Schizophrenia Research 250 (2022) 137–142

Contents lists available at ScienceDirect

Schizophrenia Research

journal homepage: www.elsevier.com/locate/schres

Do they make these sounds to hurt me? The mediating role of emotion regulation, anxiety and hostile attributions in the relationship between misophonia and paranoia-like thoughts

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ARTICLE INFO

Keywords:
Paranoia
Paranoia-like thoughts
Misophonia
Emotion regulation
Anxiety
Hostile attributions

ABSTRACT

Misophonia is a complex syndrome in which selective auditory stimuli, such as sounds of breathing, sniffing or eating, trigger an intense, negative emotional response. Previous studies have shown that the symptoms of misophonia coexist with a number of mental disorders, such as OCD, depression and anxiety. However, still little is known about other mental states that may be present in this context. A total of 312 people from the non-clinical sample participated in an online correlational study, which aimed at investigating whether there is a significant association between misophonia symptoms and paranoia-like thoughts, as well as to examine what factors might underlie this potential relationship. The results revealed that misophonia positively correlates with paranoia-like thoughts. A serial mediation analysis showed that difficulties in regulating emotions, anxiety and hostile attributions are significant mediators in the relationship between misophonia and paranoia-like thoughts. Importantly, these mediators, above all, form a potential coherent explanatory mechanism underlying this association. Hence, our results highlight the important role of socio-cognitive factors in the conceptualization of misophonia and its relation to paranoia-like thoughts.

1. Introduction

Misophonia ("hatred of sounds"), first described by Jastreboff and Jastreboff (2001), is a fairly new, complex neurophysiological and behavioral syndrome (Ferrer-Torres and Giménez-Llort, 2022), where a range of selective auditory stimuli (mainly sounds made by other people) cause an intense, negative and unbearable emotional reaction in the individual. In response to specific stimuli (called "triggering" or "misophonic" sounds), such as nasal (e.g., breathing, sniffing) or eating sounds (e.g., chewing) (Vitoratou et al., 2021), a person manifests a strong physical (e.g., increased heart rate) (Ferrer-Torres and Giménez-Llort, 2021) and/or unpleasant emotional reaction (e.g., anger, anxiety, disgust, avoidance or hatred) (Brout et al., 2018). Although misophonia is not formally classified as a psychiatric disorder as there are still insufficient diagnostic criteria to formulate such a diagnosis (Ferrer-Torres and Giménez-Llort, 2022), a recent review suggests that "misophonia, or some syndrome in which misophonia is a key feature, may represent a new mental disorder" (Taylor, 2017). Recent studies have shown that misophonia is associated with reduced life quality, comorbidity, high intensity of negative emotions, as well as behaviors that may affect interpersonal relationships in the long term (Claiborn et al., 2020).

It has been hypothesized that misophonic responses are both biological and shaped by environmental influences (Brout et al., 2018). The existing literature emphasizes that misophonia is activated in response to a specific context rather than to a given sound itself (Edelstein et al., 2013). For instance, it has been shown that misophonia symptoms evoke a more negative emotional reaction when a particular sound is made by a family member or a close friend (Edelstein et al., 2013). Avoiding triggering situations (i.e., safety behaviors; as proven common in misophonia), while initially preventing exposure and cue-related distress, can often result in social withdrawal, and thus significantly impact daily and interpersonal functioning (Jager et al., 2020). Although avoidance and escape strategies are most commonly reported in misophonia, approach-oriented behaviors, such as confronting others or adopting a hostile attitude, are also being noted (Schadegg et al., 2021). A recent qualitative study found that individuals suffering from misophonia perceived that other people purposely emit these triggering sounds "to underline their maladaptive interpersonal schemas" (Natalini et al., 2020). Moreover, it has been shown that when a person thinks

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https://doi.org/10.1016/j.schres.2022.11.005
Received 12 August 2022; Received in revised form 28 September 2022; Accepted 5 November 2022
Available online 18 November 2022

other people are *intentionally* making the triggering sounds, an even more intense negative emotional response takes place (Reid et al., 2016; Natalini et al., 2020). Therefore, assigning hostile intentions to other people seems not only to occur, but also to exacerbate the symptoms of misophonia.

