Measuring Misophonia: Assessing the psychometric properties of the MisoQuest and its ability to predict cognitive impacts of triggering sounds

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Abstract: Misophonia is a disorder involving an aversion to specific ordinary sounds, such as chewing and breathing. These "trigger" sounds are easily ignored by typically developed listeners, but elicit negative emotional reactions, physiological stress, and cognitive impairment in people with misophonia. While the severity of this reaction differs across individuals, it is often accompanied by psychological distress. Nevertheless, misophonia is not yet classified as a psychological disorder in diagnostic manuals, largely because it is unclear how it should be defined and assessed. Accordingly, the current study aimed to assess the utility of the English language version of the MisoQuest - a recently developed measure of misophonia severity - in a sample of 139 participants, including 44 people with misophonia and 95 controls (96 female, 34 male, 9 transgender/non-binary/non-conforming/agender; 90 White/Caucasian, 10 Black/African Descent, 10 East Asian, 10 South Asian, 3 Middle Eastern/Arab, 3 Latinx/Hispanic, and 13 people from mixed ethnic backgrounds). We first demonstrate that, similar to the original Polish assessment, the English MisoQuest has excellent internal consistency and strong test-retest reliability. Additionally, we provide the first evidence that the MisoQuest specifically taps misophonia symptom severity rather than generalized anxiety or broader sensory sensitivities. Finally, we establish evidence of criterion validity, demonstrating that higher MisoQuest scores predict poorer performance on cognitive tasks in the presence of trigger sounds. Overall, this study indicates that the MisoQuest is a reliable and useful measure for identifying misophonia in English-speaking individuals and that scores on this measure are related to clinically relevant outcomes.

Keywords: Misophonia, MisoQuest, cross-cultural validation, Stroop effect, reading comprehension

Public Significance Statement: We evaluated the reliability and validity of a measure for misophonia called the MisoQuest. Results indicate that the MisoQuest is a useful measure for identifying misophonia in English-speaking individuals and that scores on this measure are related to clinically relevant outcomes.

Misophonia is a psychologically distressing experience involving an extreme aversion to certain ordinary sounds. The clinical presentation of misophonia was first described by Jastreboff & Jastreboff in 2001 and has since garnered increasing awareness among clinicians and researchers. Despite researcher consensus that misophonia is a discrete disorder, there remains a lack of consensus regarding how misophonia should be characterized and assessed (Swedo et al., 2022).

Misophonia Characterization

Misophonia is a decreased sound tolerance disorder involving an aversion to specific "trigger" sounds (Siepsiak, Śliwerski, et al., 2020). Any sound can be a trigger for someone with misophonia, but common triggers are human-produced, repetitive sounds like chewing and breathing (Claiborn et al., 2020; Rouw & Erfanian, 2018). When someone with misophonia hears a trigger sound, it elicits a physiological stress response and feelings of intense anger, anxiety, and/or disgust (Edelstein et al., 2013; Kumar et al., 2017; Schröder et al., 2013)

Variation in emotional responses to sound is normal, but misophonic reactions can be functionally impairing and clinically significant. Some individuals affected by misophonia describe experiencing pain, suicidal ideation, and/or an inability to enjoy life because of their ongoing symptoms (Alekri & Al Saif, 2019; Hocaoglu, 2018). In addition, behavioral studies demonstrate that people with misophonia experience impaired attention and memory in the presence of trigger sounds when compared to healthy controls (Daniels et al., 2020; Frank et al., 2020; Seaborne & Fiorella, 2018; Silva & Sanchez, 2019) These trigger-specific cognitive deficits represent functional impairments that are central to the conceptualization of misophonia.

Accordingly, validated assessments for misophonia should produce scores that are meaningfully associated with these deficits.

Evidence-based clinical assessments and interventions are imperative to the management and treatment of misophonia. However, misophonia is not currently listed in psychiatric diagnostic manuals such as the Diagnostic and Statistical Manual for Mental Disorders (DSM; Gold, 2014). As a result, individuals with misophonia are often misdiagnosed and left without evidence-based treatment options (Brout et al., 2018; Claiborn et al., 2020; Potgieter et al., 2019) This is especially concerning because misophonia has been estimated to affect a staggering 15-20% of individuals (Naylor et al., 2021; Wu et al., 2014; Zhou et al., 2017). This point prevalence is alarmingly high given the potential severity of misophonia; however, these estimates were not derived from agreed upon diagnostic criteria. Rather, the prevalence of misophonia has been estimated using self-report measures that do not have rigorously validated clinical cut-offs (Naylor et al., 2021; Wu et al., 2014; Zhou et al., 2017). Thus, while 15-20% of the population *may* experience misophonia symptoms, clinically significant cases are likely rarer. Regardless, the misophonia literature is sparse (<100 empirical articles published as of 2022; Swedo et al., 2022), suggesting that little is known about a condition that potentially affects many. Validated measures for misophonia are therefore crucial for accurately capturing prevalence, improving clinical practice, and advancing the limited field of research.

Misophonia Assessment

The most widely used self-report measures for misophonia are the Amsterdam Misophonia Scale (A-MISO-S; Schröder et al., 2013) and the Misophonia Questionnaire (MQ; Wu et al., 2014). The popularity of these measures likely reflects the fact that they were the first

to be developed rather than evidence of their validity (Rosenthal et al., 2021). Both the A-MISO-S and MQ were adapted from scales designed to measure Obsessive-Compulsive behaviors, but the conceptualization of misophonia as an obsessive-compulsive disorder (OCD) has since been criticized. Rather, scientific evidence suggests that while misophonia is highly comorbid with OCD, it is similarly comorbid with other psychological disorders, including mood disorders, anxiety disorders, post-traumatic stress disorder, and attention deficit hyperactivity disorder (Claiborn et al., 2020; Jager et al., 2020; Rouw & Erfanian, 2018). In addition, the symptoms captured by OCD measures do not appear to correlate with misophonia-related impairment (Remmert et al., 2022). The psychometric evidence supporting the A-MISO-S and MQ is also incomplete, and comprises data collected exclusively from high school and undergraduate samples (Naylor et al., 2021; Sarıgedik & Gulle, 2021; Wu et al., 2014). Thus, the generalizability of these measures for use with diverse age groups is unclear.

