatening or stressful life events.” As the precise (and perhaps idiosyncratic) manner in which youth interpreted this prompt is unknown, the variability that this instruction may have introduced into participant responding may have manifested as measurement error in the present study.

A final question concerns the differential magnitude of relations among misophonia features and adaptive and maladaptive facets of cognitive emotion regulation found in the present study. That is, mainly maladaptive— but not adaptive— facets of cognitive emotion regulation were significantly associated with misophonia features. Of these maladaptive facets, only self-blame was uniquely associated with misophonia symptomology. Such findings are consistent with cognitive and affective reactions of youth with misophonia described in published case studies (e.g., Johnson et al., 2013; Lewin et al., 2022; Schneider & Arch, 2017) that highlight experiences of hopelessness, perceived lack of control, and self-critical thoughts. Nevertheless, more work is needed to better understand the differential strength of cognitive emotional regulation processes in pediatric misophonia, as these repertoires may be more malleable and amenable to intervention efforts compared to engrained neurological-based

sensory processing systems (Palumbo et al., 2018; Schneider & Arch, 2015). This parallels many contextual behavioral science-based intervention approaches (e.g., acceptance and commitment therapy; S.C. Hayes et al., 2012) that target *reactions to* internal events, rather than the internal events themselves, which may be less amenable to modification.

Measurement Issues and other Caveats

Interpretations of findings concerning trait mindfulness and cognitive emotion regulation-self-blame as candidate mechanisms in pediatric misophonia require caution in light of the exploratory nature of the present study, as well as the numerous analyses conducted that yielded nonsignificant results (i.e., possibility of Type-I errors). These nonsignificant findings point to future research questions, such as why the moderating effect of mindfulness was only found on adaptive functioning in peer relationships, but not family ones or overall life satisfaction. We speculate that the salient role of family accommodation in perpetuating misophonia symptomology in youth (Dover & McGuire, 2023; Johnson et al., 2013; Storch et al., under review) may contribute to an underestimation of deficits in adaptive functioning in familial relationships. However, more research is needed to understand the differential moderating effects of mindfulness in misophonia to better match patients to intervention kernels (S.C. Hayes et al., 2021).

The measurement of misophonia features in the present study, along with differential magnitude of findings from these measures, also merits attention. More specifically, misophonia features were measured using the A-MISO-S (Schröder et al., 2013) and the MAQ (Johnson, 2014). While the correlation of 0.55 between the MAQ and A-MISO-S does suggest some overlap, it also raises the possibility that the two measures may be capturing unique features of misophonia— an assertion supported by recent psychometric research on these measures (XXX-

MASKED, under review). More specifically, examination of items from these questionnaires (i.e., content validity) suggests that the A-MISO-S captures misophonia symptom severity and impairment, while the MAQ appears to focus more on broader aspects of the impact of misophonia on a respondent's life context. Interestingly, many of the MAQ items focus on the emotional impact of misophonia, as well as interference in social domains. Furthermore, the aforementioned psychometric evaluation of the MAQ in youth with misophonia (XXX-MASKED) found that it includes subscales tapping into pessimism about getting better as well as other people not recognizing the impact of the misophonia symptoms. This raises the possibility of some conceptual overlap between misophonia impairment measured by the MAQ and cognitive emotion regulation facets and domains of adaptive functioning, which may partially explain our more robust findings concerning the MAQ compared to the A-MISO-S. Additionally, to the extent that mindfulness may also be considered a process of adaptive emotion regulation (Chambers et al., 2009; Kabat-Zinn, 1990; Linehan, 1993), the relatively stronger correlation between mindfulness measured by the CAMM and MAQ scores compared to A-MISO-S ones is not entirely surprising.

Finally, the potentially questionable psychometric properties of the measures of misophonia used in the present study require consideration, as sub-optimal measurement ultimately reduces the confidence of inferences drawn from a given study's results (Haynes et al., 2019). More specifically, the A-MISO-S conceptualizes and measures misophonia from the framework of obsessive-compulsive disorder (Schröder et al., 2013). However, recent research has begun to cast doubt on the classification status of misophonia as an OCD (McKay et al., 2018), which entails the A-MISO-S may lack content validity. While recent research has emerged suggesting that the A-MISO-S and MAQ do indeed possess evidence of adequate

psychometric properties in terms of reliability and construct (i.e., convergent and divergent) validity in a sample of youth with misophonia (XXX-MASKED, under review), more work is sorely needed both in terms of classification and measurement of misophonia.