One of the most extreme states associated with high levels of disturbing thoughts that someone has hostile intentions and is deliberately trying to hurt the person is called paranoia (Freeman et al., 2005). According to the hierarchy of paranoia (Freeman et al., 2005) and the existing theoretical models of delusions (Freeman et al., 2002), paranoia-like thoughts can be (among others) built on or triggered by a constant stress, continual anxiety or social concerns, including feelings of vulnerability and worrisome thoughts that the world (or other people) could be potentially dangerous. Recent studies have shown that the presence of a hostile attribution bias (the tendency to interpret the actions of others as intentional and hostile rather than accidental or benevolent intention) is related to paranoia and may also act as a significant predictor of paranoid thoughts (Buck et al., 2020; Combs et al., 2007). While the symptoms of misophonia have been found to be associated or coexisting with a number of other psychiatric disorders such as anxiety, depression, obsessive-compulsive disorder (OCD) or eating disorders (Ferrer-Torres and Giménez-Llort, 2022), they have never been, to the best of our knowledge, investigated in the context of paranoia-like thoughts, which are fairly common in the general population (Freeman et al., 2011).

Since negative emotional states (including anxiety), difficulties in regulating emotions and assigning hostile intentions to other people turn out to be significant correlates of misophonia (Cassiello-Robbins et al., 2020; Reid et al., 2016), and are also significant predictors of paranoia-like thoughts (Buck et al., 2020; Westermann et al., 2013), they share a common theoretical background. As the suffering associated with the symptoms of misophonia concerns the presence of selective sounds (often, these are everyday sounds that cannot be easily avoided without being completely isolated from other people, i.e. breathing or eating sounds, especially made by people in the closest environment), people suffering from misophonia live in a state of constant, extreme stress which can make them feel vulnerable to harm in the long term. Vulnerability, on the other hand, is thought to be the foundation upon which paranoia-like thoughts are built (Freeman et al., 2005). Therefore, it is crucial to examine whether these two distressing mental states are interrelated and to understand the potential mechanisms underlying this association.

Safety behaviors (such as avoidance or escape) undertaken to avoid triggering stimuli associated with misophonia can maintain its symptoms and lead to difficulties in coping or regulating emotions over time (Guetta et al., 2022). Emotion regulation is defined by strategies and the ability to monitor, evaluate and modify one's emotional reaction, mainly in terms of its intense and temporal characteristics (Thompson, 1994). Difficulties in regulating (i.e. identifying, understanding, or modulating) emotions, can lead, however, to many negative outcomes (Bjureberg et al., 2016). Recent studies have shown that difficulties in regulating emotions are associated with increased symptoms of misophonia (Cassiello-Robbins et al., 2020; Guetta et al., 2022). Escape or avoidance behaviors, as emotion regulation or prevention strategies, in response to triggering stimuli can amplify the negative emotional response and, in turn, lead to increased anxiety and distress. This is also in line with another theoretical model in which emotion regulation plays an important role in the etiology of anxiety disorders (Cisler et al., 2010). An elevated anxiety, on the other hand, has been found to be associated with increased hostility (Hertsgaard and Light, 1984; Tellawi et al., 2016).

Hence, the purpose of this study was to investigate, for the very first time, whether there is an association between misophonia symptoms and paranoia-like thoughts in a non-clinical sample. In the next step, we intended to propose a theoretical model that could explain this potential relationship and open the door to further experimental research on this phenomenon in the future. Therefore, we created and tested an exploratory, serial mediation model in which the relationship between misophonia and paranoia-like thoughts is mediated by emotion regulation, anxiety and hostile attributions. People experiencing misophonia symptoms have difficulty regulating their own negative emotions caused by, e.g. misophonic sounds. This, in turn, can further elevate their anxiety levels, leading to the attribution of hostile intentions to those making the triggering sounds (i.e. assuming they are making the sounds on purpose). This, if left untreated and not employing adaptive coping strategies, can further turn into increased levels of paranoia-like thoughts and a generalization of these hostile attributions by assuming that other people may want to intentionally hurt them (making sounds that are triggering or in another way). In this article, we will attempt to verify this exploratory, theoretical hypothesis.