To address the absence of a well-validated measure for misophonia, Siepsiak and colleagues (2020a) developed a new self-report measure for misophonia; the MisoQuest is a unidimensional scale comprising 14 Likert-rated items that tap a single underlying construct: misophonia severity. The MisoQuest was shown to have strong internal consistency (Cronbach's alpha = 0.95) and scores were highly stable over a period of five weeks (interclass correlation coefficient = 0.84; (Siepsiak et al., 2020a). In addition, these psychometric data were acquired from a more diverse sample, providing greater generalizability (Siepsiak et al., 2020a). A receiver operating characteristic analysis of the data provided by Siepsiak and colleagues (2020a) indicated that a cut-off score of 61 resulted in the highest overall accuracy at separating controls (MisoQuest scores between 14-60) from people with misophonia (MisoQuest scores ≥ 61; Enzler et al., 2021). In a follow-up study using that cut-off value, nearly all participants who received a

MisoQuest score of 61 or greater were diagnosed with misophonia using a structured clinical interview, indicating that the MisoQuest has high specificity (96.3%; Siepsiak et al., 2020b). However, a number of participants who were diagnosed with misophonia using the structured interview scored lower than 61 on the MisoQuest, indicating poorer sensitivity (66.67%; Siepsiak et al., 2020b).

In addition to the MisoQuest, a number of other self-report measures have recently been developed to assess misophonia. These include the Selective Sound Sensitivity Syndrome Scale (S-Five; Vitoratou et al., 2021), the Duke Misophonia Questionnaire (DMQ; Rosenthal et al., 2021), and the Berlin Misophonia Questionnaire Revised (BMQ-R; Remmert et al., 2022), which also have promising psychometric properties. However, in comparison to these other measures, the MisoQuest has fewer items and may be particularly useful as a rapid screening tool.

Overall, the MisoQuest appears to be a reliable and valid measure for identifying misophonia. However, the MisoQuest was written in Polish and validated in Polish-speaking samples before being translated into English by the research team alongside other researchers and interpreters. Several studies have since used the English language MisoQuest to assess misophonia severity (Bagrowska et al., 2022; Enzler et al., 2021; Savard et al., 2022); however, a cross-cultural validation study had yet to be conducted and the properties of the English-translated MisoQuest remain unknown.

The Present Study

The goal of this study was to advance the characterization and assessment of misophonia by tackling the following aims: 1) evaluate the psychometric properties (factor structure, internal consistency, and test-retest reliability) of the English language MisoQuest; 2) establish

preliminary evidence of convergent and discriminant validity of the MisoQuest; 3) investigate group differences in cognitive performance in the presence of different sounds using the MisoQuest cut-off score to group those with and without clinically-significant misophonia; and 4) evaluate MisoQuest scores as a dimensional predictor of cognitive performance in the presence of trigger sounds while controlling for general anxiety and sensory hypersensitivity.

To address aims three and four, the current study used two cognitive tasks: a Stroop task and a reading comprehension task. Both tasks have been used to identify trigger-specific cognitive deficits in those with misophonia (Daniels et al., 2020; Seaborne & Fiorella, 2018), but are considered to assess different cognitive processes. The Stroop task is used widely throughout psychology research as an indicator of cognitive control and selective attention (Bugg, 2012), whereas reading comprehension is an indicator of sustained attention and memory-related processes (Palladino et al., 2001). By using both tasks, the current study will evaluate the type of cognitive deficits that are associated with MisoQuest scores.

In accordance with the psychometric data supporting the original, Polish version of the MisoQuest, we hypothesized that the English language MisoQuest would have a unidimensional factor structure with strong internal consistency and test-retest reliability after five weeks. Next, we hypothesized that scores on the MisoQuest would be strongly correlated with scores on another misophonia measure (the S-Five) but only weakly or moderately correlated with scores on measures for anxiety (the General Anxiety Disorder scale [GAD-7]) and sensory hypersensitivity (the Sensory Hyperactivity Scale [SHS]). We hypothesized that individuals scoring 61 or greater on the MisoQuest (the previously identified cutoff score for clinically relevant misophonia)would perform worse than control participants on the Stroop and reading comprehension tasks in the presence of trigger sounds. Finally, we hypothesized that MisoQuest

scores would predict cognitive performance on the Stroop and reading comprehension tasks in the presence of trigger sounds across the spectrum of symptom severity, independent of scores on measures for anxiety and sensory hypersensitivity.

Methods

This study was approved by the University of Western Ontario Research Ethics Board. Study hypotheses and procedures were pre-registered prospectively before data were collected on the Open Science Forum; see https://osf.io/nxhuk. Raw data, supplementary materials, and task code are available at https://osf.io/3pf68.

Participant Characteristics

To calculate the required sample size for this study, an a priori power analysis was run using G*Power (Faul et al., 2007). This analysis was designed to estimate the sample size required to perform a fixed model linear multiple regression with a power of 0.9 and a significance threshold of $\alpha = 0.05$. The results suggested that a minimum sample size of 90 participants (45 per cognitive task) would be required to detect a small effect size. We expected to observe a small effect size (based on the standards of Cohen et al., 1988) because similar effect sizes have been observed in laboratory studies of cognitive functioning in people with misophonia (Frank et al., 2020; Guetta et al., 2022; Simner et al., 2021).

Participants were recruited through CloudResearch (New York, NY), the University of Western Ontario SONA psychology research participation pool, and online advertisements circulated to misophonia support groups (including the SoQuiet misophonia research pool). A total of 151 participants were recruited (see Figure 1); however, after excluding participants who

did not pass the attention checks (described below), a sample of 139 participants was included in the analyses. Forty-four participants met the MisoQuest cut-off for clinically significant misophonia and the remaining 95 participants comprised the control group (see Table 1). The sample was 65% White/Caucasian, 9% East Asian, 9% South Asian, 8% Black/African Descent, 5% Latinx/Hispanic, 3% Middle Eastern, and 1% Indigenous Peoples of Canada. Participants also reported their total household income over the past year: 17% of the sample reported an income less than $25,000, 20% reported $25,000-$49,999, 32% reported $50,000-$99,999, 27% reported $100,000-$199,999, and 4% of the sample reported an income greater than $200,000. All participants were 17 years or older, proficient in English, had normal or corrected-to-normal vision, and no known hearing impairments.

