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DECREASED SOUND TOLERANCE (DST): PREVALENCE, CLINICAL CORRELATES, AND DEVELOPMENT OF A DST ASSESSMENT INSTRUMENT

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A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University

by

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Table of Contents

List of Tables

Page

List of Figures

Page

Abstract

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Decreased sound tolerance (DST) conditions, including misophonia and hyperacusis, are emerging clinical conditions in behavioral medicine. Misophonia involves an extreme emotional response (often anger, disgust, or annoyance) to specific sounds (such as people chewing, swallowing, tapping their foot on the floor, etc.), while hyperacusis is defined by high sensitivity to sounds below normal sound sensitivity thresholds. Although research on these DST conditions is increasing, clearly defined prevalence rates, associations with other mental health conditions, and development of assessment tools that can identify and differentiate DST symptoms are needed. Research and clinical reports also suggest that DST problems are more likely to occur in individuals affected by tinnitus, and that drawing upon a bio-psychosocial conceptualization of tinnitus and other behavioral medicine conditions may be useful in understanding and treating DST conditions. This cross-sectional survey study was administered to college student (*N*=451) and community adult (*N*=375) samples and investigated DST prevalence rates, clinical correlates, and risk factors and mechanisms of action for misophonia and hyperacusis. In addition, the study developed and

validated a new scale to identify misophonia and hyperacusis type sound sensitivity. Nearly 35% of individuals surveyed reported some degree of general auditory sensitivity, with 15-63% endorsing misophonia symptoms, and 17-26% endorsing hyperacusis symptoms, with rates depending on assessment method. Moderate to strong correlations were found between DST conditions and other mental and physical health conditions, including obsessive compulsive disorder, autism-spectrum traits, anxiety, depression, social phobia, medical conditions, and somatic and neurobehavioral symptoms. Mediation models revealed that the process by which misophonia symptoms become clinically significant and functionally impairing is partially mediated by amplification of bodily sensations and anxiety sensitivity. Risk factors for functional impairment related to misophonia symptoms were identified in moderation analyses and included neuroticism, synesthesia, and sensory sensitivity. An assessment instrument, the DST-10, and its subscales the Loudness Sensitivity Scale and Human Sounds Scale, was subjected to exploratory and confirmatory factor analysis and initial evidence for construct validity was demonstrated. This study was the first to assess hyperacusis, misophonia, and tinnitus rates in large general population samples and provides initial support for conceptualizing DST problems as behavioral medicine conditions.

Decreased Sound Tolerance (DST): Prevalence, Clinical Correlates, and Development of a DST Assessment Instrument

Conditions related to decreased sound tolerance (DST) are frequently encountered by audiologists, neurologists, and otolaryngologists, and have received increased attention by researchers in these fields in recent years. Within medical and audiology settings, DST diagnoses include hyperacusis, misophonia, and phonophobia (Baguley & McFerran, 2011; Jastreboff & Jastreboff, 2004). Hyperacusis involves abnormal sensitivity to moderate and low volume sounds (Baguley, 2003; Jastreboff & Jastreboff, 2004), while both misophonia and phonophobia have been defined as an extreme emotional response to specific sounds within a normal functioning auditory system (Jastreboff & Jastreboff, 2004; Møller, 2011a). These conditions were originally identified as a result of their apparent association with tinnitus, an auditory condition involving perception of ringing in the ears accompanied by emotional distress and functional impairment. Research has begun to reveal that these conditions occur independently from tinnitus and that psychosocial factors are crucial in understanding these auditory sensitivities (Andersson et al., 2005; Hadjipavlou, Baer, Lau, & Howard, 2008). Table 1 provides an overview of the relevant diagnostic labels covered in this report, their defining symptoms, emotional and behavioral responses, and estimated prevalence rates, based on the literature to date. (An updated version of this table, Table 17, is included in the Discussion section of this report with findings from the current study incorporated.)

Despite their reported high prevalence in both medical settings (Jastreboff & Jastreboff, 2004; Jastreboff & Jastreboff, 2006) and the general population (Fabijanska, Rogowski, Bartnik, & Skarzynski, 1999), and their apparent psychological implications, these conditions are clinically under-recognized and empirically under-studied within the psychological community. Indeed, none of the DST conditions are formally recognized or described within the Diagnostic and Statistical

Table 1.