2. Methods

2.1. Participants

The sampling method used in this study was a convenience sample. As this study was part of another, larger project, it was addressed to adults aged 18 to 40 years, which was the main inclusion criterion employed. Participants were recruited online through social media advertising and the "snowball method". The online advertisement contained a link redirecting to the target survey, which was placed on the Qualtrics platform. The participant's task was to answer all the survey questions. A total of 312 subjects (64.7 % female) signed an online consent form and took part in the online study which was approved by the local ethics committee and was conducted in accordance with the latest version of the Declaration of Helsinki.

2.2. Measures

Green Paranoid Thoughts Scale - Revised (R-GPTS) (Freeman et al., 2021) is a self-report 18 item-scale that measures the level of paranoia-like thoughts (based on last month's experiences) on two subscales – ideas of reference and ideas of persecution. The total score can range from 0 to 72, where higher scores indicate higher levels of paranoia-like thoughts. Cronbach's alpha for this scale in our study was 0.93.

MisoQuest – A questionnaire for assessing decreased sound tolerance (Siepsiak et al., 2020a, 2020b) is a newly developed self-report questionnaire for measuring the severity of misophonia symptoms based on the last month's experiences. It contains 14 items loaded into one factor. The total score can range from 14 to 70, with higher scores indicating higher levels of misophonia symptoms. A clinical cut-off point was proposed for 61 of 70 points. Cronbach's alpha in our study was 0.95.

Difficulties in Emotion Regulation Scale (DERS) (Gratz and Roemer, 2004) measures the level of emotion regulation problems on a 36-item self-report scale. The total score ranges from 36 to 180, where the higher scores indicate greater difficulties with emotion regulation. Cronbach's alpha for this scale in our study was 0.96.

The Ambiguous Intentions Hostility Questionnaire (AIHQ) (Combs et al., 2007) measures hostile social-cognitive biases. In this scale, participants are presented with five written vignettes that describe ambiguous social situations. After each scenario, the participant is asked to complete a self-report scale regarding intention, blameworthiness and own anger towards the person(s) in response to the given situation. Participants are also asked to answer two open-ended questions about their interpretation of the person's motives and how they would react to the situation. The self-report items, when added together, form a "blame score." Open-ended questions are scored by an independent scorer and form two other subscales: "hostility bias" and "aggression bias". We only use a "blame score" in our study, which has been shown to have a good internal consistency among both schizophrenia patients and controls, as well as to be related to clinically-rated hostility and suspiciousness (Buck et al., 2017). The total score can range from 5 to 80, with higher scores

indicating an increased tendency to perceive the intentions of others as hostile. Polish version of the scale was used (Zajenkowska et al., 2020). Cronbach's alpha for this scale in our study was 0.89.

Generalized Anxiety Disorder 7 (GAD-7) (Spitzer et al., 2006) is a 7-item self-report scale measuring the severity of generalized anxiety symptoms. The total score ranges from 0 to 21, where higher scores indicate higher levels of generalized anxiety. Cronbach's alpha for this scale in our study was 0.91.

2.3. Statistical analyses

Statistical analyses were performed in SPSS 27. Two tailed Pearson's correlation analyses were conducted to explore the relationships between paranoia-like thoughts, misophonia symptoms, emotion regulation, hostile attributions and anxiety. Student's *t*-test was used to test group differences (participants with and without diagnosis of mental disorders) in misophonia symptoms and paranoia-like thoughts. The one-way ANOVA was used to explore the differences in misophonia symptoms and paranoia-like thoughts between genders. Serial mediation analysis carried out using the model 6 in the PROCESS macro (Preacher and Hayes, 2004), following the bootstrapping procedure with 5000 resample, was performed to investigate the mediating effect of emotion regulation, anxiety and hostile attributions in the relationship between misophonia symptoms and paranoia-like thoughts. Due to the relatively high percentage of people who declared having a diagnosis of mental disorders in their lifetime (30.4 %), and also due to a significantly higher proportion of women (64.7 %) than men (33.3 %) in the sample, both the diagnosis and gender were added as covariates to the mediation model.