Figure 1

Participant Flow Chart

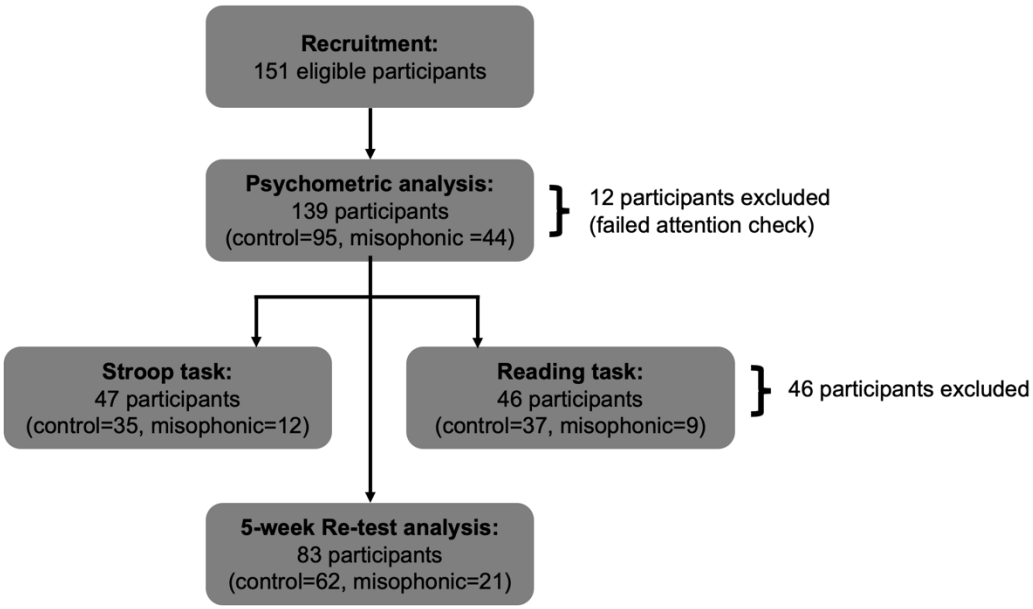


Table 1

Participant Characteristics

	Control (n=95)	***Misophonia (n=44)***
MisoQuest Score	*Range: 14-59 (mean = 39.5)*	*Range: 61-70 (mean = 65)*
Age	*Range: 18-73 (mean = 36.5)*	*Range: 17-72 (mean = 39.5)*
Gender	*63% female, 33% male, 2% transgender male, 2% non-binary*	*83% female, 9% male, 2% non-binary, 2% gender non-conforming, 2% agender*

Procedure

The study was conducted online using participants' personal computers. Interested and eligible participants were provided a link to a survey hosted on Qualtrics (Provo, UT). Informed consent was collected, and participants were prompted to complete a self-report assessment battery that included a demographics questionnaire as well as measures for misophonia severity (the MisoQuest and S-Five), generalized anxiety (GAD-7), and sensory hypersensitivity (SHS). Four attention checks were embedded throughout this battery and required participants to select a specific response option (e.g., Please select '7') to indicate that they were reading and responding to each item. Participants who did not select the appropriate response on any of the four attention checks were excluded from all analyses (n = 12).

Once participants completed the assessment battery, they followed a link to one of two behavioral tasks (*either* a Stroop or reading comprehension task) written in PsychoPy/PsychoJS (Peirce et al., 2019) and hosted on Pavlovia (Nottingham, UK). To minimize environmental variability, participants were asked to dim their lights, turn up the brightness on their computer screen, minimize distractions, and adjust their computer volume to a level that was loud but not uncomfortable. Participants then completed three blocks of their assigned task, each presented in a different background sound condition: in silence; in the presence of a generally aversive sound (baby crying); or in the presence of a common misophonic trigger sound (a person chewing). The three sound conditions were presented to participants in a random order and were counterbalanced across participants to control for order effects. After completing their assigned behavioral task, participants were asked if at any point during the experiment they had turned the sound off, or reduced the volume such that they could not hear the sounds. Participants who responded "yes" to this question, or did not complete the task in its entirety, or reported encountering technical issues that would preclude the interpretation of their data were excluded from the behavioral analyses (n= 47). Finally, five weeks following the completion of the initial study, participants received a new link hosted on Qualtrics and were asked to complete the MisoQuest a second time.

Measures

Demographics Questionnaire

This questionnaire obtained information about a participant's age, gender, ethnicity, education level, socioeconomic status, and mental health diagnoses. This information was used to ensure similarity across groups and determine the generalizability of study results. In addition,

participants' education level was categorized as low (some primary, completed primary, some secondary, secondary degree), medium (some university but no degree, vocational degree), and high (bachelor's degree, graduate or professional degree) for use as a predictor variable in the regression models.

MisoQuest

The MisoQuest (Siepsiak et al., 2020a) is a 14-item self-report survey that assesses misophonia symptom severity, with questions about emotional reactions to sound and resulting distress and social impairment. The items are rated on a 5-point Likert scale (from 1=I definitely do not agree to 5=I definitely agree) and are summed to produce a total score ranging from 14 (no misophonia symptoms) to 70 (severe misophonia symptoms). Scores greater than or equal to 61 indicate the presence of clinically significant misophonia.

Selective Sound Sensitivity Syndrome Scale (S-Five)

Participants' misophonia severity was also quantified using the Selective Sound Sensitivity Syndrome Scale (S-Five; Vitoratou et al., 2021) in order to evaluate convergent validity. The S-Five is a comprehensive, clinically oriented self-report measure that assesses misophonia severity using 25 items distributed across five subscales: internalizing, externalizing, perceived threat, outbursts, and impact. The items are rated on an 11-point scale (from 0=Not at all true to 10=Completely true) and are summed with higher overall scores indicating greater misophonia severity. The S-Five has strong internal consistency, test-retest reliability, and preliminary evidence of convergent and discriminant validity (Vitoratou et al., 2021, 2023).

Generalized Anxiety Disorders Scale (GAD-7)

The Generalized Anxiety Disorders Scale (GAD-7; Spitzer et al., 2006) is a 7-item unidimensional scale measuring worry and anxiety symptoms. The items are rated on a 4-point scale (from 0=Not at all to 3=Nearly every day) and are summed to produce a total score ranging from 0 (no or minimal anxiety) to 21 (severe anxiety). The GAD-7 has excellent internal consistency and strong evidence of construct validity (Johnson et al., 2019).

