CLINICAL AND NEUROPSYCHOLOGICAL CORRELATES OF MISOPHONIA

By

Tanya A. Herrera, B.A.

A thesis submitted to the Graduate Council of
Texas State University in partial fulfillment
of the requirements for the degree of Master of Arts
with a Major in Psychological Research
May 2022

Committee Members:

Amitai Abramovitch, Chair

Rebecca Deason

Reiko Graham

FAIR USE AND AUTHOR'S PERMISSION STATEMENT

Fair Use

Duplication Permission

DEDICATION

To Natalia – You always believed in me, even when I did not believe in myself. You encouraged me to keep going despite my fears of advancing my career. Thank you for being my motivation, inspiration, and above all else, a great sister.

ACKNOWLEDGEMENTS

I would like to thank Dr. Amitai Abramovitch, my thesis chair, and mentor, for your guidance in my thesis project and incredible support throughout the master's program. I would also like to thank my other committee members, Dr. Rebecca Deason and Dr. Reiko Graham, for your valuable feedback throughout the writing process.

TABLE OF CONTENTS

Page

LIST OF TABLES

Table **Page**

I. INTRODUCTION

Misophonia – a term coined by Jastreboff and Jastreboff (2001a) – can be directly translated from Greek to "*hatred of sound.*" It is a chronic disorder characterized by a strong dislike of specific auditory stimuli associated with specific sounds produced by humans (e.g., mouth smacking, chewing, mouth breathing, pen clicking, and tapping) that results in an intense negative emotional reaction (Edelstein et al., 2013; Wu et al., 2014). This emotional experience may include irritability, anxiety, and extreme anger (Cusack et al., 2018; Schroder et al., 2013; Wu et al., 2014) that can be accompanied by an impulsive 'explosive' behavioral response or avoidance (Potgieter et al., 2019). Although some progress has been made in the past 20 years in understanding the mechanisms of misophonia, it is yet to be recognized as a formal disorder. Much more research is needed to understand multiple aspects of misophonia (Cowan et al., 2022; Frank et al., 2020).

Historically before the use of 'misophonia', the condition was known as 'selective sound sensitivity syndrome' (4S; Cavanna & Seri, 2015; Jastreboff & Jastreboff, 2001a; Spankovich & Hall, 2014). In their seminal study, Jastreboff and Jastreboff (2001a) observed a clinical sample of what they believed to be a subset of individuals with hyperacusis and tinnitus that followed a distinct pattern. Tinnitus is a symptom characterized by the perception of sounds in the absence of an external acoustic stimulation presented in a high-pitched ringing, hissing, or humming, whereas hyperacusis is characterized by intolerance, perceived loudness, and hyperawareness of non-specific everyday sounds (Aazh et al., 2019). Both conditions are related to sensitivity and negative attitudes towards non-specific auditory stimuli, regardless of

their type and source (Jastreboff et al., 2001). While initially misophonia was assumed to be associated to these conditions due to their similar affective and perceptual experience (Cavanna & Seri, 2015; Jastreboff & Jastreboff, 2001b; Potgieter et al., 2019), it was recognized as its distinct disorder since all aversive sounds experienced, as reported by patients, were attributed to a human source (Jastreboff & Jastreboff, 2001a). However, it is important to note that hyperacusis and tinnitus are formally coded in the 11th edition of the International Classification of Disease (ICD-11; World Health Organization, 2019) and misophonia is not (Cavanna & Seri, 2015; Potgieter et al., 2019). This is surprising since there seems to be sufficient data to warrant recognition of misophonia as a formal disorder (Potgieter et al., 2019).

Since the disorder is not currently recognized, it is not surprising that there is no formal diagnostic algorithm, which poses a challenge in terms of psychopathological, biological, and clinical research into the disorder. However, over the last two decades, various measures of misophonia have been developed to assess the type of triggers, severity of sensitivity, corresponding emotional response to trigger sounds, and psychological, and physiological correlations. The most used measures include the Misophonia Questionnaire typically used in non-clinical samples (MQ; Wu et al., 2014) and the Amsterdam Misophonia Scale focused on a clinical population (A-MISO-S; Schroder et al., 2013). Both self-report measures have been used to describe the emotional experience and related symptomology of misophonia and have been associated with psychopathologies such as OCD/OCPD, ADHD, and PTSD (Cassiello-Robbins et al., 2020; Wu et al., 2014). As research for the treatment of misophonia continues to develop and with only a recent publishment that established consensus for definition

(Swedo et al., 2022), there seems to be an inconsistency of standardized criteria across physicians. This has greatly hindered research and treatment for individuals with misophonia, affecting reimbursement by insurance and disability benefits.

Literature on the epidemiology of misophonia including prevalence, age at onset, and the course of the disorder is still in its early stages. Prevalence seems to be dependent on the population, and potentially different definitions of misophonia may be used by different research groups. Thus, these estimates range significantly. For example, one study that uses the MQ found a high prevalence (20%) of misophonia in a US college sample, whereas another study that utilized the MQ reported a low prevalence (6%) in a sample of Chinese students (Wu et al., 2014; Zhou et al., 2017). Other studies reported higher prevalence rates (3%) in psychiatric samples or audiology samples (McFerran, 2016). In terms of age of onset, early research suggested that misophonia symptoms can be traced back to childhood, typically between the age of 8-13 (Edelstein et al., 2013; Schroder et al., 2013; Schroder et al., 2017), while other report misophonia onsets during adolescent years (Dozier, 2015; Rouw & Erfanian, 2018). Research on the course of the disorder is scarce but in a recent study (Rouw & Erfanian, 2018), 77% of participants reported that their symptoms worsened over time. Comparable studies reported similar findings in over 50% of their participants (Edelstein et al., 2013). While studies do not seem to report ethnicity or race in misophonia (Claiborn et al., 2020; Jager et al., 2020; Wu et al., 2014), only a few have reported any differences between gender, albeit small or uneven sample sizes (Claiborn et al., 2020; Erfanian et al., 2020).

Mechanisms of misophonia

Evidence suggests that the misophonic reaction involves physiological processes related to sympathetic nervous system activation, triggering a fight-or-flight response and hyperactivity in areas largely related to the limbic system, particularly the amygdala (Edelstein et al., 2013; Kumar et al., 2017). This symptom repertoire may cause disturbances in an individual's everyday functions, such as avoiding dinner with family, avoiding going out to restaurants, or using headphones to avoid trigger sounds (Schroder et al., 2013; Wu et al., 2014). Misophonia triggers can include sounds related to eating (e.g., chewing, swallowing, slurping), the sound of rustling (e.g., paper, plastic), repetitive tapping (e.g., pen on the table, foot on the floor), and nasal sounds (e.g., sniffing and inhaling; Wu et al., 2014). It has been suggested that even specific spoken sounds, particularly those that involved or included the consonant, /s/, /t/, /ch/, and /k/, elicit these emotional responses (Colucci, 2016; Geller et al., 2001). Notably, although these triggers are rather varied, all those sounds are known to provoke immediate aversive physiological reactions, verbal aggression, and physical aggression in some cases (Schroder et al., 2013).

While there is literature examining psychological and physiological correlates of misophonia, there is a need to study cognitive function associated with the disorder. Most studies have been focused on physiological responses related to aversive sounds while evaluating amygdala activation (Edelstein et al., 2013; Kumar et al., 2017). Moreover, past research largely focused on the evaluation of the psychological experience related to trigger sounds (e.g., anxiety and stress symptoms), but more current investigations point to an important association of misophonia with deficient emotional regulation, rigidity,

and impulse control (Cassiello-Robbins et al., 2020; Guetta, Cassiello-Robbins, Trumbull, et al., 2022; Wu et al., 2014). Despite speculation that this disorder may be processed and experienced multimodally, there is little known about cognitive function in misophonia with less than a handful of studies published in the last 5 years (Daniels et al., 2020; Eijsker et al., 2019; Frank et al., 2020). Importantly, in the context of psychopathology, neuropsychological testing can assess 'cold' or 'hot cognitive function. 'Cold' cognitive functioning refers to cognitive function under neutral conditions whereas 'hot' cognitive functioning is observed when a task is performed under emotionally charged conditions or stimuli. Only two studies have examined the 'hot' cognitive functioning, and only one has examined 'cold' cognitive functioning (Daniels et al., 2020; Eijsker et al., 2019; Frank et al., 2020; Salehinejad et al., 2021). Those who examined hot cognitive function, such as Daniels and colleagues (2020), found that a Stroop effect and a slower-response time were associated with misophonia trigger sounds. Frank and colleagues (2020) found worse alerting attention when exposed to misophonia trigger sounds. However, the role of executive function in misophonia has not been understood despite efforts. For example, the only study that assessed 'cold' cognitive function did not find impaired response inhibition among their misophonia participants (Eijsker et al., 2019). In conclusion, there is a need for a more comprehensive examination of cold cognitive function in misophonia, particularly since it is an episodic disorder. Therefore, the present study will observe both neurocognitive mechanisms and their clinical correlations in misophonia.

Measures of misophonia

Various self-report measures for the assessment of the severity of misophonic symptoms exist, evaluating several aspects of this disorder. There are some previous attempts in the development of measures that were subject to psychometric work and thus, are not currently in use: such as The Misophonia Activation Scale, (MAS-1; Fitzmaurice, 2014), Misophonia Physiological Response Scale (MPRS; Bauman & Dozier, 2015), Misophonia Trigger Severity Scale (MTS; Dozier, 2015), and Misophonia Emotional Response (MER; Dozier, 2013).

As mentioned, one of the most widely used scales for the assessment of misophonia symptoms is the MQ (Wu et al., 2014). This questionnaire includes three sections that assess the presence, consequent emotions and behaviors, and severity of these sound sensitivities. The first subscale, Misophonia Symptom, describes specific sounds and examines the sound sensitivities. Then, the Misophonia Emotional and Behavioral Scale rate emotional and behavioral reactions relating to misophonic symptoms. A sample item can be seen as "become anxious or distressed", (Wu et al., 2014). The final section, Misophonia Severity Scale was adapted from the NIMH Global Obsessive-Compulsive Scale to be used for misophonia. This is meant for the participant to give a rating of their sound sensitivity on a scale ranging from 1 – 15, *minimal* to *very severe*. A score greater than or equal to 7 indicated clinically significant symptoms (Wu et al., 2014). A second measure, the A-MISO-S was proposed by Schroder and colleagues (2013), adapted from the Yale-Brown Obsessive-Compulsive Scale (Y-BOCS; Goodman et al., 1989). This measure was developed to assess misophonia symptom severity. It is a 6-item scale, where patients are asked about the amount of time

they have experienced misophonia symptoms, interference with social functioning, levels of anger relating to misophonia, the control they had over that anger, resistance against the impulse, and the general amount of time they spent avoiding these situations (Schroder et al, 2013). Additionally, scores between 0-and 24 are considered as follows in misophonic symptoms: *subclinical*, *mild*, *moderate*, *severe*, and *extreme* (Schroder, 2013).

These two measures are the most widely used in literature and both possess sound psychometric properties. Although the two measures differ in several aspects, the MQ is more frequently used and was developed among a college student sample (Wu et al., 2014) whereas the A-MISO-S is utilized in clinical settings (Schroder et al, 2013). Therefore, the present study will be implementing the MQ.