3. Results

Sample characteristics can be found in Table 1. A post-hoc power analysis, with a sample size of 312 and alpha level set to $p < 0.05$, was performed using G*Power3 (Faul et al., 2007). The post hoc analysis revealed a power of 0.82, indicating adequate sample power for this study. The mean value of misophonia in our sample was 30.81 (SD = 13.65), which indicates slightly lower (yet comparable) results than in case of healthy subjects (M = 35.32, SD = 12.67) in another study using the same scale (Siepsiak et al., 2022).

The results of the correlation analyses are presented in Table 2. Significant correlations were found between all studied variables. Misophonia was positively correlated with paranoia-like thoughts ($r = 0.497$, $p < 0.001$), which means that the higher the intensity of misophonia symptoms the higher the level of paranoia-like thoughts.

3.1. Serial mediation analysis

Fig. 1 presents the results of the serial mediation analysis. The purpose of this analysis was to investigate the role of difficulties in emotion regulation, anxiety and hostile attributions in the relationship between misophonia and paranoia-like thoughts.

The results revealed that the standardized total effect of misophonia on paranoia-like thoughts significantly differed from zero ($\beta = 0.504$, 95 % CI = 0.352 to 0.521, $p < 0.001$). The direct effect of misophonia on paranoia-like thoughts also was significant ($\beta = 0.309$, 95 % CI = 0.185 to 0.349, $p < 0.001$), which means that the mediation is complementary. The total standardized indirect effect was significant ($\beta = 0.196$, 95 % CI = 0.135 to 0.261), with a significant serial mediation effect being observed from misophonia via emotion regulation, anxiety and hostile attributions to paranoia-like thoughts ($\beta = 0.01$, 95 % CI = 0.001 to 0.016). All the other indirect pathways from misophonia to paranoia-like thoughts were also significant: via emotion regulation only ($\beta = 0.053$, 95 % CI = 0.012 to 0.1), via anxiety only ($\beta = 0.041$, 95 % CI = 0.01 to 0.079), via hostile attributions only ($\beta = 0.031$, 95 % CI = 0.01 to 0.06), via emotion regulation and anxiety ($\beta = 0.042$, 95 % CI = 0.01 to

Table 1
Participant demographics (n = 312).

	N (%)		M (SD)	Range
Sex		Age	29.17 (6.25)	18–40
Female	202 (64.7)	R-GPTS (paranoia)	11.21 (11.82)	0–69
Male	104 (33.3)	Reference	7.56 (6.44)	0–31
Other	6 (1.9)	Persecution	3.66 (6.30)	0–38
Education		MisoQuest (misophonia)	30.81 (13.65)	14–69
Primary	7 (2.2)	DERS (emotion regulation)	83.99 (25.62)	36–151
Vocational	1 (0.3)	AIHQ (hostile attributions)	41.71 (12.16)	15–79
Secondary	94 (30.1)	GAD-7 (anxiety)	7.33 (4.72)	0–21
Higher	210 (67.3)			
Professional situation				
Employed	227 (72.8)			
Unemployed	23 (7.4)			
Retired	2 (0.6)			
Student	102 (32.7)			
Psychiatric diagnosis	95 (30.4)			
Anxiety disorder	46 (14.7)			
Depression	68 (21.8)			
Bipolar disorder	1 (0.3)			
Schizophrenia	1 (0.3)			
OCD	8 (2.6)			
Personality disorder	16 (5.1)			
Eating disorder	5 (1.6)			
SUD	1 (0.3)			
ADS	0 (0)			
Other	17 (5.4)			
Medication use	118 (37.8)			
Antidepressants	102 (32.7)			
Anti-anxiety drugs	52 (16.7)			
Antipsychotics	5 (1.6)			
Sleeping pills	18 (5.8)			
Mood stabilizers	17 (5.4)			
Other	13 (4.2)			

Note: OCD – obsessive-compulsive disorder, SUD – substance use disorder, ADS – alcohol dependence syndrome, R-GPTS - Green Paranoid Thoughts Scale - Revised, DERS – Difficulties in Emotion Regulation Scale, AIHQ – The Ambiguous Intentions Hostility Questionnaire, GAD-7 – Generalized Anxiety Disorder 7.