Sensory Hypersensitivity Scale (SHS)

The Sensory Hypersensitivity Scale (SHS; Dixon et al., 2016) is a 25-item self-report survey that assesses sensory over-responsivity. The items are rated on a 5-point Likert scale (from 1=Strongly Disagree to 5=Strongly Agree) and are summed with higher total scores indicating greater sensory over-responsivity. The SHS assesses sensitivity across nine subscales, which correspond to different sensory stimuli, including light, sound, touch, taste, smell, pain, and temperature. The SHS has good internal consistency and evidence of discriminant validity (SHS scores weakly correlate with measures of depression and anxiety [Dixon et al., 2016]). The SHS sound subscale has similarly strong internal consistency.

Behavioral Tasks & Materials

Auditory Stimuli

The sound of an individual chewing gum was selected for the misophonic trigger condition because it contained several elements of triggering mouth sounds (i.e., chewing, lip smacking, and wet saliva sounds), which are among the most common triggers for misophonia (Enzler et al., 2021; Vitoratou et al., 2021). Indeed, one study found that 96.5% of individuals

with self-reported misophonia endorsed mouth sounds as one of their triggers (Claiborn et al., 2020). Similarly, the sound of a baby crying sound was selected for the aversive sound condition because it is universally considered to be unpleasant (Green et al., 1995) and is considered similarly aversive by individuals with and without misophonia (Kumar et al., 2017). The gum chewing and baby crying sound files were retrieved from online sources and normalized to have the same root-mean-square amplitude.

Stroop Task

In each trial of the Stroop task, participants were presented with a color word ("red", "green", or "blue") on their computer screen and instructed to use their keyboard arrow keys to indicate the color of the text as quickly and accurately as possible while ignoring the semantic meaning of the word (the mapping of colors to arrow keys was presented at the bottom of the screen as a reminder throughout the experiment). On congruent trials, the color of the text matched the meaning of the word (e.g., the word "red" written in the red text), while on incongruent trials, the color of the text differed from the meaning of the word (e.g., the word "red" written in blue text). Participants completed one block of 30 practice trials, followed by three blocks of 72 experimental trials, each presented in one of the three sound conditions. Within each experimental block , participants were presented with 36 congruent trials and 36 incongruent trials (in random order) with a 500 ms interval between trials.

The Stroop effect was quantified as the difference between a participant's mean reaction time on congruent trials and incongruent trials. Only trials where the participant responded correctly were included in this analysis. The magnitude of the Stroop effect for each sound condition was used as an index of cognitive control and selective attention, where a larger Stroop

effect indicates poorer cognitive control and selective attention. Mean percent accuracy across all trials was also analyzed for each sound condition to supplement the interpretation of Stroop effect results.

Reading Comprehension Task

In the reading comprehension task, participants read three short stories on their computer screen (one per sound condition) and answered recall questions after each story. The three stories were "*The Pea Blossom*", "*Sunshine Stories*", and "*The Snowman*" - short children's fairy tales written by Hans Christian Andersen with similar word counts. The text of each story was presented across multiple screens, and participants progressed from one screen to the next by pressing the spacebar on their keyboard. Before beginning the experiment, participants were informed that they would be directed to answer a series of recall questions when they had completed each story, or after 5 minutes had elapsed (whichever came first). Following each story, participants were given as much time as they needed to answer ten multiple choice questions (each with five response options: one correct and four incorrect). The questions were presented on the computer screen one at a time and participants were instructed to use their keyboard keys to select the response option they thought was correct.

Reading comprehension accuracy was quantified as the percentage of multiple-choice questions that the participant answered correctly. Reading comprehension accuracy for each sound condition was used as an indicator of sustained attention and working memory, where decreased accuracy indicated poorer sustained attention, encoding, and/or retrieval.

Data Analytic Strategy

Psychometric Analyses

The 14 items of the Polish MisoQuest load onto a single factor, meaning they assess a single underlying construct: misophonia severity (Siepsiak et al., 2020a). To assess whether the factor structure of the English language MisoQuest is consistent with the Polish MisoQuest, confirmatory factor analysis (CFA) was conducted using a unidimensional model. The goodness-of-fit of this model to the data was evaluated using a Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and Root Mean Square Error of Approximation (RMSEA). Internal consistency was evaluated using Cronbach's alpha to further assess the homogeneity of the MisoQuest.

To evaluate the convergent and discriminant validity of the MisoQuest, Pearson correlation coefficients were computed between each participant's MisoQuest score and their scores on the S-Five,GAD-7, and SHS. Finally, test-retest reliability was evaluated by re-administering the MisoQuest to participants five weeks following completion of the initial study and computing the interclass correlation coefficient.

Behavioral Task Analyses

For categorical analyses, participants were divided into groups comprising those with and without clinically significant misophonia using the proposed cut-off score for the MisoQuest (Siepsiak et al., 2020a). Participants with scores from 14-60 comprised the control group and participants with scores 61-70 comprised the misophonia group. A two-way ANOVA with group (control, misophonia) as a between-subjects factor and sound type (silence, aversive, trigger) as a within-subjects factor was conducted for each task. The magnitude of the Stroop effect and reading comprehension accuracy were used as dependent variables in the two analyses. The

standard alpha of 0.05 was used to determine the presence of a significant main effect or interaction, and type III sums of squares were specified to account for differences in sample sizes across groups. Since directional predictions were established a priori, we performed one-tailed t-tests to interpret significant effects where applicable.

In addition to categorical analyses, the MisoQuest was evaluated as a dimensional measure by determining whether MisoQuest scores predict task performance across the full range of sound sensitivity using multiple linear regression. This analysis investigated the influence of three predictor variables (MisoQuest, GAD-7, and SHS) on each dependent variable (Stroop effect and reading comprehension accuracy). In addition to the reported regression coefficients, Pearson correlations were also computed to evaluate the relation between MisoQuest scores and performance outcomes. Since Pearson correlations are susceptible to outlier influence, bivariate outliers were identified by calculating the Mahalanobis distance for each observation in the correlation, which was compared to the critical value on the chi-squared distribution using an alpha of 0.05. All correlation analyses were conducted before and after the removal of identified outliers and interpreted accordingly.