Limitations and Conclusion

The present study requires interpretation in light of several limitations. First, the cross-sectional design precludes inferences about causal relationships. Second, a large number of statistical tests were run without correction for Type 1 errors in order to facilitate preliminary, exploratory research, though this raises the possibility of false positives—a possibility that may be especially salient within the context of six separate moderation models. Third, while one of the strengths of the present study is the use of multiple informants (i.e., caregiver and child), all variables were measured via retrospective self- or other-report questionnaires, suggesting the possibility of shared method variance (Haynes et al., 2019). Fourth, while our sample was well-characterized in terms of assessment of psychiatric diagnoses, study participants were mostly White and female, which limits the generalization of findings to diverse populations. Fifth, while the use of multiple methods of assessment in terms of verification of misophonia in study participants lends some confidence in the characterization of the sample, to date, there exists no formally agreed-upon consensus for the diagnostic classification of misophonia (Taylor, 2017). Thus, the lack of clarity in terms of diagnosis and conceptual boundaries of misophonia may have contributed to excessive heterogeneity of presenting concerns and introduced measurement error. Finally, the percentage of total variance in misophonia symptomology explained by independent variables in the present study ranged from 20-40%, which means that more work is needed to understand additional explanatory process variables within pediatric misophonia.

With these limitations in mind, the present study contributes to the pediatric misophonia literature by increasing our understanding of psychological processes underlying impairment in functioning due to misophonia symptoms, including mindfulness and emotion regulation. Findings from the present study also align with past intervention development studies for pediatric misophonia (Dover & McGuire, 2023; Lewin et al., 2022; Schneider & Arch, 2017) positing mindfulness and emotion regulation as promising treatment targets. More research is needed to confirm exploratory findings from the present study and further elucidate salient, manipulable processes of change in misophonia that can be functionally targeted by empirically supported principles (S.C. Hayes & Hofmann, 2020).

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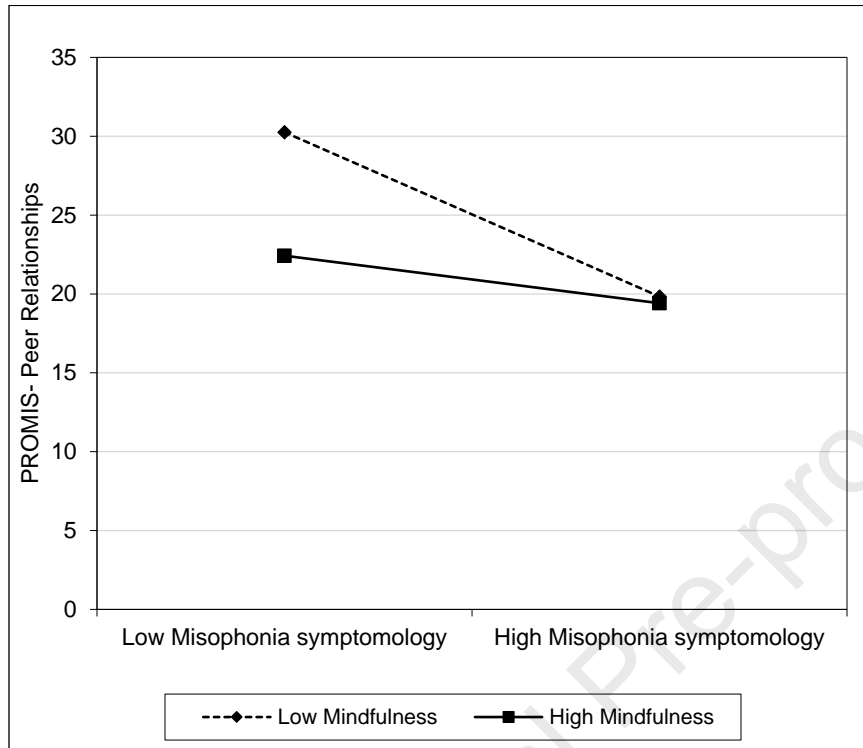
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Figure 1. *Interaction plot of the association between misophonia symptomology and PROMIS-peer relationships at different levels of mindfulness*



Note. The low and high mindfulness slopes represent levels of mindfulness at -1 and $+1$ standard deviations (SD) relative to the mean.

Table 1. *Sample characteristics and demographic variables*

Characteristic	Total (<i>n</i> = 102)	
	<i>M</i>	<i>SD</i>
<i>Age</i>	13.7	2.5
	Percent	<i>n</i>
<i>Gender</i>		
Male	28.4	29
Female	67.6	69
Other	3.9	4
<i>Race</i>		
Black or African American	2.9	3
Asian	3.9	4
White	87.3	89
Other	2.0	2
Missing	3.9	4
<i>Primary comorbid psychiatric diagnosis</i>		
Major depressive disorder	29.4	30
Bipolar disorder	2.0	2
Social anxiety disorder	6.9	7
Specific phobia	4.9	5
Obsessive-compulsive disorder	4.9	5
Tourette's or tic disorder	5.0	5
ADHD	9.8	10
Generalized anxiety disorder	16.7	17
No diagnosis	20.5	21