Table 2
Correlational matrix (n = 312).

	R-GPTS	MisoQuest	DERS	AIHQ
R-GPTS	-			
MisoQuest	0.497***	-		
DERS	0.494***	0.330***	-	
AIHQ	0.450***	0.317***	0.445***	-
GAD-7	0.520***	0.413***	0.718***	0.433***

Note: R-GPTS - Green Paranoid Thoughts Scale - Revised, DERS – Difficulties in Emotion Regulation Scale, AIHQ – The Ambiguous Intentions Hostility Questionnaire, GAD-7 – Generalized Anxiety Disorder 7.
*** <0.001.

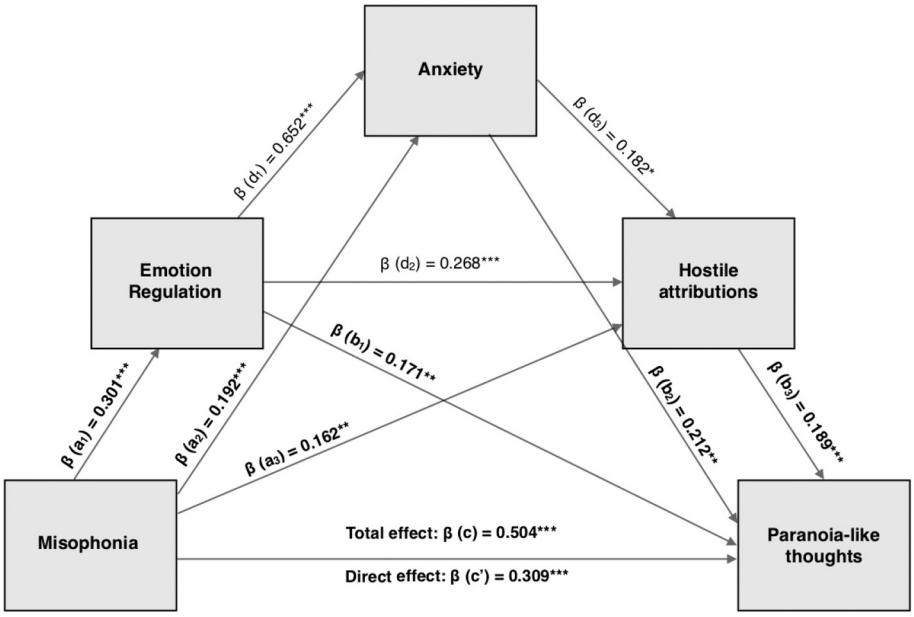

Fig. 1. Serial mediation analysis. The mediating role of difficulties in emotion regulation, anxiety and hostile attributions in the relationship between misophonia symptoms and paranoia-like thoughts.
Note: * < 0.05, ** < 0.01, *** < 0.001.

0.08), via emotion regulation and hostile attributions ($\beta = 0.016$, 95 % CI = 0.004 to 0.033) as well as via anxiety and hostile attributions ($\beta =$ 0.01, 95 % CI = 0.001 to 0.016). The total effect explained 26.81 % of the variance in paranoia-like thoughts, and the mediated model explained 44.27 % of the variance. Gender ($p < 0.05$) and lifetime diagnosis of psychiatric disorders ($p > 0.05$) were included as covariates in the model.

The independent samples *t*-tests revealed no significant difference in both the level of misophonia symptoms ($p = 0.312$) and in the level of paranoia-like thoughts ($p = 0.127$) between people who declared having a diagnosis of mental disorders at some point in their lifetime and people without a diagnosis. The one-way ANOVA showed no significant difference in the level of paranoia-like thoughts between the genders ($p =$ 0.112), but did show a significant difference in the level of misophonia symptoms ($p = 0.04$). Post-hoc analysis revealed a greater (at the trend level, $p = 0.06$) severity of misophonia in women ($M = 31.99$, $SD =$ 13.81) than in men ($M = 28.18$, $SD = 12.8$). The differences between women/men and people who stated their gender as "other" were not significant.