Results

MisoQuest Psychometric Properties

A confirmatory factor analysis (CFA) was conducted to verify the factor structure of the English language MisoQuest. CFA using a unidimensional model yielded the following model fit indices: CFI = 0.920, TLI = 0.906, and RMSEA = 0.117. The CFI and TLI values suggest that the proposed unidimensional model is a good fit for the observed data (Hu & Bentler, 1999). However, an RMSEA value of 0.117 suggests a poor fit, and indicates that the unidimensional

model may not accurately reproduce the observed pattern of covariance (Hu & Bentler, 1999). Given the disagreement between model fit indices, an exploratory factor analysis (EFA) was conducted using principal component analysis to determine if an alternative model may better fit the data. This EFA provided a single factor accounting for 69.4% of the total variance explained, indicating that a unidimensional model best fit the observed data. The standardized factor loadings ranged from 0.714-0.895 (see Table 2) and the internal consistency of the MisoQuest was high (Cronbach's alpha = 0.966), indicating that the items are strongly correlated with one another and reliably assess a common underlying construct.

Table 1

MisoQuest Factor Loadings

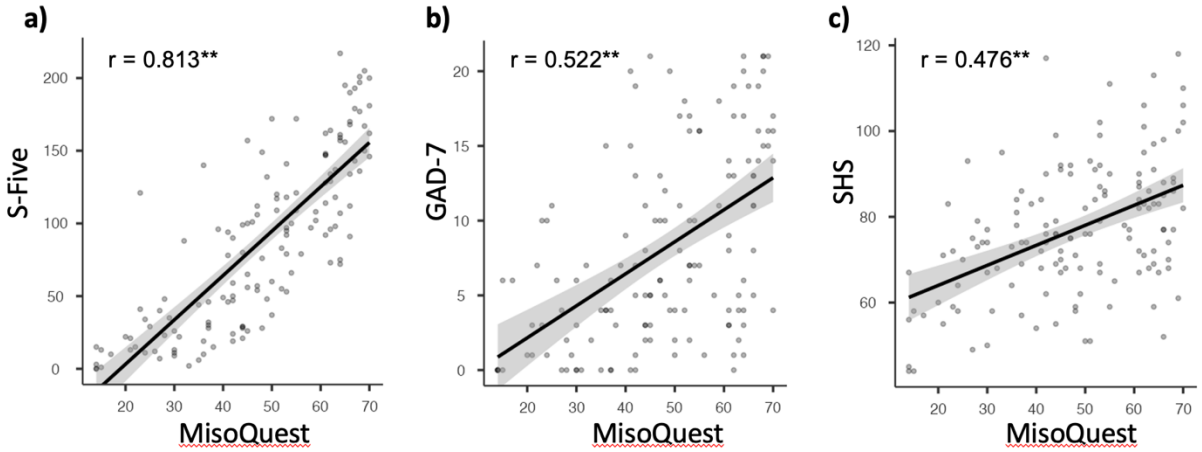
Factor	***Indicator***	***Factor Loading***
Misophonia Severity	*Item 1: Some sounds bother me so much that I have difficulty controlling my emotions.*	*0.895*
	Item 2: Unpleasant sounds make me feel overwhelmed.	*0.870*
	Item 3: I become anxious at the mere thought of an unpleasant sound.	*0.786*
	Item 4: I believe that my reactions to sounds are exaggerated, but I can't get rid of them.	*0.868*
	Item 5: When I hear unpleasant sounds, I start sensing emotions in my body (e.g., I sweat, feel pain, feel pressure, my muscles tense).	*0.840*

	Item 6: I start feeling anger the moment I see a thing/animal/person that might make an unpleasant sound at any time.	*0.714*
	Item 7: I put a lot of effort into controlling emotions when I hear an unpleasant sound.	*0.780*
	Item 8: If I can, I avoid meeting with certain people because of the sounds they make.	*0.770*
	Item 9: I find some sounds made by the human body unbearable.	*0.777*
	Item 10: I feel that my mental state worsens if I cannot leave a place where there's an unpleasant sound.	*0.864*
	Item 11: I often think about how to drown out unpleasant sounds.	*0.745*
	Item 12: Some unpleasant sounds make me instantly angry.	*0.864*
	Item 13: I am scared that unpleasant sounds may impact my future.	*0.762*
	Item 14: When meeting with other people, I am sometimes irritated because of unpleasant sounds that are present.	*0.834*

The convergent validity analysis (see Figure 2a) revealed a strong, positive correlation between scores on the MisoQuest and scores on the S-Five ($r = 0.813$, $p < 0.001$), which demonstrates a high degree of convergence between measures designed to assess the same construct (misophonia severity). There were also significant positive correlations between MisoQuest scores and scores on the GAD-7 ($r = 0.522$, $p < 0.001$; Figure 2b), the SHS ($r = 0.476$, $p < 0.001$; Figure 2c), and the SHS sound subscale ($r = 0.447$, $p < 0.001$), indicating that individuals with more severe misophonia symptoms tend to have more severe anxiety and sensory hypersensitivity. Although these variables are meaningfully associated, the relations between scores on the MisoQuest and measures for distinct constructs (GAD-7, SHS, and SHS sound subscale) are weaker than the relation between scores on the MisoQuest and another measure for misophonia (S-Five), thereby demonstrating discriminant validity.

Figure 2

MisoQuest Convergent & Discriminant Validity Analysis



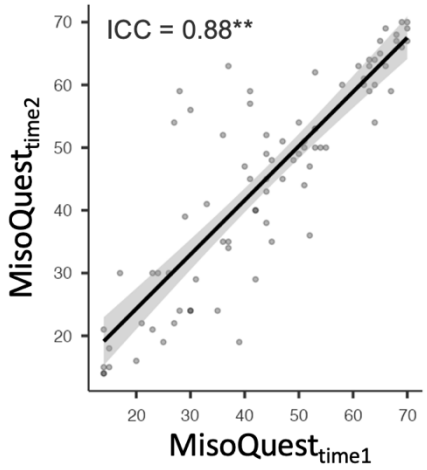
Note. Figure 2a depicts the Pearson correlation between MisoQuest scores and S-Five scores; Figure2b depicts the Pearson correlation between MisoQuest scores and GAD-7

scores; Figure2c depicts the Pearson correlation between MisoQuest scores and SHS scores. The shaded area represents the standard error, **p < 0.001.