Proposed Diagnostic Criteria

Misophonia is not recognized as a formal disorder, and thus there are no formal DSM diagnostic criteria for the disorder. Schroder and colleagues (2013) were the first to suggest a diagnostic algorithm, which consists of 6 criteria. Criterion A refers to the presence or anticipation of a sound specifically produced by a human that invokes a strong physical reaction, which begins with irritation or disgust that becomes anger (Schroder et al., 2013). Criteria B and C refer to the anger triggering a sense of loss of self-control with rare but potential aggression in outbursts as well as the individual evaluating this anger or disgust as excessive and out of proportion (Schroder et al., 2013). Criteria D and E refer to the avoidance of the provoking stressor, or, if unable to avoid it, having to endure the encounter with severe discomfort, anger, or disgust, and such

encounter causing significant distress or interference in their day-to-day life (Schroder et al., 2013). Finally, criterion F recognized that these emotional responses (anger, disgust, and avoidance) to trigger sounds are not explained or accounted for other disorders, such as obsessive-compulsive disorder or post-traumatic stress disorder (Schroder et al., 2013).

In light of accumulating research, a revision to this algorithm has been proposed more recently (Dozier et al., 2017). The initial criterion describes that minimal intensity stimulus that will elicit a response (Schroder et al., 2013). However, Dozier and colleagues (2017) build on this definition and suggest that if a high-intensity stimulus is needed to elicit a response, then it should not support a misophonia diagnosis (Dozier et al., 2017). The newly proposed criteria highlight the dysregulation of (negative) emotions and thoughts as well as the emotional experience of the trigger. While the debate continues, the common practice is to first rule out any auditory problems via hearing tests that show normal thresholds (no hearing loss nor distortion), and individuals must not have a history of neurological dysfunction or trauma (Potgieter et al., 2019; Schroder et al., 2013). Without empirically derived diagnostic criteria, there is no ICD-11 code or official Diagnostic and Statistical Manual of Mental Disorders (DSM-5) diagnostic criteria. Overall, there seems to be a need for a more structured interview, with the first attempt for a clinical interview being published this year (Guetta, Cassiello-Robbins, Anand, et al., 2022).

Treatment

Initial attempts to employ treatment for misophonia utilized the Tinnitus Habituation Therapy, which focuses on inhibition of sound. With this treatment,

Jastreboff (2014) reported promising results, noting an 80% improvement in symptoms. However, this study has been criticized due to its lack of quantitative assessment of symptoms and its failure to examine patients with misophonia versus ones with hyperacusis with or without misophonia (Frank & McKay, 2019; Potgieter et al., 2019).

Currently, Cognitive Behavioral Therapy (CBT) has been proposed as the first-line treatment for misophonia, which includes a primary Exposure and Response Prevention component as proposed by Schroder (2017). In their study, the author used 4 possible therapeutic techniques in different groups to address the various aspects of this disorder. The first group focused on the attentional bias toward misophonic triggers, which included task concentration training (TCT; Mulkens, 2001). The second group was asked to confront the emotional component of the disorder (the intense anger and disgust that follow the triggers) with counterconditioning (Schroder, 2017). Then, the third group used stimulus manipulation to address the uncontrollability and impulsive control experienced with misophonic triggers. Finally, the last group relied on relaxation exercises to reduce irritability and improve the tolerance of potential triggers. Unfortunately, while the CBT group exhibited a significant reduction of misophonia symptoms, only half of the sample showed significant improvement (Schroder, 2017). Schneider and Arch reviewed an adolescent misophonia case study using a mindfulness component from CBT and reported a significant reduction of anger outbursts and irritability and increased tolerance after 10-weekly sessions (Schneider et al., 2017). However, this information should be interpreted with caution as this was just a case study.

In a letter to the editor, Webber and Storch (2015) argue that Exposure therapy is

not necessarily the most effective for misophonia. In addition, the authors note that as misophonia is developing as a distinct disorder, treatment literature is largely based on case studies and the effect sizes are rather small (Webber & Storch, 2015). They also suggested that there is not a 'one-size fits all treatment for misophonia. While CBT can be considered the best treatment for people with anxiety/distress triggers, cognitive restructuring is more beneficial for those individuals that react with severe anger outbursts or rage (Webber & Storch, 2015). Indeed, more recent suggested treatment for misophonia includes interventions that augment classic CBT. For example, Frank and Mckay (2019) proposed exposure treatment focusing on inhibitory learning for the adult population with misophonia. Participants were asked to attend stress management classes followed by exposure or they received exposure prior to treatment with psychoeducation provided before starting stress education classes. Through exposure (listening to aversive sounds via headphones and/or in-person), they were expected to implement an inhibitory learning mechanism, through the engagement of the stimulus versus avoidance of the stimulus and change cognition of the trigger (Frank et al, 2019).

Finally, a scoping review discussed medication as a treatment for misophonia, and only two case studies reported using SSRIs and benzodiazepines with marginal improvement in individuals with misophonia compared to the control sample (Potgieter et al., 2019; Tunç & Başbuğ, 2017; Vidal et al., 2017). Potgieter and colleagues (2019) concluded that effect sizes and their non-significant results do not support further studies on medication as therapy. Nevertheless, there is a need for more studies to validate the current proposed treatment, particularly with greater effect sizes and overall larger sample size. Unfortunately, because of the ongoing debate concerning criteria selection

and consensus of measures, it is difficult to research treatment options for these individuals.

Related Medical Conditions

As aforementioned, there is an association between misophonia, tinnitus, and hyperacusis as they tend to co-occur. Their overlap is a natural consequence of their similar attributes, such as their perceptual properties while having normal hearing thresholds. Jastreboff and Jastreboff initially theorized that misophonia was a subset group of hyperacusis and related to tinnitus. However, while both conditions can cause distress in people's lives and result in avoidance, misophonia is most associated with human cues and followed by an immediate, significant emotional response after triggers and is considered a discrete disorder (Jastreboff, 2001; Wu, 2014; Edelstein, 2013). Therefore, misophonia can coexist with hyperacusis and tinnitus; in a brief analysis of Jastreboff and colleagues' study in 2001, they found evidence of this overlap in multiple patients at their tinnitus clinic (57% misophonia with/without hyperacusis; 28.9% misophonia without hyperacusis; Baguley & Fagelson, 2013). More recently, Jager and colleagues (2020) found only 2% with tinnitus and 1% with hyperacusis within a sample of 779 self-reported misophonia subjects. This study directly contradicts Jastreboff and colleagues (2001a) study and shows that while misophonia can be associated/overlapped with tinnitus and hyperacusis, it is not necessarily a subtype of those two conditions.

Comorbidity with Psychopathology

Initially, Jastreboff and colleagues found that only 5% of their sample with misophonia were being treated or had been diagnosed with a psychiatric disorder and

challenged misophonia's association with psychopathology (Jastreboff & Jastreboff, 2014). They theorized that the disorder seemed independent of neurological damage and more specifically, mental health. However, accumulating evidence contrasts with the latter premise. Research varies widely in terms of the prevalence of comorbidity of misophonia with DSM disorders, presumably given the variability in terms of the operational definition of misophonia across studies. However, there are some general indications that misophonia is associated with psychopathology (Erfanian et al., 2020; Potgieter et al., 2019). Schroder and colleagues (2013) used the Structured Clinical Interview for DSM-IV Axis II Personality Disorders (SCID-II) and the A-MISO-S to assess comorbidities in a misophonia sample. They observed elevated rates of comorbidity with Obsessive-Compulsive Personality Disorder (OCPD; 54.4%), which was considered by the authors as a risk factor for misophonia. They also speculated that ADHD (4.8%) may be related to misophonia due to distractibility and attentional shifts between visual and auditory cues (Schroder et al., 2013). More recent research affirmed these findings and identified prevalent comorbidities. Erfanian and colleagues (2019) administered the MINI International Neuropsychiatric Interview to evaluate the relationship between misophonia and affective disorders, where 9.61% of participants met the criteria for major depression disorder (MDD), 11.53% with OCD, and 15.38% with post-traumatic stress disorder (PTSD). Similarly, Jager and colleagues (2020) examined 575 participants who scored above the MQ clinical cutoff and found that 10% of the participants met the criteria for mood disorders including, 9% for anxiety-related disorders, and 5% for Attention-Deficit disorder. Cassiello-Robbins and colleagues (2021) found 32.7% with anxiety-related disorders, 18.4% with MDD, and 18.4% with

PTSD within their clinical sample. To note, most of the current literature has reflected community or clinical samples but not college samples. Overall, there is ample evidence that psychopathology is related to misophonia with many individuals suffering from misophonia, also struggling with DSM disorders, especially mood disorders, OCD-related disorders, PTSD, and ADHD.

Clinical Correlates of misophonia

Beyond the elevated DSM comorbidity rates associated with misophonia, research indicate elevated clinical correlates related to misophonia. Misophonia was first reported in medical settings (audiology patient population) where psychiatric and psychological clinical correlates were largely overlooked. However, accumulating evidence over the past few years suggests that misophonia is associated with psychological and emotional correlates. These correlates most likely stem from the significant emotional response related to misophonia trigger sounds/visuals. Wu and colleagues (2014) observed elevated obsessive-compulsive, depression, and anxiety symptoms within their proposed clinical misophonia population compared to controls. Furthermore, Cassiello-Robbins and colleagues (2021) found that those individuals with severe misophonic symptoms reported higher depression and anxiety symptoms than those with subclinical misophonia scores. The more updated proposed model seems to emphasize rigidity, where the trigger seems to occur due to the inappropriateness of the sound and the behavioral responses nearly always occur among family members (Cowan et al., 2022; Dozier et al., 2017; Guetta, Cassiello-Robbins, Trumbull, et al., 2022). It is becoming increasingly clear that misophonia is primarily a psychological disorder.

Neurobiological Correlates of misophonia

Although very little neuroimaging research has been published in the context of misophonia, in a seminal study, Kumar and colleagues (2012) described using functional magnetic resonance imaging (fMRI) to explore the basis of neuronal auditory and emotional correlates related to misophonia. The general model of auditory processes indicates that unpleasant sounds are processed at a higher level of the auditory cortex (from the superior temporal gyrus), which is proximal to the amygdala. In turn, amygdala activity reflects both the feature and valence of the auditory stimulus. Therefore, the amygdala appears to fine-tune the auditory cortex conforming to the valence in sounds, particularly for aversive sounds which are processed more rapidly. In a follow-up fMRI study, data were acquired while 20 participants with misophonia symptoms and 22 matched-control groups listened to three types of sounds (trigger sounds, unpleasant sounds, and neutral sounds) and were asked to rate the sounds from 1 – 4 by how distressing/annoyance they felt (Kumar et al., 2017). After a few trials, those in the misophonia group rated a higher annoyance to trigger sounds than the control. Furthermore, those in the misophonia group rated the general unpleasant sounds much lower than the control group. The fMRI results indicated hyperactivity of the anterior insular cortex (AIC), ventromedial prefrontal cortex, posteromedial cortex, hippocampus, and amygdala correlated with emotional and physiological responses characterized by misophonia response when misophonia-specific trigger sounds were played (Kumar et al., 2017). Furthermore, there were higher activation parameters seen in the left and right anterior insula for the misophonia group, during trigger sounds than during the unpleasant or neutral sounds. This supports that these areas may be involved in emotional

processes and perception signals. Thus, the importance of these structures is becoming more relevant to the aversive auditory stimuli experience in misophonia (Kumar et al., 2017; Schroder et al., 2019).