4. Discussion

Misophonia has appeared in the psychological and psychiatric literature only recently. Nevertheless, it has already gained enormous interest from researchers in various fields. While the subject is still being extensively studied, much has already been established. For instance, we already know that the symptoms of misophonia coexist with a number of other mental disorders, such as OCD, ADHD, depression or anxiety (Potgieter et al., 2019; Ferrer-Torres and Giménez-Llort, 2022; Siepsiak and Dragan, 2019). However, still little is known about different mental conditions that may be related to misophonia severity. In this study, we aimed to investigate whether there is an association between misophonia symptoms and paranoia-like thoughts in a non-clinical sample, and if so, what are the possible factors underlying this relationship.

First of all, in line with the results of previous studies, we show that the symptoms of misophonia positively correlate with difficulties in emotion regulation (e.g., Cassiello-Robbins et al., 2020; Guetta et al., 2022) and increased levels of anxiety (e.g., Siepsiak et al., 2020a, 2020b). Moreover, a significant positive correlation was found with hostile attributions measured with a validated scale (Combs et al., 2007), which is in congruence with the existing qualitative case study data (Reid et al., 2016; Natalini et al., 2020) on attributing hostile intentions to people making triggering sounds by the misophonia sufferers. Hence, these results highlight the important role of the cognitive-emotional aspects in the conceptualization of misophonia.

What is particularly important and what was the main research question of our study, the results revealed that misophonia is positively correlated with paranoia-like thoughts. Moreover, we found that difficulties in regulating emotions, anxiety, and hostile attributions are not only significant mediators of the relationship between misophonia and paranoia-like thoughts, but, most of all, form a coherent explanatory mechanism underlying this association. Namely, based on our findings we may hypothesize that people experiencing misophonia symptoms have difficulties in regulating their negative emotions caused by the presence of intolerable misophonic sounds. Further, due to the lack of effective emotion regulation strategies, these negative emotional states associated with hatred sounds may be exaggerated. Indeed, the inability to deal with unpleasant emotions can contribute to an increase in overall anxiety (Cisler et al., 2010). The consequence of this may be adopting defensive strategies in the form of hostile attitude towards people who may intentionally emit the triggering sounds. Attributing hostile intentions to other people in this particular situation, which is presumably associated with an elevated level of anxiety, can further develop into more intense and generalized thoughts that other people may intentionally want to hurt them, e.g. emitting the triggering sounds or in another threatening way. The negative emotional states associated with the presence of misophonic sounds makes the person more vulnerable to harm, as triggers, frequently being an inseparable part of everyday social functioning, are often inevitable. Vulnerability, in turn, is the basis upon which paranoia-like thoughts are built (Freeman et al., 2005), hence supporting our inference.

Nevertheless, although the directional model was tested, the data on which we built this theoretical hypothesis and our line of reasoning, is correlational, which means that no cause-and-effect conclusions can be drawn. Although this model turned out to be significant, it can be assumed that the relationships between these variables are bidirectional, and their order in the mediation model may change and take the form of a feedback loop mechanism. Moreover, the results of our study

showed that the mediation was complementary, which may indicate that misophonia symptoms directly (apart from the mediating role of emotion regulation, anxiety and hostile attributions) affect paranoia-like thoughts or that there are other mediators of this relationship, that were not included in our model. Our study was the very first step towards better understanding the relation between misophonia and paranoia-like thoughts and its mechanisms. The correlational nature of the study, however, can be considered as a limitation. Hence, further research, especially using experimental or longitudinal methods, which would allow establishing the causality of this association, as well as applying structured clinical interviews, is warranted.