Finally, the test-retest reliability analysis demonstrated consistent results over a five-week interval. The interclass correlation coefficient between MisoQuest scores obtained at the two time points was strong (ICC [68.0] = 0.88, p < 0.001), indicating a high degree of reliability across this time period (Figure 3).

Figure 3

MisoQuest Test-Retest Reliability Analysis



Note. Figure 3 depicts the Pearson correlation between MisoQuest scores at time point 1 and MisoQuest scores at time point 2 (five weeks later). The shaded area represents the standard error, **p < 0.001.

Behavioral Task Results

Of the 139 participants that completed the assessment battery, 46 were excluded from the behavioral analyses because they did not complete their assigned task in its entirety, reported experiencing technical difficulties, or reported turning their computer volume way down or off such that they were not listening to the study sounds while completing the task. In total, 47 participants were included in the Stroop task analyses (35 controls, 12 people with misophonia) and 46 participants were included in the reading task analyses (37 controls, 9 people with misophonia). Notably, 88.6% of the people with misophonia included in the behavioral analyses reported the sound of someone chewing gum as a trigger, indicating that the stimulus used for the misophonic trigger condition likely produced the desired reaction in most of the misophonic sample.

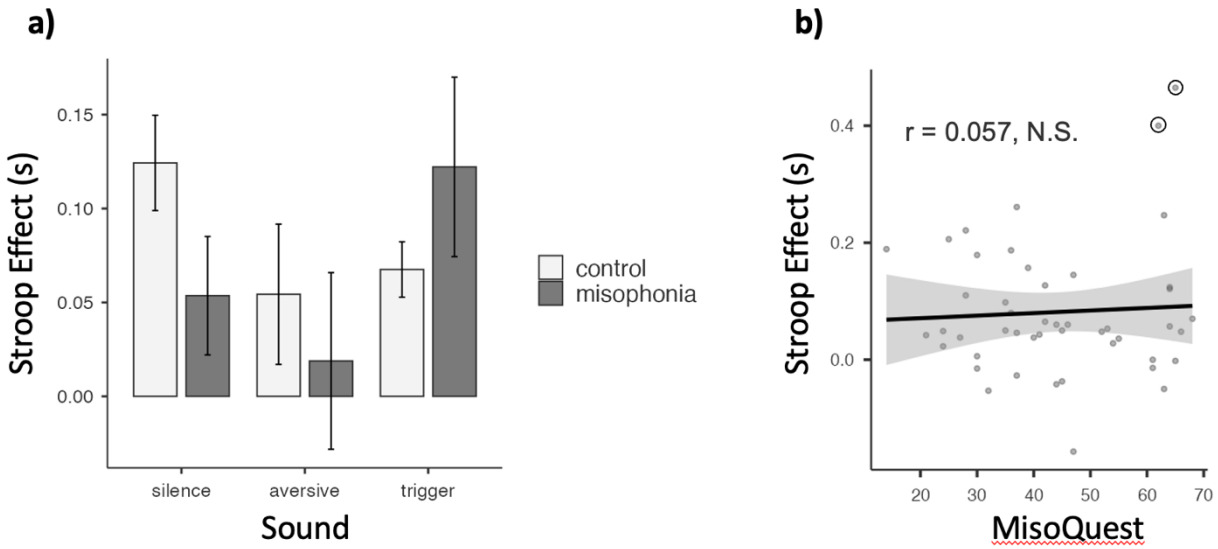
Stroop Task

A repeated measures ANOVA conducted on Stroop effect magnitudes (the difference in reaction times between incongruent and congruent trials) revealed no significant main effect of group ($F[1, 45] = 0.192$, $p = 0.663$, $\eta^2 = 0.002$), no significant main effect of sound type ($F[2, 45] = 2.13$, $p = 0.125$, $\eta^2 = 0.021$), and no significant interaction ($F[2, 45] = 2.16$, $p = 0.121$, $\eta^2 = 0.021$; Figure 4a). A repeated measures ANOVA conducted on overall accuracy values (the percentage of correct responses across all trial types) revealed no significant main effect of group ($F[1, 45] = 0.015$, $p = 0.903$, $\eta^2 = 0.000$), no significant main effect of sound type ($F[2, 45] = 1.37$, $p = 0.259$, $\eta^2 = 0.001$), and no significant interaction ($F[2, 45] = 2.29$, $p = 0.107$, $\eta^2 = 0.001$).

To analyze the influence of four predictor variables (MisoQuest scores, GAD-7 scores, SHS scores, and education level [low-medium vs medium-high]) on the outcome of interest (Stroop effect in the presence of trigger sounds), a multiple linear regression was conducted to determine the portion of variance in the outcome variable attributed to the combination of predictors. The overall regression was non-significant ($R = 0.203$, $R^2 = 0.0413$, adjusted $R^2 = -0.0816$, $F[5, 40] = 0.336$, $p = 0.888$). Furthermore, the Pearson correlation between MisoQuest scores and Stroop effect in the trigger condition was also non-significant ($r = 0.057$, $p = 0.706$; Figure 4b). Two bivariate outliers were identified and subsequently removed from the analysis; however, the resulting correlation remained non-significant ($r = -0.186$, $p = 0.232$).

Figure 4

Stroop Effect



Note. Figure 4a depicts the mean Stroop effect score for the control group (light grey) and misophonia group (dark grey) for each sound condition, the error bars represent the standard error of the mean. Figure 4b depicts the Pearson correlation between MisoQuest

scores and Stroop effect magnitudes for the trigger condition. The shaded area represents the standard error, bivariate outliers are circled.