Cognitive Function in misophonia

Although cognitive functions have been extensively examined in the context of psychopathology, there is a dearth of research into cognitive function in misophonia (Abramovitch et al., 2021). A recent study observing the 'cold cognitive' function examined inhibitory response in misophonia using the stop-signal task (SST; Eijsker et al., 2019). The authors compared 25 participants with misophonia compared to control participants while undergoing fMRI imaging. No group differences were found, nor was impaired response inhibition identified. Instead, the authors observed that the participants in the misophonia group favored accuracy over speed based on the SST response time, entailing a cautionary response pattern that is seen in anxiety disorders (Eijsker et al., 2019). Those in the misophonia group showed increased activity in success inhibition than in the control group in the left dorsolateral prefrontal cortex region (Eijsker et al., 2019). In another study, specifically assessing interference response, participants were asked to complete the Stroop test while being exposed to misophonic trigger sounds and universally unpleasant sounds (Daniels et al., 2020). A larger Stroop effect was observed, and a slower-response time was associated with misophonia (Daniels et al., 2020).

With only a few studies examining cognitive function in misophonia, there is a need to understand the neurocognitive correlates. Given the dearth of information on cognitive function in misophonia, it is important to comprehensively examine the

neuropsychological profile of misophonia. For example, there is no research examining general attention distractibility, or other executive functions than just inhibitory functions. Thus, a comprehensive evaluation of 'cold' cognitive function using psychometrically valid neuropsychological tests, outside the realm of trigger sounds would be important to investigate.

II. PURPOSE

Given that relatively little is known about misophonia in general and, there is nearly no information about cognitive function in misophonia, the purpose of this study is to fill a meaningful gap in the literature by assessing both the neuropsychological profile of misophonia and its association with clinical aspects of the disorders. Notably given the dearth of information about misophonia and contrasting models, some emphasizing brain pathology whereas others suggest a central role of obsessive-compulsive related rigidity and emotional regulation, it is hard to draw clear directional hypotheses about cognitive function in misophonia. Moreover, since misophonia is in essence an episodic disorder associated with objective external triggers, as well as one where individuals may inhibit their responses in many settings other than the family environment, it is also difficult to speculate about cold cognitive functions in the absence of such triggers. However, in light of research suggesting elevation of several major symptoms (largely anxiety and stress) and given that recent work suggested that underperformance on cognitive tests (with medium effect sizes on average) is transdiagnostic across disorders and in the context of elevated symptoms (Abramovitch et al., 2021), it is reasonable to expect elevated clinical symptoms and thus, lower cognitive functioning associated with misophonia.

III. METHODS

Participants

Ninety-six participants were drawn from a larger study examining the cognitive function and clinical correlates of misophonia. Participants were recruited at Texas State University via ads, flyers, and emails. Inclusion criteria included minimum age of 18, intact or corrected vision, and fluency in English. Exclusion criteria included age > 65 and any history of major neurological conditions (e.g., epilepsy, brain injury). Participants were asked to avoid recreational drugs, prescription benzodiazepines, stimulant medications, or more than two alcoholic drinks in the 24 hours prior to the experiment.

The overall study sample consisted of 67 females (69.80%) and 29 males (30.20%). The average age of participants was 20.91 (SD = 2.87). The sample was ethnically diverse with 59.40% non-Hispanic participants (n = 57), followed by 33.30% Hispanic (n = 32), and 6.30% other (n = 6). Furthermore, the participant primarily identified as American White 43.20% (n = 41), then Hispanic 30.50% (n = 29), Black 14.70% (n = 14), Asian 9.50% (n = 9), Native Hawaiian 1.10% (n = 1), and American Indian 1.10% (n = 1), respectively. The average amount of years of education was 15.04 (SD = 1.63).

Measures

Clinical Measures

Mini-International Neuropsychiatric Interview 7.0 (MINI; Sheehan et al., 1998). The MINI is a valid and reliably used semi-structured screening interview. The MINI 7.0 covers primary DSM-5 disorders and has good psychometric properties (Sheehan et al., 1998).

Depression, Stress, Anxiety Scale-21 (DASS-21; Lovibond & Lovibond, 1995). The DASS-21 is a self-report questionnaire that measures the severity of depression, anxiety, and stress symptoms. Each item is scored from 0 – "*did not apply to me at all over the last week*" to 3 – "*applied to me very much or most of the time over the past week*". The DASS-21 demonstrates good to excellent reliability and validity (Lovibond & Lovibond, 1995). The DASS-21 demonstrates good–excellent reliability and validity in non-clinical samples (Sinclair et al., 2012) and clinical samples (Clara, 2001). Similarly, in the present study, good to excellent reliability was found for each of the DASS subscales (Cronbach's $\alpha = 0.92$, 0.74, and 0.83), for depression, anxiety, and stress respectively.

Six Item-State Trait Anxiety Inventory (STAI; Marteau & Bekker, 1992). This is a 6-item short form self-report questionnaire adapted from the State-Trait Anxiety Inventory. The STAI-6 demonstrates good internal consistency in non-clinical samples ($\alpha = 0.82$) (Marteau & Bekker, 1992). In the present study, good reliability was found for the STAI ($\alpha = 0.86$).

The Eysenck Impulsiveness-Venturesomeness-Empathy Questionnaire (I-7; Eysenck et al., 1985). This is a 54-item self-report questionnaire that utilized a "*yes or no*" format that includes three subscales: Impulsiveness (19 items), Venturesomeness (16 items), and Empathy (19 items). The measure demonstrates good psychometric properties in non-clinical samples including good internal consistency ($\alpha = 0.83$; Eysenck et al., 1985). The outcome of interest in the present study was the I-7 Impulsiveness subscale score. In the present study, good internal consistency was found ($\alpha = 0.83$).

Barkley Functional Impairment Scale (BFIS; Barkley, 2011). This 15-item questionnaire was used to assess functional impairment in multiple domains of everyday life (e.g., school/work, social, physical, relationships, etc.), related to executive functioning. This scale demonstrates good psychometric properties (Barkley, 2011). Due to a technical error, only the first 10 BFIS items were administered. However, the scale's manual indicates that the manual was developed to allow assessment of each item as a construct, as well as provide itemized norms. Thus, each item was used as a domain indicator and no summary score was utilized.

Misophonia Questionnaire (MQ; Wu et al., 2014). The MQ consists of 17 items and is comprised of three sections. The first two subscales focus on the symptoms and behavior towards the trigger sounds, and the third assesses the severity of the symptoms. The MQ proposes a 'clinical' cutoff (MQ-3) where a score of 7 or higher on the single item sound sensitivity score indicates clinically significant misophonia. This cutoff has been used in multiple misophonia studies which facilitates comparisons between studies (Guetta, Cassiello-Robbins, Trumbull, et al., 2022; Schadegg et al., 2021). The test shows

good psychometric properties in non-clinical samples (Wu et al., 2014). The present study found excellent reliability for the MQ-1 ($\alpha = 0.83$) and the MQ-2 ($\alpha = 0.83$).

Neuropsychological Measures

Executive Functions.

The Trail Making Test (Delis et al., 2001). The Trail Making Test (TMT) is a subtest of the Delis Kaplan Executive Function Systems Battery. It includes two parts known as Trail Making A and B, (TM-A and TM-B). The TM-B measures set-shifting and participants are instructed to draw a line connecting circled numbers and letters while alternating between letters and numbers in ascending and alphabetical order. The total time in seconds in both A and B are the primary outcome measures that were used in this study.

The Wisconsin Card Sorting Test (WCST; Loong, 1990). The WCST evaluates set-shifting, concept formation, and the ability to utilize environmental feedback for cognitive sets (Loong, 1990). In the task, 4 exemplar cards are presented to participants, as well as a stack of cards. Each time, the stimulus presentation has a defined sorting rule set. After basic instructions, in which the researcher did not disclose the preordained sorting rule, participants are given feedback (correct, or incorrect) if they followed the correct rule relating to dimensions of the shape (i.e., sorting according to color, shape, or number shapes). Through trial and error, participants identify the current rule. Once participants place 10 cards correctly, the rule category is judged as completed, and the experimenter then changes the rule (e.g., number of shapes, to color) without informing the examinee. Perseverative errors entail the number of cards from the same category the

participant had placed after receiving an 'incorrect' response for the same type of category in the previous card. The percent of preservative errors and the total number of categories were used as outcome measures in the present study.

The Tower of London (TOL; Shallice, 1982). The TOL assesses planning ability and problem-solving skills. This task requires participants to focus on goal arrangement (e.g., moving beads from a standard initial position to match the "goal" arrangement) while following specific rules regarding changing the location of the beads. The goal is for participants to recreate the beads arrangement model using the smallest number of steps. The total excess moves beyond the minimum required to complete the model were used as the outcome measure in the present study.

Verbal Fluency (VF; Delis et al., 2001). This task evaluates two facets of verbal fluency, namely, phonemic/letter fluency and category/semantic fluency. In phonemic fluency, individuals were required to produce as many words as possible that begin with a certain letter in one minute. For semantic/category fluency, individuals were required to produce as many words related to a specific category. The total number of words for letter fluency and category fluency were used as outcome measures.

The Symbol Span Test (Wechsler, 2009). This is a subtest of the Wechsler Memory Scale – IV (WMS-IV) assesses visual working memory. Participants were shown multiple simple abstract symbols rapidly, every five seconds from a book. After the showing was removed, they were asked to identify which symbols were previously displayed and in the correct order from a page with the correct designs and foils. The total number of correct trials will be used as the outcome measure.

The Digit Span Task (Wechsler, 2009). This is a subtest of the Wechsler Adult Intelligence Scale-IV (WAIS-IV) that assesses verbal working memory, specifically maintenance and manipulation. The test requires participants to reiterate a series of digits and letters according to different rules related to three conditions: In the DS Forward participants are asked to respond by reiterating the series of numbers in the same order. DS Backwards entails reading back the number series from last to first, and the DS Sequencing involves a series of letters and numbers to be reiterated the digits in ascending order and letters in the alphabet order. DS Forward, DS backward, DS sequencing, subscale scores, and the overall DS total score were used as outcome measures in the present study.

The Connor's Continuous Performance Test – 3rd Edition (CPT-III; Conners, 2014). The CPT-III is a continuous performance test that evaluates sustained and selective attention, as well as response inhibition and processing speed. The number of commission errors was used as an indicator of response inhibition. Due to a technical error, t-scores, and not raw scores were used as outcome measures in the analyses.

Memory.

The Rey-Osterneth Complex Figure Test (RCFT; Osterrieth, 1944). The RCFT is a nonverbal memory test that examines visuospatial memory as well as visuospatial functions. Participants were shown a complex shape on a stimulus card, and then instructed to copy the shape, and later were asked to draw the figure from memory on a blank piece of paper in two-time points (3 minutes and 30 minutes). In the present study,

immediate copy, short delayed (3 minutes), and long-delayed recall (30 minutes) were used as an outcome measure for nonverbal memory.

The California Verbal Learning Test (CVLT; Delis et al., 2000). The CVLT is an auditory-verbal memory task where the participants were read a list of simple words five times in a row with immediate recall after each read, followed by a short interference task (being read and asked to recall the second list of words). After 20 minutes participants are administered free and cued recall assessments of the words in list A. The outcome measures used in the present study are the total number of words recalled correctly in both the short and long delay and the cumulative number of words on trials 1-5.

Attention.

The CPT-III (Conners, 2014). The hit reaction time (HRT) standard deviation and omission errors were used as outcome measures to assess aspects of sustained attention.

Processing Speed.

The CPT-III (Conners, 2014). The average hit reaction time for ‘go’ stimuli was used as an additional outcome measure to assess processing speed.

The TM-A (Delis et al., 2001). This is a measure of processing speed with a graphomotor component. This test requires participants to draw a line connecting circled numbers as fast as possible. The outcome measure of interest in the present study is the total time in seconds.