Table 2. *Correlations and descriptive statistics for study variables*

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1 MAQ	-														
2 A-MISO-S	.55**	-													
3 CERQ-k-self-blame	.62**	.22*	-												
4 CERQ-k-acceptance	.32**	.21*	.32**	-											
5 CERQ-k-rumination	.47**	.06	.64**	.24*	-										
6 CERQ-k-positive refocusing	-.08	-.15	-.13	.08	.01	-									
7 CERQ-k-planning	.03	-.09	.19	.07	.27**	.34**	-								
8 CERQ-k-positive reappraisal	-.02	.004	.03	.10	.16	.33**	.48**	-							
9 CERQ-k-perspective	.07	.05	.07	.21*	.14	.46**	.22*	.50**	-						
10 CERQ-k-catastrophizing	.47**	.20	.54**	.32**	.48**	-.15	.04	-.07	-.08	-					
11 CERQ-k-other blame	.22*	.11	.09	.36**	.15	.11	.10	.03	.02	.29**	-				
12 CAMM	-.60**	-.24*	-.65**	-.41**	-.63**	.02	-.09	-.13	-.08	-.45**	-.22*	-			
13 PROMIS-P-P-PR	-.32**	-.18	-.11	-.02	-.06	.14	.17	.23*	.22*	.002	-.07	.06	-		
14 PROMIS-P-P-FR	-.27**	-.26**	-.26**	.07	-.20*	.28**	.06	.10	.21*	-.17	-.01	.17	.33**	-	
15 PROMIS-P-P-LS	-.40**	-.18	-.35**	-.14	-.28**	.16	.05	.08	.16	-.24*	-.11	.16	.50**	.49**	-
Mean	36.63	15.11	7.12	8.63	7.90	6.86	8.35	6.74	8.86	6.24	4.86	23.21	25.84	31.57	27.11
SD	14.15	2.81	4.49	3.15	4.58	3.57	3.04	3.61	3.68	3.56	3.65	8.03	6.20	4.64	6.66

Note: * $p < .05$, ** $p < .01$; MAQ = Misophonia Assessment Questionnaire; A-MISO-S = Amsterdam Misophonia Scale; CERQ-k = Cognitive Emotion

Regulation Questionnaire, child version; CAMM = Child and Adolescent Mindfulness Measure; PROMIS-P-P-PR = PROMIS Pediatric Parent Proxy Peer

Relationships Measure; PROMIS-P-P-FR = PROMIS Pediatric Parent Proxy Family Relationships Measure; PROMIS-P-P-LS = PROMIS Pediatric Parent Proxy Life Satisfaction Measure.

Table 3. *Linear regression models of candidate mechanisms predicting misophonia symptomology*

Model variables	<i>MAQ as criterion</i>			<i>A-MISO-S as criterion</i>		
	$R^2 = 0.427; F(9, 96) = 8.956, p = <0.001$			$R^2 = 0.042; F(9, 96) = 1.463, p = 0.175$		
	β	t	p	β	t	p
Constant	-	2.614	0.011	-	6.000	< 0.001
Age	0.012	0.134	0.893	-0.046	-0.402	0.689
Gender	0.103	1.228	0.223	-0.095	-0.877	0.383
Psychiatric diagnosis	-0.038	-0.442	0.660	-0.117	-1.068	0.289
CAMM	-0.280	-2.368	0.020	-0.171	-1.119	0.266
CERQ-k-self-blame	0.324	2.659	0.009	0.184	1.169	0.245
CERQ-k-acceptance	0.034	0.370	0.712	0.100	0.851	0.397
CERQ-k-rumination	-0.044	-0.386	0.700	-0.204	-1.389	0.168
CERQ-k-catastrophizing	0.146	1.433	0.156	0.057	0.428	0.670
CERQ-k-other blame	0.078	0.901	0.370	0.008	0.070	0.944

Note: β , standardized regression coefficient; MAQ = Misophonia Assessment Questionnaire; A-MISO-S = Amsterdam Misophonia Scale; CERQ-k = Cognitive Emotion Regulation Questionnaire, child version; CAMM = Child and Adolescent Mindfulness Measure.