Reading Comprehension Task

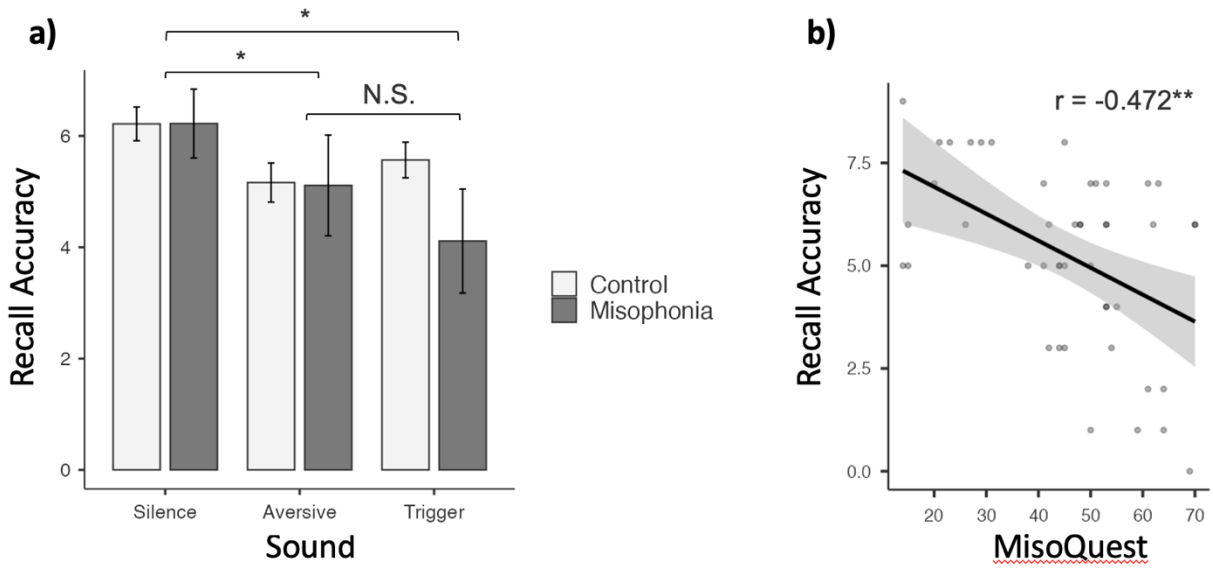
A repeated measures ANOVA conducted on reading accuracy scores revealed no significant main effect of group ($F[1, 44] = 0.696$, $p = 0.409$, $\eta^2 = 0.009$), a significant main effect of sound type ($F[2, 44] = 5.85$, $p = 0.004$, $\eta^2 = 0.049$), and no significant interaction ($F[2, 44] = 4.97$, $p = 0.155$, $\eta^2 = 0.016$; Figure 5a). Thus, while there are no apparent group differences in reading accuracy scores between controls and people with misophonia, both groups performed worse in the presence of aversive ($t[44] = 2.480$, $p_{tukey} = 0.044$) and trigger sounds ($t[44] = 3.035$, $p_{tukey} = 0.011$) compared to silence. To ensure accuracy scores were not confounded by a group difference in time-on-task (i.e., to determine whether people with misophonia were advancing through the screens of text more quickly than control participants in an effort to bring about the end of the trial more quickly), an exploratory analysis of reading time was performed. A repeated measures ANOVA revealed no significant main effect of group ($F[1, 44] = 0.000$, $p = 0.976$, $\eta^2 = 0.000$), a significant main effect of sound type ($F[2, 44] = 5.44$, $p = 0.006$, $\eta^2 = 0.029$), and no significant interaction ($F[2, 44] = 2.39$, $p = 0.098$, $\eta^2 = 0.013$). Both groups spent more time reading in silence compared to aversive ($t[44] = 2.757$, $p_{tukey} = 0.023$) and trigger sounds ($t[44] = 2.704$, $p_{tukey} = 0.026$).

To analyze the influence of the four predictor variables (MisoQuest scores, GAD-7 scores, SHS scores, and education level [low-medium vs. medium-high]) on the outcome of interest (reading comprehension in the presence of trigger sounds) a multiple linear regression was conducted to determine the portion of variance in the outcome variable attributed to the

combination of predictors. The overall regression was significant ($R = 0.511$ $R^2 = 0.261$, adjusted $R^2 = 0.169$, $F[5, 40] = 2.83$, $p = 0.028$). To assess the contributions of individual predictors, the magnitude and statistical significance of the standardized regression coefficients were examined. MisoQuest scores significantly predicted the outcome of interest ($B = -0.368$, $p = 0.038$), while GAD-7 scores ($B = -0.049$, $p = 0.772$), SHS scores ($B = -0.134$, $p = 0.366$), and education level ($B = -0.101$-0.525, $p = 0.380$-0.741) had non-significant regression coefficients. This suggests that the severity of an individual's misophonia predicts reading comprehension accuracy in the presence of trigger sounds, independent from their GAD-7 score, SHS score, and education level. The Pearson correlation between MisoQuest scores and reading comprehension accuracy scores was significant ($r = -0.472$, $p<0.001$; Figure 5b), indicating that greater misophonia severity is associated with poorer reading comprehension in the presence of trigger sounds.

Figure 5

Reading Comprehension Accuracy



Note: Figure 5a depicts the mean recall accuracy for the control group (light grey) and misophonia group (dark grey) for each sound condition, the error bars represent the standard error of the mean, *p < 0.05. Figure 4b depicts the Pearson correlation between MisoQuest scores and recall accuracy for the trigger condition. The shaded area represents the standard error, **p < 0.001.

In contrast, the overall regression was non-significant when reading comprehension in presence of aversive sounds ($R = 0.371$, $R^2 = 0.138$, adjusted $R^2 = 0.030$, $F[5.0, 40.0] = 1.28$, $p = 0.292$) and reading comprehension in silence ($R = 0.276$, $R^2 = 0.076$, adjusted $R^2 = -0.040$, $F[5, 40] = 0.658$, $p = 0.657$) were used as outcome variables. This indicates that MisoQuest scores are not predictive of reading comprehension accuracy in non-trigger sound conditions.

Discussion

The primary objective of the current study was to advance misophonia assessment by conducting a cross-cultural validation of the MisoQuest–a promising self-report measure for misophonia. The study contributes to a growing body of evidence supporting the reliability and validity of the MisoQuest, and provides novel insight into the substantive associations between misophonia symptom severity and commonly associated cognitive impairments. The MisoQuest was originally developed in Polish and had previously only been evaluated in Polish-speaking samples; thus, the current study bridged a critical gap in misophonia assessment by evaluating the psychometric properties of the English language MisoQuest in an English-speaking sample.

In alignment with the findings of Siepsiak & colleagues (2020a), we demonstrated that the MisoQuest has excellent internal consistency and strong stability across a five-week interval.