Visuospatial Function.

The RCFT (RCFT; Osterrieth, 1944). The RCFT copy score was used as a measure of visuospatial function.

Procedure

Participants who responded to the study recruitment ads scheduled a visit time to complete the experiment. The testing session took place individually in a quiet research lab room. Participants first signed informed consent, and subsequently completed a demographic questionnaire. Then, participants completed the MINI interview, followed by the neuropsychological assessments and the self-report questionnaires, which were counterbalanced. The MQ was administered on the day of the experiment as well as a follow-up between 3-5 weeks. This study was approved by Texas State University Institutional Review Board by the declaration of Helsinki.

Statistical Analyses

All statistical analyses were conducted using IBM SPSS v.27.0 (2020). The control and misophonia groups were created by using the MQ single item severity (Wu et al., 2014), which states that a score of 7 or more is considered clinical (misophonia group) and those with 6 or lower are seen as sub-clinical (control group). Then, for our misophonia group, we used the upper quartile of the clinical group. Nominal demographic variables were analyzed using Pearson's Chi-Squared test, whereas group differences in continuous demographic variables were assessed using analysis of variance (ANOVA). Subsequently, a series of ANOVAs were conducted to assess group

differences in neuropsychological outcomes and clinical symptom measures, such as the DASS-21, I-7, STAI-state, and BFIS. Due to unequal groups, violations of homogeneity of variance were probable so Welch's statistic of robust test for equality of means was employed if needed (Welch, 1938) to maintain power while maintaining alpha at the desired level (Glantz & Slinker, 2001). Pearson-zero order correlations were used to assess correlations between symptoms and neuropsychological outcomes. Given the high number of comparisons and the risk of familywise inflation of type I errors, a correction for multiple comparisons was employed across comparisons, using the Holm-Bonferroni method (Holm, 1979). Effect size magnitude was interpreted based on Cohen's *d* (2013) where small, medium and large effect sizes correspond to 0.2, 0.5, and 0.8, respectively. Additionally, all comparative analyses of neuropsychological outcomes were conducted on raw test scores. However, to facilitate objective interpretation of the test scores in terms of the presence of impairment in each domain, results are also presented in standardized Z scores produced via test norms (See Appendix).

IV. RESULTS

Demographic Variables

Demographic comparisons between groups are presented in Table 1. There were no significant differences in age between the control group (M = 20.83, SD = 3.07) and the misophonia group (M = 21.06, SD = 2.45). All participants were college students with average years of education for the control group (M = 15.03, SD = 1.83) and the misophonia group (M = 15.03, SD = 1.12). The sample was characterized by a plurality of females (69.8%) in the groups with no significant differences. The study sample was ethnically and racially diverse with a minority of participants identifying as White American (43.20%) with no significant difference in race between the groups.

Table 1. *Demographic and clinical characteristics of control/misophonia groups*

	Control (n=64)	Misophonia (n=32)	Entire Sample (N=96)		
Variable	Mean (SD); %(n)			F/X^2	Sig.
Gender				2.47	0.16
Female	75.00% (48)	59.40% (19)	69.80% (67)		
Male	25.00% (16)	40.60% (13)	30.20% (29)		
Age (years)	20.83 (3.07)	21.06 (2.45)	20.91 (2.87)	0.14	0.71
Education (years)	15.05 (1.83)	15.03 (1.12)	15.04 (1.63)	0.002	0.97
Ethnicity				2.47	0.48
Hispanic	35.90% (23)	28.10% (9)	33.30% (32)		
Non-Hispanic	57.80% (37)	62.50% (20)	59.40% (57)		
Other	6.30% (4)	6.30% (2)	6.30% (6)		
Race				5.05	0.41

American Indian/Alaskan Native	0% (0)	3.20% (1)	1.10% (1)		
American Black	15.60% (10)	12.90% (4)	14.70% (14)		
Asian	6.30% (4)	16.10% (5)	9.50% (9)		
Native Hawaiian/Other Pacific Islander	1.60% (1)	0.00% (0)	1.10% (1)		
American White	45.30% (29)	38.70% (12)	43.20% (41)		
Hispanic/Latino	31.30% (20)	29.00% (9)	30.50% (29)		
MQ					
MQ-1 (trigger sounds)	8.83 (6.19)	16.91 (7.13)	11.55 (7.53)	32.64	**0.01****
MQ-2 (behavioral/emotional reaction)	6.90 (5.88)	18.63 (8.86)	10.77 (8.89)	41.96	**0.01****
MQ-3 (severity of symptoms)	2.25 (0.80)	9.09 (2.09)	4.53 (3.52)	321.40	**0.01****
DASS-21					
DASS-21 Depression	3.41 (3.85)	4.32 (4.68)	3.71 (4.13)	1.03	0.31
DASS-21 Anxiety	3.14 (3.15)	4.84 (3.58)	3.69 (3.37)	5.56	**0.02****
DASS-21 Stress	3.80 (3.70)	5.35 (3.83)	4.31 (3.79)	3.62	0.06
I-7 Impulsivity	7.71 (3.25)	10.06 (3.32)	8.49 (3.44)	10.70	**0.002****
STAI-State	9.56 (3.02)	11.87(4.40)	10.32 (3.67)	7.04	**0.01****

Note: DASS-21: Depression-Anxiety-Stress Scale; I-7: Impulsiveness and Venturesomeness Questionnaire; STAI-State: Six Item-State Trait Anxiety Inventory. *p<.05 **p<.01.

Neuropsychological Test Performance

Executive Function.

Set Shifting. Comparisons between the groups on set-shifting indicated no significant differences between the groups on TM-B total time ($p = 0.12$), WCST percent preservative errors on the ($p = 0.15$), and the total number of WCST categories completed ($p = 0.25$). The effect sizes ranged between $d = 0.27 – 0.36$; see Table 2.

Planning. No significant group difference was found in the TOL number of excess moves ($p = 0.47$, $d = 0.16$).

Working Memory. In terms of verbal WM, no significant group differences were found on the DS forward ($p = 0.13$, $d = 0.33$), DS backward ($p = 0.74$, $d = 0.07$), and DS sequencing ($p = 0.24$, $d = 0.26$) scores, as well as on the DS total score ($p = 0.91$, $d = 0.02$). In terms of spatial working memory, such as symbol span, did not indicate any significant differences ($p = 0.94$, $d = 0.33$; see Table 2).

Verbal Fluency. A significant difference was found in the category/semantic fluency between groups where the misophonia group underperformed compared to controls ($p = 0.02$) with a small-medium effect size ($d = 0.47$; refer to Table 2). This comparison survived correction for multiple comparisons**.** However, there were no significant differences in letter/phonemic fluency between the study samples ($p = 0.45$, $d = 0.16$).

Response Inhibition. In terms of response inhibition, there were no significant group differences in the CPT total number of commission errors ($p = 0.93$, $d = 0.02$).

Memory.

Verbal Memory. Significant group differences were found on the CVLT short delay recall where the misophonia sample underperformed in this measure ($p = 0.01$, $d = 0.61$). This comparison survived correction for multiple comparisons**.** No significant differences were found in the sum of trials 1-5 and the long delay recall. However,

although not significant, small effect sizes favoring performance in the control group were found, ranging between 0.37 – 0.63.

Non-verbal Memory. No significant group differences were found on the RCFT immediate memory ($p = 0.37$), and delayed memory ($p = 0.19$) trials with small effect sizes for the immediate ($d = 0.20$) and delayed ($d = 0.30$) memory trials (see Table 2).

Processing Speed.

There were no significant differences in the TM-A (a graphomotor task) between the two groups ($p = 0.14$, $d = 0.31$). Similarly, in the computerized CPT-III task, the average response time for go stimuli did not differ significantly between groups ($p = 0.32$, $d = 0.23$).

Table 2. *Neuropsychological test performance across misophonia and control groups*

	Control	Misophonia		F	Sig.	Cohen's d
	M(SD)	M(SD)	df			
Set shifting						
Trail Making B	69.86 (32.91)	80.00 (23.25)	(1, 94)	2.43	0.12	0.36
WCST Preservative Errors	8.63 (4.54)	10.25 (6.05)	(1, 92)	2.14	0.15	0.30
WCST Categories Completed	5.77 (0.88)	5.44 (1.52)	(1, 41.88)	1.34	0.25	0.27
Planning						
TOL Excess Moves	5.80 (6.60)	6.91 (7.69)	(1, 90)	0.52	0.47	0.16
Working Memory						
DS Forward Total	10.59 (2.07)	11.28 (2.08)	(1, 94)	2.35	0.13	0.33
DS Backward Total	9.25 (1.96)	9.09 (2.52)	(1, 94)	0.11	0.74	0.07
DS Sequencing Total	9.52 (2.40)	8.91 (2.31)	(1, 94)	1.41	0.24	0.26
DS Total	29.31 (5.15)	29.19 (5.23)	(1, 94)	0.01	0.91	0.02
Symbol Span Total	28.92 (6.02)	29.03 (6.53)	(1, 94)	0.01	0.94	0.02
Verbal Fluency						
Letter Total	40.02 (10.44)	38.63 (7.11)	(1, 85.15)	0.59	0.45	0.16
Category Total	42.61 (8.38)	39.38 (5.10)	(1, 90.25)	5.48	**0.02****	0.47
Response Inhibition						
CPT Commission Errors	50.30 (9.51)	50.13 (7.28)	(1, 93)	0.01	0.93	0.02
Verbal Memory						
CVLT Short Delay Recall	12.34 (2.13)	10.59 (3.33)	(1, 44.10)	7.34	**0.01****	0.63
CVLT Sum of Trials 1-5	55.56 (8.10)	52.28 (9.52)	(1, 94)	3.11	0.08	0.37
CVLT Long Delay Recall	12.84 (2.15)	11.69 (3.01)	(1, 47.39)	3.76	0.06	0.44
Non-verbal Memory						
RCFT Immediate	23.19 (7.05)	21.91(5.62)	(1, 94)	0.80	0.37	0.20
RCFT Delayed	22.83 (6.90)	20.97 (5.45)	(1, 94)	1.77	0.19	0.30
Processing Speed						
Trail Making A	24.25 (7.24)	26.72 (8.51)	(1, 94)	2.21	0.14	0.31
CPT Mean RT[1]	47.54 (10.41)	49.62 (7.68)	(1, 93)	1.00	0.32	0.23
Attention						

CPT Omission Errors[1]	48.73 (8.66)	48.84 (8.76)	(1, 93)	0.004	0.95	0.01
CPT RT SD[1]	47.13 (10.32)	49.09 (8.00)	(1, 93)	0.89	0.35	0.21
Visuospatial Function						
RCFT Copy	34.95 (1.24)	34.11(2.87)	(1, 36.95)	2.52	0.12	0.38

Note: Analyses were conducted on raw scores; [1]: outcome measures were conducted in t-scores. CVLT, California-Verbal Learning Test II; RCFT, Rey Complex Figure Test; DS, Digit Span; WCST, Wisconsin Card Sorting Test; TOL, Tower of London; CPT, Conners' Continuous Performance Test; RT, Reaction time; SD, Standard Deviation. Note. *p<.05 **p<.01.

Attention.

No significant group differences were found in the number of CPT-III omission errors ($p = 0.95$) or reaction time standard deviation ($p = 0.35$), but a small effect size was found to favor the performance in the control group, particularly in the CPT RT SD ($d = 0.21$).

Visuospatial function.