Our findings also revealed significant (at the trend level) differences between the genders in the misophonia symptoms severity. In line with previous studies (Erfanian et al., 2019; Rouw and Erfanian, 2018), misophonia seemed to affect women more than men. However, the existing research regarding the role of gender in misophonia is inconsistent. A very recent study (Savard et al., 2022) revealed that misophonia did not differ between men and women, but additional analysis showed that one item on the misophonia questionnaire appeared to differentiate between the sexes and referred to the physiological component of emotions. However, it has not been proven to be specific to misophonia, as men and women typically differ in their self-reported responses to negative emotional stimuli, which is not necessarily reflected in their physiological responses (Poláčková Šolcová and Lačev, 2017). Future research aimed directly at gender differences in the context of misophonia is then needed.

We intended to conduct the study on a non-clinical sample, as it was found that both paranoia-like thoughts (Freeman et al., 2011) and misophonia symptoms (Wu et al., 2014; Kılıç et al., 2021) are, to some extent, prevalent in the general non-clinical population. However, a relatively large percentage (30.4 %) of the respondents participating in the study declared that they had some kind of psychiatric diagnosis in their lifetime, mainly depression (21.8 %) and anxiety (14.7 %). These numbers are also in line with a very recent meta-analysis (Chekole and Abate, 2021) which showed that the prevalence of anxiety and depression (mostly reported diagnoses in our study) is estimated at 33.59 % and 29.98 %, respectively. Nevertheless, the presence of the declared diagnosis was added as a covariate to the mediation analysis to limit the potential impact of the diagnosis on the results. However, the effects remained significant, suggesting that both paranoia-like thoughts and misophonia symptoms may appear and coexist in a healthy population, contributing to elevated stress levels and becoming a risk factor for more severe psychological symptoms if left untreated.

Even though our study was conducted primarily on a non-clinical sample, we can cautiously assume that our results may have potential clinical implications. If replicated in clinical samples, moderate relationships between paranoia-like thoughts and misophonia may suggest that hatred sounds emitted by other people are a source of significant distress and exaggerated safety behaviors (e.g., social withdrawal) complicating both symptoms of paranoia as well as misophonia. Furthermore, misophonia, as associated with interpersonal context, may be additional factor increasing emotional dysregulation associated with paranoia. To our best knowledge, the relationship between misophonia and paranoia or psychosis in general, was not considered in the existing therapy protocols. Although there are no proven psychological therapy protocols for treating misophonia symptoms as yet, cognitive behavioral therapy (CBT) is considered to be a promising and effective treatment for misophonia (Ferrer-Torres and Giménez-Llort, 2022). Further research on clinical samples is warranted to explore the potential role of misophonia in clinical paranoia or psychosis in general, as well as in relation to other psychotic-like experiences, e.g. auditory hallucinations. Another direction for future research may be to investigate sensory gating (brain processes engaged to selectively filter irrelevant sensory stimuli) as a potential common ground factor in the link between misophonia and psychosis, as it has been shown that sensory gating can be impaired in both syndromes (Brout et al., 2018; Shen et al., 2020).

To conclude, the results of our study enriched the existing literature with an additional factor playing a role in the conceptualization of misophonia, i.e. paranoia-like thoughts. Moreover, we proposed an exploratory model that describes a potential coherent mechanism underlying the relationship between misophonia symptoms and paranoia-like thoughts. Namely, we highlighted the role of difficulties in emotion regulation, anxiety, and hostile attributions as significant mediators, which collectively emphasize the key role of socio-cognitive factors in misophonia. Hence, our findings suggest that misophonia is significantly related to interpersonal trust and at least partially cognitive and emotional processes play a role in shaping this relation.

Funding sources

This work was supported by the SONATA BIS grant from the National Science Center, Poland (ŁG, 2019/34/E/HS6/00279).

CRediT authorship contribution statement

Paulina Bagrowska: Conceptualization, Methodology, Investigation, Formal analysis, Visualization, Project administration, Data curation, Writing – original draft. **Renata Pionke-Ubych:** Methodology, Formal analysis, Writing – review & editing. **Łukasz Gawęda:** Funding acquisition, Supervision, Writing – review & editing.

Declaration of competing interest

The authors have declared that there are no conflicts of interest in relation to the subject of this study.

Acknowledgements

The authors would like to thank all respondents for participating in the study.

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