This indicates that the MisoQuest is a reliable measure for assessing misophonia symptom severity in English-speaking individuals. In addition to replicating the analyses of Siepsiak & colleagues (2020a), we sought to assess the convergent and discriminant validity of the MisoQuest. We demonstrated that MisoQuest scores are strongly associated with scores on another measure for misophonia and only moderately associated with scores on measures for anxiety and general sensory hypersensitivity. Misophonia severity is known to be associated with the severity of anxiety (Bagrowska et al., 2022; Schadegg et al., 2021) and sensory hypersensitivity symptoms (Wu et al., 2014), so moderate associations between these measures likely reflect the comorbidity between these constructs. Thus, our results align with our hypotheses and suggest that the MisoQuest specifically assesses misophonia - a crucial step towards ascertaining the overall construct validity of the MisoQuest. Overall, the psychometric evidence presented here grants researchers and clinicians improved confidence in their ability to accurately assess misophonia severity in English-speaking individuals, and will strengthen the claims of previous and future research studies using the MisoQuest. However, measurement validation is an ongoing process and researchers should continue to evaluate the factor structure, reliability, and validity of the MisoQuest in diverse samples.

The sample size for the current study was estimated a priori to ensure a small effect could be detected in the regression analyses that examined the relationship between cognitive impairments and the full range of MisoQuest scores. However, the resulting samples were ultimately underpowered to detect group differences in cognitive outcomes on the Stroop and reading comprehension tasks due to the small number of individuals who reached the MisoQuest cut-off score (n = 12 and n = 9 respectively, where n = 18 was deemed necessary to effectively power the analyses). A trend was observed whereby individuals with clinically significant

misophonia showed larger Stroop effects and poorer reading comprehension accuracy in the presence of trigger sounds relative to performance in silence than individuals without misophonia. However, these results largely failed to reach statistical significance and should be interpreted accordingly. The MisoQuest cut-off score used to divide participants with and without clinically significant misophonia yields high diagnostic accuracy (Enzler et al., 2021) but sacrifices sensitivity (Siepsiak et al., 2020b), meaning that some individuals with misophonia were likely not captured using this cut-off. The categorical approach to misophonia assessment may therefore make it challenging for researchers to recruit large enough misophonia samples to power their desired analyses.

Our dimensional analyses revealed that in the presence of trigger sounds, individuals with higher MisoQuest scores had poorer reading comprehension accuracy. These results suggest that misophonia symptom severity is associated with the magnitude of trigger-specific deficits. In addition, MisoQuest scores were found to predict reading comprehension accuracy independent from general anxiety, sensory hypersensitivity, and education level. However, contrary to previous studies (Daniels et al., 2020; Silva & Sanchez, 2019), MisoQuest scores did not predict an increased Stroop effect when the trigger sound condition was considered in isolation. This suggests that misophonia-specific factors captured by the MisoQuest, such as aversive emotional reactions to trigger sounds, may be related to deficits in working memory and sustained attention, but not selective attention. Importantly, impairments in sustained attention are clinically relevant; previous research in clinical populations has shown that deficits in sustained attention are better predictors of distress and social impairment than deficits in selective attention (Andrade et al., 2009). Future studies may opt to use neuroimaging techniques in conjunction

with mediation analyses to establish the specific mechanisms underlying deficits in working memory and sustained attention.

Some critics have argued that the MisoQuest captures the presence of misophonia but not the severity of symptoms (Rosenthal et al., 2021). The finding that trigger-specific cognitive deficits scale with MisoQuest scores contradicts that claim and suggests that the MisoQuest may be used as a dimensional measure. By treating misophonia as a dimensional construct, researchers can capture a wider range of variability, more effectively power their analyses, achieve greater flexibility in statistical modeling, and develop a more nuanced interpretation of individual differences. Despite these advantages, categorical approaches remain relevant to certain research questions (e.g., regarding the prevalence and onset of misophonia) as well as clinical decision-making. Researchers and clinicians using the MisoQuest categorically should carefully consider if the proposed cut-off score is appropriate for their intended use of the measure.

Study Limitations

It is important to interpret these findings in the context of their limitations. First, the study was conducted online in an effort to recruit a large sample of participants with severe misophonia. While online experiments are certainly more accessible, they sacrifice some experimental control. First, the current study likely experienced greater attrition rates than if the study had been conducted in a lab. A total of 46 participants who completed the survey portion of the study were not included in the behavioral analyses, either because they did not complete their assigned task, experienced technical difficulties, or reported adjusting their computer volume such that they did not listen to the experimental sounds. This group included a

disproportionate number of people with misophonia, which may have impacted the significance and effect size of the results presented here. Conceivably, many of the participants who reported turning their computer volume down or off may have done so as a result of the distress they were experiencing; as a result, our sample may be biased toward those who experienced less distress or were able to effectively manage their distress. Next, while the Stroop task is a known indicator of selective attention and cognitive control, the reading comprehension task used in this study has not been validated. Rather, the materials for this task were selected and developed by the study team for use in the current study. The recall questions were expected to discriminate between those with and without a strong understanding of the stories but have not been formally evaluated. Finally, while the MisoQuest showed strong convergent validity with the S-Five, there is currently no consensus 'gold-standard' diagnostic tool against which the MisoQuest could be compared against. Future studies may opt to include interview-based assessments (e.g., the Duke Misophonia Interview; Guetta et al., 2022), which might further inform the validity of the MisoQuest.

Constraints on Generality

The sample recruited in the current study comprised a sample of 139 participants, including 44 people with misophonia and 95 controls (96 female, 34 male, 9 transgender/non-binary/non-conforming/agender; 90 White/Caucasian, 10 Black/African Descent, 10 East Asian, 10 South Asian, 3 Middle Eastern/Arab, 3 Latinx/Hispanic, and 13 people from mixed ethnic backgrounds). Thus, while this sample was age and socioeconomically diverse, it was predominantly composed of white females. It is unclear if there are discernable differences in the presentation of misophonia among genders and ethnicities, meaning that these results may not

generalize to different populations. Thus, the results presented here represent a step towards validating the English-translated MisoQuest, but do not indicate that the MisoQuest is validated for use with *all* English-speaking individuals.

Conclusion

People with misophonia struggle with aversive reactions to everyday sounds in a modern world that is filled with noise. This experience can be psychologically distressing, socially isolating, and since misophonia is not yet recognized in diagnostic manuals, difficult to identify and manage. The results of this work will therefore not only serve to improve misophonia assessment but also better understand misophonia as a clinical phenomenon and shape the classification process.

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