Finally, there was no significant difference in the RCFT copy trial between the misophonia and control groups ($p = 0.12$, $d = 0.38$).

Clinical and Diagnostic Indices

A series of Pearson's X^2 tests were conducted to compare the groups on DSM disorders via the MINI interview. No significant differences in either lifetime or current disorders were found between the groups. Overall, 24% of the sample presented with at least one current condition, and 53.10% had at least one-lifetime condition, with no significant difference between the groups. However, although no significant differences were found between the groups on any disorder, the prevalence of OCD in the misophonia group (9.4%), was threefold higher than in the control group (3.1%).

Similarly, within the misophonia group, the prevalence of ADHD (15.6%), and panic disorder (6.3%), were nearly twice as prevalent than the control group (ADHD =9.4%; panic disorder 3.1%).

In terms of clinical symptoms, the misophonia group presented with significantly higher levels of general anxiety as measured by the DASS-21 Anxiety ($p = 0.02$, $d = 0.5$), state-anxiety as measured by the STAI ($p = 0.01$, $d = 0.62$), and impulsivity ($p = 0.002$, $d = 0.71$) as measured by the I-7. No significant group differences were found for depression and stress symptoms as measured by the DASS-21 Depression ($p = 0.31$, $d = 0.22$) and the DASS-21 Stress ($p = 0.06$, $d = 0.41$; see Table 1).

Table 3. *Prevalence of DSM disorders in the misophonia and control groups*

	Control (n = 64)	Miso (n = 32)			Total (N = 96)
Disorder	%(n)/ M(SD)	%(n)/ M(SD)	X^2/t	Sig.	%(n)/ M(SD)
Current					
Major Depressive Disorder	7.80% (5)	3.10% (1)	0.80	0.66	6.30% (6)
Social Anxiety Disorder	3.10% (2)	3.10% (1)	0.00	1.00	3.10% (3)
Generalized Anxiety Disorder	4.70% (3)	3.10% (1)	0.13	1.00	4.20% (4)
Panic Disorder	3.10% (2)	6.30% (2)	0.55	0.60	4.20% (4)
Agoraphobia	3.2% (2)	3.2% (1)	0.00	1.00	3.10% (3)
Post-Traumatic Stress Disorder	1.60% (1)	3.10% (1)	0.26	1.00	2.10% (2)
Obsessive-Compulsive Disorder	3.10% (2)	9.40% (3)	1.69	0.33	5.20% (5)
Bulimia Nervosa	3.10% (2)	3.10% (1)	0.00	1.00	3.10% (3)
Attention-Deficit Hyperactivity Disorder	9.40% (6)	15.60% (5)	0.82	0.50	11.50% (11)
Substance Abuse Disorder	7.80% (5)	9.40%. (3)	0.07	1.00	8.30% (8)
Currently Any Disorder	26.60% (17)	18.80% (6)	0.72	0.46	24% (23)
Lifetime					
Major Depressive Disorder	42.20% (27)	34.40% (11)	0.54	0.51	39.58% (38)
Bipolar Disorder	6.30% (4)	3.10% (1)	0.42	0.66	5.20% (5)

Panic Disorder	7.80% (5)	9.40% (3)	0.07	1.00	8.30% (8)
Any Lifetime Disorder	54.7% (35)	50% (16)	0.19	0.67	53.1% (51)
Average Number of Disorders	0.55 (0.91)	0.69 (1.26)	0.63	0.53	0.59 (1.03)

Note: using Fisher's Exact test reported for the above variables.

Functional Indices

A series of ANOVAs were conducted to assess group differences in the BFIS functional indices. The misophonia group reported significantly higher functional impairments on the home-chores ($p = 0.05$), money-management ($p = 0.01$), and driving ($p = 0.02$) domains (Table 4), with medium sizes for the three domains ($d = 0.47$, 0.61, and 0.58, respectively). No significant differences were found in any other BFIS domains. Notably, all domain scores within the two groups did not cross the measures normative cutoff scores to indicate a meaningful functional impairment (Barkley, 2011).

Table 4. *Barkley's Functional Impairment domains in misophonia and control groups*

	Control (n=64)	Miso (n=32)	Entire Sample (N=96)			
Variable		Mean (SD)		F	Sig.	Cohen's *d*
Home-family	1.58 (2.11)	2.52 (2.86)	1.88 (2.41)	2.63	0.11	0.37
Home-chores	1.94 (1.98)	3.16 (3.08)	2.34 (2.45)	4.08	**0.05**	**0.47**
Work	1.64 (2.03)	2.29 (2.98)	1.85 (2.38)	1.20	0.28	0.25
Social - strangers	2.67 (2.40)	3.45 (3.05)	2.93 (2.64)	1.56	0.22	0.28
Social - friends	1.58 (1.83)	2.29 (2.44)	1.81 (2.06)	2.08	0.16	0.33
Community Activities	1.77 (2.05)	2.13 (2.64)	1.88 (2.25)	0.45	0.50	0.15
Education	2.73 (2.28)	3.77 (3.14)	3.07 (2.62)	2.71	0.11	0.38
Marriage/cohabitation	1.72 (2.59)	2.45 (3.15)	1.96 (2.79)	1.26	0.27	0.25
Money-management	2.95 (2.50)	4.65 (3.06)	3.51 (2.80)	8.23	**0.01**	**0.61**
Driving	0.78 (1.79)	2.06 (2.54)	1.20 (2.14)	6.38	**0.02**	**0.58**

Note: *p<.05 **p<.01.

Correlations between Neuropsychological and Misophonia outcomes

Pearson's zero-order correlations were computed between neuropsychological outcomes and the MQ subscale scores within the misophonia group. Several sporadic correlations were found within the misophonia group, namely between DS Forward and the MQ-3 (r = -0.45, p = 0.02), and between the RCFT Immediate memory score and the MQ-1 subscale (r = -0.36, p = 0.04). Within the entire study sample, a significant negative correlation was found between the MQ-3 score and the CVLT-Short delay recall score (r = -0.27, p = 0.01).

However, a systematic pattern of associations emerged within the two groups between misophonia severity indices and the attention domain outcomes. In terms of CPT-Omission errors significant positive correlations were found between the number of omission errors and MQ-1 (r = 0.41; p = 0.02) and MQ-2 (r = 0.42; p = 0.02) subscales in the misophonia group as well as in the entire study sample, all of which entailing strong correlations in the MQ-1 (r = 0.24, p = 0.02) and MQ-2 (r = 0.32, p = 0.002), as noted by Bosco and colleagues (2015). No other significant associations were found between the MQ subscales and executive function, processing speed, attention, and visuospatial function indices. No other significant associations were found between MQ subscales and executive function indices.

Table 5. *Pearson's zero-order correlations between neuropsychological test performance and MQ scores*

		MQ-1	MQ-2	MQ-3
Set shifting				
Trail Making B	Misophonia	0.17	-0.09	-0.04
	Total	0.02	0.07	0.15
WCST Preservative Errors	Misophonia	0.06	-0.15	-0.26
	Total	0.04	0.04	0.08
WCST Categories Completed	Misophonia	0.25	0.26	0.24
	Total	0.11	0.05	-0.07
Planning				
TOL Excess Moves	Misophonia	-0.09	-0.18	-0.17
	Total	-0.02	0.01	0.04
Working Memory				
DS Forward Total	Misophonia	0.03	0.24	**-0.42***
	Total	0.05	0.09	0.07
DS Backward Total	Misophonia	0.18	0.05	-0.09
	Total	0.10	-0.10	-0.05
DS Sequencing Total	Misophonia	-0.06	0.18	-0.17
	Total	-0.19	-0.15	-0.15
DS Total	Misophonia	0.06	0.19	-0.27
	Total	-0.04	-0.08	-0.07
Symbol Span Total	Misophonia	-0.11	0.21	0.11
	Total	-0.04	-0.02	0.02
Verbal Fluency				
Letter Total	Misophonia	-0.12	-0.06	-0.30
	Total	-0.15	-0.18	-0.13
Category Total	Misophonia	0.26	0.03	0.07
	Total	-0.05	-0.15	-0.20
Response Inhibition				
CPT Commission Errors	Misophonia	-0.03	0.05	-0.01
	Total	0.10	0.09	0.01
Verbal Memory				
CVLT Short Delay Recall	Misophonia	0.07	0.21	0.02

	Total	-0.10	-0.05	**-0.27****
CVLT Sum of Trials 1-5	Misophonia	0.09	0.15	0.12
	Total	-0.03	-0.06	-0.13
CVLT Long Delay Recall	Misophonia	0.13	0.19	0.10
	Total	-0.02	-0.10	-0.18
Non-verbal Memory				
RCFT Immediate	Misophonia	**-0.36***	-0.01	0.07
	Total	-0.20	-0.10	-0.09
RCFT Delayed	Misophonia	-0.29	0.10	0.06
	Total	-0.20	-0.11	-0.13
Processing Speed				
Trail Making A	Misophonia	0.08	0.10	-0.02
	Total	0.15	0.15	0.15
CPT Mean RT	Misophonia	-0.07	0.02	-0.13
	Total	-0.03	0.09	0.08
Attention				
CPT Omission Errors	Misophonia	**0.41***	**0.42***	0.09
	Total	**0.24***	**0.32****	0.06
CPT RT SD	Misophonia	0.03	0.09	-0.11
	Total	0.07	0.20	0.11
Visuospatial function				
RCFT Copy	Misophonia	-0.19	0.08	0.13
	Total	-0.13	-0.09	-0.15

Note. *p<.05 **p<.01.

Correlations between Clinical Symptoms and Misophonia Severity

Correlations between general clinical symptoms and misophonia symptoms were examined separately within the misophonia group and the entire study sample. Correlations were assessed between outcome measures of anxiety, depression, stress, and impulsivity with the three subscale scores of the MQ, namely, types of and severity of

misophonic trigger sounds (MQ-1), types and severity of the misophonic reaction to these sounds (MQ-2), and the single items sound sensitivity subscale score (MQ-3; see Table 5).

A significant positive correlation was found between DASS-21 Depression and the MQ-1 ($r = 0.23$, $p = 0.03$) only within the entire sample. No other significant correlations were found with DASS-21 Depression. No significant correlations were found between the DASS-21 Anxiety subscales, and each of the three misophonia scores within the entire study sample or within the misophonia sample. However, in terms of State-anxiety, there was a significant and positive correlation between the STAI-State score, with the three sections of the MQ (MQ-1, $r = 0.30$, $p = 0.004$; MQ-2, $r = 0.23$, $p = 0.03$; MQ-3, $r = 0.23$, $p = 0.03$; see Table 5) within the entire study sample, but not within the misophonia sample.

Significant positive correlations were found between the DASS-21 Stress subscale within the entire study sample with the MQ-2 ($r = 0.34$, $p = 0.001$), and MQ-3 ($r = 0.25$, $p = 0.02$). No significant associations were found within the misophonia sample. Finally, within the entire study sample, I-7 impulsivity was found to be significantly and positively correlated with the MQ-1 ($r = 0.22$, $p = 0.04$), and with the MQ-2 ($r = 0.42$, $p < 0.001$) subscale score, and MQ3 ($r = 0.38$, $p < 0.001$). However, within the misophonia sample, although similar significant positive associations were found between I-7 impulsivity and the MQ-2 subscale score (misophonic response; $r = 0.45$, $p = 0.02$), and MQ3 (single items sound sensitivity/severity score; $r = 0.45$, $p = 0.01$). There was no significant correlation was found between I-7 Impulsivity and types of and severity misophonic trigger sounds (MQ-1; see Table 5).