Table 4. Two-way interaction regression models predicting adaptive functioning variables

Mindfulness as moderator				CERQ-K-self-blame as moderator			
PROMIS-P-P-PR $R^2 = 0.263; F(6, 95) = 5.678, p < 0.001$				PROMIS-P-P-PR $R^2 = 0.134; F(6, 91) = 2.349, p = 0.037$			
Model variables	β (SE)	t	p	Model variables	β (SE)	t	p
Constant	51.485 (7.064)	7.290	< 0.001	Constant	27.079 (4.878)	5.551	< 0.001
Age	- 0.313 (0.237)	- 1.317	0.191	Age	- 0.277 (0.252)	- 1.099	0.275
Gender	2.072 (1.215)	1.705	0.092	Gender	1.160 (1.313)	0.883	0.379
Psych. Diagnosis	4.074 (1.577)	2.584	0.011	Psych. Diagnosis	2.363 (1.633)	1.447	0.151
MAQ	- 0.616 (0.139)	- 4.427	0.001	MAQ	- 0.099 (0.082)	- 1.220	0.226
CAMM	- 0.854 (0.211)	- 4.049	0.001	CERQ-k-self-blame	0.529 (0.438)	1.206	0.231
MAQ x CAMM	0.016 (0.005)	3.287	0.001	MAQ x CERQ-K-self-blame	- 0.008 (0.010)	- 0.781	0.437
PROMIS-P-P-FR $R^2 = 0.102; F(6, 95) = 1.804, p = 0.106$				PROMIS-P-P-FR $R^2 = 0.109; F(6, 91) = 1.862, p = 0.096$			
Model variables	β (SE)	t	p	Model variables	β (SE)	t	p
Constant	32.104 (5.843)	5.495	< 0.001	Constant	31.879 (3.797)	8.396	< 0.001
Age	- 0.116 (0.196)	-0.592	0.555	Age	- 0.077 (0.196)	- 0.391	0.697
Gender	1.313 (1.005)	1.306	0.195	Gender	1.538 (1.022)	1.505	0.136
Psych. Diagnosis	0.830 (1.304)	0.636	0.526	Psych. Diagnosis	0.391 (1.271)	0.308	0.759
MAQ	- 0.054 (0.115)	- 0.468	0.641	MAQ	- 0.026 (0.063)	- 0.412	0.681
CAMM	0.042 (0.175)	0.242	0.809	CERQ-k-self-blame	- 0.030 (0.341)	- 0.089	0.929
MAQ x CAMM	- 0.001 (0.004)	- 0.354	0.725	MAQ x CERQ-k-self-blame	- 0.004 (0.008)	- 0.531	0.597
PROMIS-P-P-LS $R^2 = 0.211; F(6, 91) = 4.062, p = 0.001$				PROMIS-P-P-LS $R^2 = 0.193; F(6, 91) = 3.619, p = 0.003$			
Model variables	β (SE)	t	p	Model variables	β (SE)	t	p
Constant	51.175 (8.134)	6.291	< 0.001	Constant	38.377 (5.229)	7.339	< 0.001
Age	- 0.412 (0.268)	- 1.535	0.128	Age	- 0.183 (0.270)	- 0.678	0.499
Gender	0.448 (1.368)	0.328	0.744	Gender	0.378 (1.407)	0.269	0.789
Psych. Diagnosis	1.020 (1.777)	0.574	0.567	Psych. Diagnosis	- 0.656 (1.750)	0.375	0.709
MAQ	- 0.417 (0.161)	- 2.586	0.011	MAQ	- 0.193 (0.087)	- 2.207	0.030
CAMM	- 0.457 (0.245)	- 1.864	0.066	CERQ-k-self-blame	- 0.587 (0.470)	- 1.249	0.215
MAQ x CAMM	0.007 (0.006)	1.220	0.226	MAQ x CERQ-k-self-blame	0.009 (0.011)	0.799	0.427

Note: MAQ = Misophonia Assessment Questionnaire; CERQ-k = Cognitive Emotion Regulation Questionnaire, child version; CAMM = Child and Adolescent Mindfulness Measure; PROMIS-P-P-PR = PROMIS Pediatric Parent Proxy Peer Relationships Measure; PROMIS-P-P-FR = PROMIS Pediatric Parent Proxy Family Relationships Measure; PROMIS-P-P-LS = PROMIS Pediatric Parent Proxy Life Satisfaction Measure

Highlights

- Misophonia involves intense sensitivity and affective reactions to ordinary human-generated sounds
- Mindfulness and cognitive emotion regulation are two potential processes in pediatric misophonia
- We examined said processes in relation to adaptive functioning and symptomology
- In 102 youth with misophonia, symptomology was associated with process variables
- Mindfulness moderated link between symptomology and functioning in peer relationships
- Implications of findings for future intervention development efforts are discussed

Author disclosure

Conflicts of Interest

All authors declare no conflicts of interest.

Ethical Statements

The present study was approved by the Institutional Review Board at Baylor College of Medicine.

Informed Consent

Parents/caregivers/legal guardians of all minor child participants provided informed consent prior to participation. All children participants provided assent.

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Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.