Table 6. *Pearson's zero-order correlations between clinical variables and the MQ subscales*

		MQ-1	MQ-2	MQ-3
DASS-21 Depression	Miso	0.10	0.11	-0.19
	Total	**0.23***	0.20	0.04
DASS-21 Anxiety	Miso	0.01	-0.07	-0.01
	Total	0.15	0.20	0.19
DASS-21 Stress	Miso	0.17	0.04	-0.06
	Total	**0.34****	**0.25****	0.15
I-7 Impulsivity	Miso	0.18	**0.45****	**0.45****
	Total	**0.22***	**0.42****	**0.38****
STAI-State	Miso	0.15	0.03	-0.17
	Total	**0.30****	**0.23***	**0.23***

Note. MQ-1: Misophonia Questionnaire subscale - types of and severity of misophonic trigger sounds; MQ-2: Misophonia Questionnaire subscale - types and severity of the misophonic reaction to these sounds; MQ-3: Misophonia Questionnaire subscale - the single items sound sensitivity subscale score. *p<.05 **p<.01.

V. DISCUSSION

The study aimed to conduct the first comprehensive examination of neuropsychological functions in misophonia, as well as to assess potential clinical and functional correlates. Using the frequently used MQ cutoff, misophonia and control groups were compared on demographics, clinical, functional, and neuropsychological outcomes. No differences were found across all demographic indices between the groups. The entire study sample – characterized by a plurality of females (69.8%) – was racially and ethnically diverse with a minority of participants identifying as American White (43%).

In terms of DSM disorders, no significant differences were found between the groups in the prevalence of lifetime or current DSM disorders. This is surprising given previous reports suggest that misophonia is associated with psychopathology (Potgieter et al., 2019). Some studies report elevated rates of DSM disorders in misophonia (Cassiello-Robbins et al., 2020), whereas others report much lower prevalence rates (Jager et al., 2020; Schroder et al., 2013). Furthermore, previous misophonia research has utilized semi-structured interviews to recruit participants from the community (Cassiello-Robbins et al., 2020) and clinical-sample (Jager et al., 2020). However, one possible explanation for this non-significant finding may be related to the type of sample used in the present study, such that the sample may be highly functioning as they were all active college students. Notwithstanding, most studies consistently show elevated rates of OCD and ADHD in misophonia (Rouw & Erfanian, 2018; Taylor, 2017). Indeed, results of the present study indicate a high prevalence of ADHD in the misophonia group (15.60%), that although not significant (potentially given the small sample size), was elevated

compared to the control group (9.40%). The prevalence rate within the misophonia sample is more than three times higher than the prevalence of ADHD in adults (4.6%; Song et al., 2021). Similarly, albeit not significant, the frequency of OCD was also elevated in the misophonia group (9.40%) compared to the control group (3.10%). This prevalence rate within the misophonia group was nearly 8-fold higher than the prevalence in the general population (1.3%; Fawcett et al., 2020). The same pattern was found for panic disorder in the misophonia sample (6.20%), which was twice as high compared to the control group (3.10%; see Table 4). This is in line with studies reporting elevated rates of panic disorder or related anxiety disorders in misophonia samples (Claiborn et al., 2020; Jager et al., 2020)

In terms of clinical symptoms, there were no significant differences between the groups in depression and stress symptoms. However, there were significantly elevated symptoms of general anxiety and state anxiety in the misophonia group compared to the control group. This is analogous to previous studies that found elevated levels of anxiety symptoms in misophonia samples (Guetta, Cassiello-Robbins, Trumbull, et al., 2022; Jager et al., 2020; Wu et al., 2014). Importantly, the present study revealed higher levels of emotional impulsivity, as measured by the Eysenck I-7, in the misophonia group compared to the control group. In addition, impulsivity was found to be significantly and positively correlated with the severity of misophonic reactions and sound sensitivity, but not with the types and intensity of trigger sounds. This finding supports research that suggests misophonia is related to emotional regulation and impulsive control (Cassiello-Robbins et al., 2020). Additionally, Eijsker and colleagues (2019) examined response inhibition and impulse control and found that although there was no indication for

response inhibition deficits assessed via a computerized task (and that participants responds in a cautious manner preferring accuracy over speed), there were elevated impulse control deficits associated with the misophonic emotional reaction. This may be important as there may be a need to address the negative emotional experience separately from the impulsive reaction. The former may respond well to exposure (Cassiello-Robbins et al., 2020) and the latter, in light of our results and previous studies (Eijsker et al., 2019), suggest that targeting emotional regulation for the misophonic response and avoidance may be warrened and future clinical trials should focus on this. This also underscores the complexity of research into misophonia given its episodic nature, in which research is yet to provide a clear picture of the difference in symptoms in face of a misophonia trigger sound, as opposed to a more trait-like perspective.

Analyses of cognitive functioning vis a vis neuropsychological test performance revealed an interesting pattern of results. First, there were no significant differences in higher-order executive function across domains (i.e., response inhibition, category formation, perseveration, planning, phonemic fluency, and set-shifting). However, results indicated underperformance in lower-level cognitive function, primarily attention and verbal memory. For example, the findings of the present study suggest difficulties in the attention domain in misophonia. Specifically, significant underperformance was found in the misophonia group on the DS forward score. Although the Digit Span test is a verbal working memory task, the DS-forward part, entailing simple repetition of a series of numbers, is considered a measure of simple attention (Hale et al., 2002). Importantly, further results from the present study lend additional support for the presence of a specific association between misophonia severity and difficulties in attention function,

given that the two attention indices were significantly correlated with two MQ subscale scores within the misophonia group, as well as within the entire study sample. Although there is a dearth of research into 'cold' attention function, a small study that utilized the Attentional Network Task reported difficulties achieving and maintaining alertness during the task in a small misophonia sample (Frank et al., 2020). Moreover, initial studies suggest that trigger sounds strongly capture attention in misophonia, concluding that the difficulty in disengaging from the trigger stimuli may be associated with a deficit in selective attention, and regulation of attention in this disorder (Silva & Sanchez, 2019). Although much more research is needed, it has been recently suggested that attention function may play an important role in sensory sensitivity in general and that this has been largely neglected in research (Thielen & Gillebert, 2019).

The second pattern of results pertained to underperformance in verbal memory functions in the misophonia group, predominantly in the subdomain of memory retrieval. First, significant underperformance was found in the CVLT short delay recall trial, with a medium effect size ($d = 0.63$). In addition, albeit not significant, underperformance has been found in the misophonia group on the CVLT sum of recalled words on trials 1-5 ($d = 0.37$, $p = 0.08$), as well as on the CVLT long delay recall ($d = 0.44$, $p = 0.06$). No studies to date examined memory in misophonia and it is unclear to what extent processing speed and attention affect verbal memory in this population. However, an interesting finding in this study may provide some initial insight into a potential problem with the retrieval of verbal information. The verbal fluency task included phonemic fluency trials where participants are asked to come up with the maximum number of words beginning with certain letters in one minute (an executive function that is related to

the ability to conduct an effective unstructured information retrieval) and a category/semantic fluency trial, assessing the ability to retrieve verbal information from established semantic categories such as names of animals. In the present study, significant underperformance was found only for semantic fluency in the misophonia sample, but not in phonemic fluency. Studies suggest that phonemic (letter) fluency is a true executive function whereas semantic (category) fluency is more related to memory retrieval (Baldo et al., 2006). Indeed, studies suggest that semantic verbal fluency modality is associated with the activation of left temporal regions, whereas prefrontal cortex activation is more associated with phonemic fluency (Ghanavati et al., 2019).

In terms of processing speed, although processing speed did not differ significantly between the groups, the misophonia sample underperformed on processing speed outcome measures, exhibiting a somewhat slower reaction time for go stimuli on the CPT-III with a small effect size (d = 0.21) as well as a medium effect size indicating underperformance on the TMA (d = .31), a measure of graphomotor processing speed. These results are in line with the results of a study that found underperformance in a misophonia sample compared to controls on mean RT for go stimuli on the Stop Signal Task (d = - 0.45; Eijsker et al., 2019), but in contrast to a more recent study that found similar response speed between a misophonia and a control sample on the Embedded Figures Task (EFT; Simner et al., 2022). Of note, the EFT is not considered a neuropsychological task, which may explain why the former study found evidence for accuracy-speed tradeoff, whereas the latter did not. Regardless, given the dearth of research on processing speed in misophonia, more research is needed to examine

processing speed in general, as well as the speed-accuracy tradeoff (i.e., cautious response style).

Misophonia is undoubtedly an extraordinarily complex disorder, but the results of the present study are in support of the limited available literature suggesting that executive functions are intact in misophonia with deficiencies occurring in lower-level cognitive domains. Notably, differences found in the misophonia sample, when compared to test norms, as well as indicated by the magnitude of effect sizes compared to controls, corresponded to underperformance and not impairment. This is in line with the overall underperformance of small to medium effect sizes that have been found across cognitive domains suggesting that small to medium effects for cognitive dysfunction are transdiagnostic in psychopathology (Abramovitch et al., 2021).

Functional impairments are rarely assessed in the context of psychopathology (Abramovitch et al., 2021), and more so, in the context of misophonia research. Differences were seen in the misophonia group compared to the control in three domains, specifically in home-chores, money management, and driving. The home-chores domain is related to completing household chores and maintaining your household. Money management is related to how well debt is handled, and driving is associated with the history of citations and motor vehicle accidents. Interestingly, money-management and driving have been previously associated with ADHD samples more than the non-ADHD population, which seems to reflect the comorbidity in our sample (Bangma et al., 2019; Vaa, 2014). However, examination of functional indices compared to the BFIS test norms, indicated that although the misophonia sample reported more functional

impairments on these functional domains, these did not cross the threshold of objectively impaired functioning on any of the domains.

Finally, an examination of correlations between general clinical symptoms and misophonia symptom-severity yielded no meaningful association with severity of depression, general anxiety, or state anxiety symptoms within the misophonia sample. However, there was a clear significant positive association within the misophonia group between impulsivity and the severity of reaction to trigger sounds, and overall sound sensitivity. This is particularly important as emerging research is now considering how emotional dysregulation may play an important part in misophonia with newly proposed models also noting rigidity as part of the emotional response to the sound (Cowan et al., 2022; Guetta, Cassiello-Robbins, Trumbull, et al., 2022) that may affect the regulation of impulse control. Indeed, the role of 'emotional impulsivity' has been subject to recent interest in psychopathology research suggesting that this unresearched facet may be crucially important in our understanding of psychopathology (for a review, see Carver et al., 2017).

Limitations

The present study has several strengths including being the first study to compare misophonia and control samples on a comprehensive neuropsychological battery, administration of a valid semi-structured diagnostic interview, assessment of everyday functioning, and employment of correction for multiplicity. However, this study is not without limitations. First, the misophonia group sample size was relatively small, with a control/ misophonia participant ratio being 2:1. Nevertheless, since this is the first study

of its kind, the results of this study may be an important contribution to our understanding of misophonia and may be utilized to inform future research. Second, there were two technical issues in this study. First, due to a technical error, only ten out of the fifteen BFIS items were administered. However, as per the BFIS manual (Barkley, 2011), each item is a standalone domain with its norms, and thus the present study was able to examine 10 functional domains – which may be the first examination of functional indices in misophonia. Additionally, to obtain raw data from the CPT-III test there is a need to contact the vendor. Unfortunately, due to a technical error raw data from the CPT-III test was unavailable, however standard scores (t-scores) were available for all participants and were used in the final analyses. Finally, this study sample comprised college students which may limit generalizability.

Conclusion

Misophonia is not yet a formal condition, but emerging research suggests that it is a relatively prevalent, burdensome, and complex disorder involving sensory, neurological, psychological, and psychophysiological mechanisms. However, there is nearly no information available on cognitive functions in misophonia with most studies focusing on 'hot' cognitive function and symptom provocation in imaging, and much less on 'cold' cognitive function. Although misophonia is considered an episodic disorder, research suggests that it is associated with several psychopathological correlates, such as anxiety and emotional regulation. Results of the present study support the presence of both clinical symptoms outside misophonia episodes, as well as cognitive dysfunction in attention, processing speed, and verbal memory, which in turn are associated with misophonia severity. Furthermore, the results of the present study support the role of

emotional impulsivity in misophonia which is in line with recent research. However, since this is the first study of its kind, and given that examinations of 'cold' cognitive function research in misophonia are practically nonexistent, the results of this study should be replicated in the various samples (e.g., psychiatric and audiology samples). Indeed, there is an urgent need for further research into misophonia, particularly neuropsychological investigations that incorporate psychopathological indices.

APPENDIX SECTION

Table 7. *Neuropsychological test performance across misophonia and control groups – standardized scores*

	Control	Misophonia		F	Sig.	Cohen's *d*
	M(SD)	M(SD)	df			
Set shifting						
Trail Making B	0.14 (1.03)	-0.28 (0.87)	(1, 94)	2.43	0.12	0.36
WCST Preservative Errors	0.09 (0.98)	-0.17 (1.03	(1, 92)	2.14	0.15	0.30
WCST Categories Completed	5.77 (0.88)	5.44 (1.52)	(1, 41.88)	1.34	0.25	0.27
Planning						
TOL Excess Moves	1.41 (3.48)	0.82 (4.06)	(1, 90)	0.52	0.47	0.16
Working Memory						
DS Forward Total	-0.10 (0.99)	0.21 (1.01)	(1, 94)	2.35	0.13	0.33
DS Backward Total	0.01 (0.88)	-0.02 (1.22)	(1, 94)	0.11	0.74	0.07
DS Sequencing Total	0.10 (1.03)	-0.21 (0.92)	(1, 94)	1.41	0.24	0.26
DS Total	0.01 (0.99)	-0.02 (1.03)	(1, 94)	0.01	0.91	0.02
Symbol Span Total	-0.02 (0.98)	0.04 (1.06)	(1, 94)	0.01	0.94	0.02
Verbal Fluency						
Letter Total	0.05 (1.09)	-0.11 (0.79)	(1, 85.15)	0.59	0.45	0.16
Category Total	0.15 (1.10)	-0.30 (0.68)	(1, 90.25)	5.48	**0.02****	0.47
Response Inhibition						
CPT Commission Errors	0.03 (0.95)	0.01 (0.73)	(1, 66)	0.01	0.93	0.02
Verbal Memory						
CVLT Short Delay Recall	0.20 (0.81)	-0.40 (1.22)	(1, 44.10)	7.34	**0.01****	0.63
CVLT Sum of Trials 1-5	0.10 (0.94)	-0.20 (1.10)	(1, 94)	3.11	0.08	0.37
CVLT Long Delay Recall	0.13 (0.88)	-0.26 (1.18)	(1, 47.39)	3.76	0.06	0.44
Non-verbal Memory						
RCFT Immediate	-0.16 (3.40)	-0.88 (1.46)	(1, 94)	0.80	0.37	0.20

RCFT Delayed	-0.54 (1.57)	-1.15 (1.40)	(1, 94)	1.77	0.19	0.30
Processing Speed						
Trail Making A	0.11 (0.94)	-0.22 (1.09)	(1, 94)	2.21	0.14	0.31
CPT Mean RT	-0.25 (1.04)	-0.04 (0.77)	(1, 93)	1.00	0.32	0.23
Attention						
CPT Omission Errors	-0.13 (0.86)	-0.12 (0.88)	(1, 93)	0.004	0.95	0.01
CPT RT SD	-0.29 (1.03)	-0.09 (0.80)	(1, 93)	0.89	0.35	0.21
Visuospatial						
RCFT Copy	-0.11 (0.72)	-0.75 (1.96)	(1, 36.95)	2.52	0.12	0.38

Note: Analyses were conducted on raw scores; Means and Standard deviation are in z-scores except the WCST. CVLT, California-Verbal Learning Test II; RCFT, Rey Complex Figure Test; DS, Digit Span; WCST, Wisconsin Card Sorting Test; TOL, Tower of London; CPT, Conners' Continuous Performance Test; RT, Reaction time; SD, Standard Deviation. *p<.05 **p<.01.

REFERENCES

Aazh, H., Landgrebe, M., Danesh, A. A., & Moore, B. C. (2019). Cognitive behavioral therapy for alleviating the distress caused by tinnitus, hyperacusis, and misophonia: Current perspectives. *Psychology research and behavior management, 12*, 991.

Abramovitch, A., Short, T., & Schweiger, A. (2021). The C Factor: Cognitive dysfunction as a transdiagnostic dimension in psychopathology. *Clin Psychol Rev, 86*, 102007. https://doi.org/10.1016/j.cpr.2021.102007

Baguley, D. M., & Fagelson, M. (2013). Misophonia and Phonobia. In D. McFerran (Ed.), *Tinnitus: Clinical and Research Perspectives* (pp. 245-258). Plural Publishing, Inc.

Baldo, J. V., Schwartz, S., Wilkins, D., & Dronkers, N. F. (2006). Role of frontal versus temporal cortex in verbal fluency as revealed by voxel-based lesion symptom mapping. *Journal of the International Neuropsychological Society, 12*(6), 896-900.

Bangma, D. F., Koerts, J., Fuermaier, A., Mette, C., Zimmermann, M., Toussaint, A. K., Tucha, L., & Tucha, O. (2019). Financial decision-making in adults with ADHD. *Neuropsychology, 33*(8), 1065.

Barkley, R. A. (2011). *Barkley functional impairment scale (BFIS)*. Guilford Press.

Bosco, F. A., Aguinis, H., Singh, K., Field, J. G., & Pierce, C. A. (2015). Correlational effect size benchmarks. *Journal of Applied Psychology, 100*(2), 431.

Carver, C. S., Johnson, S. L., & Timpano, K. R. (2017). Toward a Functional View of the p Factor in Psychopathology. *Clinical Psychological Science, 5*(5), 880-889. https://doi.org/10.1177/2167702617710037

Cassiello-Robbins, C., Anand, D., McMahon, K., Brout, J., Kelley, L., & Rosenthal, M. Z. (2021). A Preliminary Investigation of the Association Between Misophonia and Symptoms of Psychopathology and Personality Disorders. *Frontiers in Psychology, 11*, 1-8. https://doi.org/10.3389/fpsyg.2020.519681

Cassiello-Robbins, C., Anand, D., McMahon, K., Guetta, R., Trumbull, J., Kelley, L., & Rosenthal, M. Z. (2020). The Mediating Role of Emotion Regulation Within the Relationship Between Neuroticism and Misophonia: A Preliminary Investigation. *Front Psychiatry, 11*(847), 1-7. https://doi.org/10.3389/fpsyt.2020.00847

Cavanna, A. E., & Seri, S. (2015). Misophonia: current perspectives. *Neuropsychiatr Dis Treat, 11*, 2117-2123. https://doi.org/10.2147/NDT.S81438

Claiborn, J. M., Dozier, T. H., Hart, S. L., & Lee, J. (2020). Self-Identified Misophonia Phenomenology, Impact, and Clinical Correlates. *Psychological Thought, 13*(2), 349-375. https://doi.org/10.37708/psyct.v13i2.454

Clara, I. P., Cox, B. J, and Enns, W. M. (2001). Confirmatory Factor Analysis of the Depression-Anxiety-Stress Scales in Depressed and Anxious Patients. *Journal of Psychopathology and Behavioral Assessment, 23*.

Cohen, J. (2013). *Statistical power analysis for the behavioral sciences*. Routledge.

Colucci, D. A. (2016). A Case of Amplified Misophonia. *The Hearing Journal*, 40.

Conners, K. C. (2014). *Conners Continuous Performance Test (Conners CPT-III) and Conners Continuous Auditory Test of Attention (Conners CATA): Technical Manual*. Multi-Health Systems.

Cowan, E. N., Marks, D. R., & Pinto, A. (2022). Misophonia: A psychological model and proposed treatment. *Journal of Obsessive-Compulsive and Related Disorders, 32*, 100691.

Cusack, S. E., Cash, T. V., & Vrana, S. R. (2018). An examination of the relationship between misophonia, anxiety sensitivity, and obsessive-compulsive symptoms. *Journal of Obsessive-Compulsive and Related Disorders, 18*, 67-72. https://doi.org/10.1016/j.jocrd.2018.06.004

Daniels, E. C., Rodriguez, A., & Zabelina, D. L. (2020). Severity of misophonia symptoms is associated with worse cognitive control when exposed to misophonia trigger sounds. *PLoS One, 15*(1), e0227118. https://doi.org/10.1371/journal.pone.0227118

Delis, D., Kramer, J., Kaplan, E., & Ober, B. (2000). California verbal learning test–second edition. *Adult version. Manual. The Psychological Corporation: San Antonio, TX*.

Delis, D. C., Kaplan, E., & Kramer, J. H. (2001). Delis-Kaplan executive function system.

Dozier, T. H. (2013). Misophonia Emotional Responses Scale [Scale].

Dozier, T. H. (2015). Counterconditioning Treatment for Misophonia. *Clinical Case Studies, 14*(5), 374-387. https://doi.org/10.1177/1534650114566924

Dozier, T. H., Lopez, M., & Pearson, C. (2017). Proposed Diagnostic Criteria for Misophonia: A Multisensory Conditioned Aversive Reflex Disorder. *Front Psychol, 8*, 1975. https://doi.org/10.3389/fpsyg.2017.01975

Edelstein, M., Brang, D., Rouw, R., & Ramachandran, V. S. (2013). Misophonia: physiological investigations and case descriptions. *Front Hum Neurosci, 7*, 296. https://doi.org/10.3389/fnhum.2013.00296

Eijsker, N., Schroder, A., Smit, D. J. A., van Wingen, G., & Denys, D. (2019). Neural Basis of Response Bias on the Stop Signal Task in Misophonia. *Front Psychiatry, 10*(October), 1-10, Article 765. https://doi.org/doi: 10.3389/fpsyt.2019.00765

Erfanian, M., Brout, J. J., & Keshavarz, A. (2020). Misophonia and affective disorders: The relationship and clinical perspective. *European Psychiatry, 41*(S1), S471-S471. https://doi.org/10.1016/j.eurpsy.2017.01.539

Erfanian, M., Kartsonaki, C., & Keshavarz, A. (2019). Misophonia and comorbid psychiatric symptoms: a preliminary study of clinical findings. *Nord J Psychiatry, 73*(4-5), 219-228. https://doi.org/10.1080/08039488.2019.1609086

Eysenck, S. B. G., Pearson, P. R., Easting, G., & Allsopp, J. F. (1985). Age norms for impulsiveness, venturesomeness, and empathy in adults. *Personality and Individual Differences, 6*(5), 613-619. https://doi.org/10.1016/0191-8869(85)90011-x

Fawcett, E. J., Power, H., & Fawcett, J. M. (2020). Women are at greater risk of OCD than men: a meta-analytic review of OCD prevalence worldwide. *The Journal of Clinical Psychiatry, 81*(4), 13075.

Fitzmaurice, G. (2014). *Misophonia Activation Scale (MAS-1)*. www.misophonia-UK.org

Frank, B., & McKay, D. (2019). The Suitability of an Inhibitory Learning Approach in Exposure When Habituation Falls: A Clinical Application to Misophonia. *Cognitive and Behavioral Practice, 26*, 130-142.

Frank, B., Roszyk, M., Hurley, L., L., D., & McKay, D. (2020). Inattention in misophonia: Difficulties achieving and maintaining alertness. *Journal of clinical and experimental neuropsychology, 42*(1), 66-75. https://doi.org/https://doi.org/10.1080/13803395.2019.1666801

Geller, D. A., Biederman, J., Faraone, S., Agranat, A., Cradock, K., Hagermoser, L., Kim, G., Frazier, J., & Coffey, B. J. (2001). Developmental aspects of obsessive compulsive disorder: findings in children, adolescents, and adults. *J.Nerv.Ment.Dis., 189*(7), 471-477. PM:11504325

Ghanavati, E., Salehinejad, M. A., Nejati, V., & Nitsche, M. A. (2019). Differential role of prefrontal, temporal and parietal cortices in verbal and figural fluency: Implications for the supramodal contribution of executive functions. *Scientific Reports, 9*(1). https://doi.org/10.1038/s41598-019-40273-7

Glantz, S. A., & Slinker, B. K. (2001). *Primer of applied regression & analysis of variance, ed*. McGraw-Hill, Inc., New York.

Goodman, W. K., Price, L. H., Rasmusse, S. A., Mazure, C., Fleischmann, R. L., Hill, C. L., Heninger, G. R., & Charney, D. S. (1989). The Yale-Brown Obsessive Compulsive Scale. *Arch Gen Psychiatry, 46*, 1006-1011.

Guetta, R., Cassiello-Robbins, C., Anand, D., & Rosenthal, M. Z. (2022). Development and psychometric exploration of a semi-structured clinical interview for Misophonia. *Personality and Individual Differences, 187*, 111416. https://doi.org/10.1016/j.paid.2021.111416

Guetta, R., Cassiello-Robbins, C., Trumbull, J., Anand, D., & Rosenthal, M. Z. (2022). Examining emotional functioning in misophonia: The role of affective instability and difficulties with emotion regulation. *PLoS One, 17*(2), 1-13. https://doi.org/https://doi-org.libproxy.txstate.edu/10.1371/journal.pone.0263230

Hale, J. B., Hoeppner, J.-A. B., & Fiorello, C. A. (2002). Analyzing digit span components for an assessment of attention processes. *Journal of psychoeducational assessment, 20*(2), 128-143.

IBM. (2020). *IBM SPSS Statistics for Macintosh, Version 27.0.* In (Version 27)

Jager, I., de Koning, P., Bost, T., Denys, D., & Vulink, N. (2020). Misophonia: Phenomenology, comorbidity, and demographics in a large sample. *PLoS One, 15*(4), e0231390. https://doi.org/10.1371/journal.pone.0231390

Jastreboff, M., & Jastreboff, P. (2014). Treatments for Decreased Sound Tolerance (Hyperacusis and Misophonia). *35*(02), 105-120. https://doi.org/10.1055/s-0034-1372527

Jastreboff, P. J., & Jastreboff, M. M. (2001a). Components of decreased sound tolerance-Hyperacusis, misophonia, phonophobia.

Jastreboff, P. J., & Jastreboff, M. M. (2001b). Hyperacusis. www.audiologyonline.com/articles/hyperacusis-1223

Kumar, S., Tansley-Hancock, O., Sedley, W., Winston, J. S., Callaghan, M. F., Allen, M., Cope, T. E., Gander, P. E., Bamiou, D. E., & Griffiths, T. D. (2017). The Brain Basis for Misophonia. *Curr Biol, 27*(4), 527-533. https://doi.org/10.1016/j.cub.2016.12.048

Kumar, S., von Kriegstein, K., Friston, K., & Griffiths, T. D. (2012). Features versus feelings: dissociable representations of the acoustic features and valence of aversive sounds. *J Neurosci, 32*(41), 14184-14192. https://doi.org/10.1523/JNEUROSCI.1759-12.2012

Loong, J. (1990). Wisconsin Card Sorting Test–IBM Version. *San Luis Obispo, CA: Wang Neuropsychological Laboratory*.

Lovibond, P. F., & Lovibond, S. H. (1995). The structure of negative emotional states: Comparison of the Depression Anxiety Stress Scales (DASS) with the Beck Depression and Anxiety Inventories. *Behaviour research and therapy, 33*(3), 335-343.

Marteau, T. M., & Bekker, H. (1992). The development of a six-item short-form of the state scale of the Spielberger State-Trait Anxiety Inventory (STAI). *British Journal of Clinical Psychology, 31*(3), 301-306. https://doi.org/10.1111/j.2044-8260.1992.tb00997.x

McFerran, D. (2016). Misophonia and phonophobia. *Tinnitus Clin Res Perspect*, 245-260.

Mulkens, S., Bögels, S. M., de Jong, P. J., & Louwers, J. (2001). Fear of blushing: Effects of task concentration training versus exposure in vivo on fear and physiology. *Anxiety Disorders, 15*, 413-432.

Osterrieth, P. (1944). Le test de copie d'une figure complex: Contribution a l'etude de la perception et de la memoire [The Complex Figure Test: Contribution to the study of perception and memory]. *Arch Psychol, 28*, 1021-1034.

Potgieter, I., MacDonald, C., Partridge, L., Cima, R., Sheldrake, J., & Hoare, D. J. (2019). Misophonia: A scoping review of research. *J Clin Psychol, 75*(7), 1203-1218. https://doi.org/10.1002/jclp.22771

Rouw, R., & Erfanian, M. (2018). A Large-Scale Study of Misophonia. *J Clin Psychol, 74*(3), 453-479. https://doi.org/10.1002/jclp.22500

Salehinejad, M. A., Ghanavati, E., Rashid, M. H. A., & Nitsche, M. A. (2021). Hot and cold executive functions in the brain: A prefrontal-cingular network. *Brain and Neuroscience Advances, 5*, 239821282110077. https://doi.org/10.1177/23982128211007769

Schadegg, M. J., Clark, H. L., & Dixon, L. J. (2021). Evaluating anxiety sensitivity as a moderator of misophonia and dimensions of aggression. *Journal of Obsessive-Compulsive and Related Disorders, 30*, 100657. https://doi.org/10.1016/j.jocrd.2021.100657

Schroder, A., van Wingen, G., Eijsker, N., San Giorgi, R., Vulink, N. C., Turbyne, C., & Denys, D. (2019). Misophonia is associated with altered brain activity in the auditory cortex and salience network. *Sci Rep, 9*(1), 7542. https://doi.org/10.1038/s41598-019-44084-8

Schroder, A., Vulink, N., & Denys, D. (2013). Misophonia: diagnostic criteria for a new psychiatric disorder. *PLoS One, 8*(1), e54706. https://doi.org/10.1371/journal.pone.0054706

Schroder, A. E., Vulink, N. C., van Loon, A. J., & Denys, D. A. (2017). Cognitive behavioral therapy is effective in misophonia: An open trial. *J Affect Disord, 217*, 289-294. https://doi.org/10.1016/j.jad.2017.04.017

Shallice, T. (1982). Specific impairments of planning. *Philosophical Transactions of the Royal Society of London. B, Biological Sciences, 298*(1089), 199-209.

Sheehan, D. V., Lecrubier, Y., Sheehan, K. H., Amorim, P., Janavs, J., Weiller, E., Hergueta, T., Baker, R., & Dunbar, G. C. (1998). The Mini-International Neuropsychiatric Interview (MINI): the development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. *Journal of clinical psychiatry, 59*(20), 22-33.

Silva, F. E. d., & Sanchez, T. G. (2019). Evaluation of selective attention in patients with misophonia. *Brazilian Journal of Otorhinolaryngology, 85*, 303-309.

Simner, J., Koursarou, S., Rinaldi, L. J., & Ward, J. (2022). Attention, flexibility, and imagery in misophonia: Does attention exacerbate everyday disliking of sound? *Journal of clinical and experimental neuropsychology*, 1-12. https://doi.org/10.1080/13803395.2022.2056581

Sinclair, S. J., Siefert, C. J., Slavin-Mulford, J. M., Stein, M. B., Renna, M., & Blais, M. A. (2012). Psychometric evaluation and normative data for the depression, anxiety, and stress scales-21 (DASS-21) in a nonclinical sample of US adults. *Evaluation & the health professions, 35*(3), 259-279.

Song, P., Zha, M., Yang, Q., Zhang, Y., Li, X., & Rudan, I. (2021). The prevalence of adult attention-deficit hyperactivity disorder: A global systematic review and meta-analysis. *Journal of Global Health, 11*. https://doi.org/10.7189/jogh.11.04009

Spankovich, C., & Hall, J. W. (2014). The Misunderstood Misophonia. *Audiology Today*, 14-23.

Swedo, S. E., Baguley, D. M., Denys, D., Dixon, L. J., Erfanian, M., Fioretti, A., Jastreboff, P. J., Kumar, S., Rosenthal, M. Z., & Rouw, R. (2022). Consensus Definition of Misophonia: A Delphi Study. *Frontiers in Neuroscience*, 224.

Taylor, S. (2017). Misophonia: A new mental disorder? *Med Hypotheses, 103*, 109-117. https://doi.org/10.1016/j.mehy.2017.05.003

Thielen, H., & Gillebert, C. R. (2019). Sensory sensitivity: Should we consider attention in addition to prediction? *Cognitive Neuroscience, 10*(3), 158-160. https://doi.org/10.1080/17588928.2019.1593125

Tunç, S., & Başbuğ, H. S. (2017). An extreme physical reaction in misophonia: stop smacking your mouth! *Psychiatry and Clinical Psychopharmacology*, *27*(4), 416-418.

Vaa, T. (2014). ADHD and relative risk of accidents in road traffic: A meta-analysis. *Accident Analysis & Prevention, 62*, 415-425. https://doi.org/10.1016/j.aap.2013.10.003

Vidal, C., Vidal, L. M., & Lage, M. J. A. (2017). Misophonia: Case Report. *European Psychiatry*, *41*(S1), S644-S644. https://doi.org/10.1016/j.eurpsy.2017.01.2259

Webber, T. A., & Storch, E. A. (2015). Toward a theoretical model of misophonia. *Gen Hosp Psychiatry, 37*(4), 369-370. https://doi.org/10.1016/j.genhosppsych.2015.03.019

Wechsler, D. (2009). *Wechsler Memory Scale: Manual (4th)* (Vol. 29). San Antonio, TX: Pearson Assessment.

Welch, B. L. (1938). The significance of the difference between two means when the population variances are unequal. *Biometrika, 29*(3/4), 350-362.

Wu, M. S., Lewin, A. B., Murphy, T. K., & Storch, E. A. (2014). Misophonia: incidence, phenomenology, and clinical correlates in an undergraduate student sample. *J Clin Psychol, 70*(10), 994-1007. https://doi.org/10.1002/jclp.22098

Zhou, X., Wu, M. S., & Storch, E. A. (2017). Misophonia symptoms among Chinese university students: Incidence, associated impairment, and clinical correlates. *Journal of Obsessive-Compulsive and Related Disorders, 14*, 7-12. https://doi.org/http://dx.doi.org/10.1016/j.jocrd.2017.05.001

World Health Organization. (2019). *International statistical classification of diseases and related health problems* (11th ed.). https://icd.who.int/