DST and Related Conditions Defining Characteristics

Diagnostic label	**Defining symptoms**	**Typical emotional and behavioral responses**	**Prevalence rates**
Decreased sound tolerance	Broad category that includes misophonia, hyperacusis, and phonophobia	Varies based on specific type (see below)	15% general population; 40-60% in tinnitus clinics
Hyperacusis	Extreme sensitivity to sounds below normal sound sensitivity thresholds	Physical/emotional pain, anxiety about sounds, sound avoidance (e.g., wearing ear protection, not leaving the house)	8-9% general population; 3% clinically significant symptoms
Misophonia	Extreme emotional response to specific, human-produced sounds (e.g., chewing, nail picking, breathing)	Rage, disgust, compulsive urge to mimic the sound, obsessive thoughts about the sound, avoidance of social situations	20% undergraduate sample, 29% tinnitus clinics
Phonophobia (see Appendix B)	Not well defined or clearly differentiated from other DSTs or from specific sound phobia	Fear/anxiety, behavioral avoidance	90% among migraine sufferers, unknown in general or other clinical samples
Tinnitus	Intermittent or continuous ringing, roaring, or buzzing in the ear(s) or head that has lasted 3 months or longer in the past year	Sleep difficulties, concentration problems, social/occupational impairment, reliance on white noise masking	7.6-20% in community adults under age 50

Manual of Mental Disorders (American Psychiatric Association, 2013), though hyperacusis and tinnitus, a potentially related auditory condition with known psychological implications, are included as “Other disorders of ear, not elsewhere classified” within the category “Diseases of the ear and mastoid process” in the International Statistical Classifications of Diseases-10 (World Health Organization, 2008). However, several developments indicate a growing interest in DSTs within the field of psychology, including the development of questionnaires assessing hyperacusis (Baguley, 2003), a randomized clinical trial evaluating cognitive behavior therapy’s efficacy of treating hyperacusis (Jüris, Andersson, Larsen, & Ekselius, 2014), publication of several case reports describing clients presenting with misophonia to mental health clinics (e.g. Kluckow, Telfer, & Abraham, 2014; Schwartz, Leyendecker, & Conlon, 2011; Webber, Johnson, & Storch, 2014), proposed psychiatric diagnostic criteria for misophonia (Schroder, Vulink, & Denys, 2013), and initial investigations of the physiological (Edelstein, Brang, Rouw, & Ramachandran, 2013) and phenomenological (Wu, Lewin, Murphy, & Storch, 2014) characteristics of individuals with misophonia.

Before the year 2013, the literature on DST conditions consisted primarily of clinical science articles in medical journals, a handful of case studies, and several audiology book chapters dedicated to the topic. Since then, at least ten new studies focused on DST conditions have been published each year. Long before DST conditions became a topic of interest in the behavioral medicine research community, audiological and psychological research demonstrated the importance of cognitive, emotional, and behavioral factors in determining the severity and chronicity of tinnitus (Andersson, 2002; Jastreboff, 2004). Drawing parallels to the field of tinnitus research is particularly apt given that researchers specializing in tinnitus are responsible for identifying DST issues, and there is substantial comorbidity between tinnitus and DST conditions, suggesting possible common psychological mechanisms. Behavioral research has led to more comprehensive assessment of tinnitus (Langguth, Searchfield, Biesinger, & Greimel, 2011) and successful treatment approaches to tinnitus, including cognitive-behavioral therapy (Hesser, Weise, Westin, & Andersson, 2011) and acceptance and commitment therapy (Westin et al., 2011). These successes encourage approaching these emerging DST conditions from a psychological perspective.

Research so far reveals that a range of psychological factors and consequences are associated with DST conditions. The available epidemiological data indicate that DSTs often occur co-morbidly with one another (Andersson et al., 2002; Hadjipavlou et al., 2008) as well as with psychological conditions including those on the obsessive-compulsive spectrums, depression, and posttraumatic stress disorder (Baguley, 2003; Fagelson, 2007; Schroder et al., 2013; Taylor, Conelea, McKay, Crowe, & Abramowitz, 2014; Wu et al., 2014). Furthermore, evidence is accruing to suggest that DSTs are associated with substantial psychological distress, behavioral avoidance, reduced quality of life, and impaired functionality (Hadjipavlou et al., 2008; Newman, Jacobson, & Spitzer, 1996; Wu et al., 2014).

Neurophysiological, environmental, cognitive-behavioral, and personality-based accounts have been proposed to explain the etiology and clinical course of DSTs (Andersson, 2002; Edelstein et al., 2013; Hadjipavlou et al., 2008; Jastreboff & Jastreboff, 2004; Jüris, Andersson, Larsen, & Ekselius, 2013; Schroder et al., 2013; Schwartz et al., 2011). Though some models have implicated abnormal activation in limbic and autonomic systems (Jastreboff & Hazell, 1993), evidence for specific physical abnormalities associated with DSTs is lacking. At present, stronger evidence exists to support the role of behavioral mechanisms in which classical and operant learning lead to a conditioned negative response to certain stimuli, producing subsequent stimulus avoidance and maintenance of a fear/anger response in the etiology of DST conditions (Hadjipavlou et al., 2008).

Researchers have also noted similarities between misophonia in particular and the patterns observed in obsessive-compulsive spectrum conditions in which a neutralizing behavior is performed in response to an intrusive stimulus to avoid the distress, anxiety, or disgust associated with it (Hadjipavlou et al., 2008; Schroder et al., 2013; Taylor et al., 2014).

The current study drew upon the existing audiology, neurology, otolaryngology, psychiatry, and psychosomatic medicine literatures on DST and integrated them into a psychological framework in order to advance knowledge about the prevalence, clinical characteristics, and assessment of these conditions. Specifically, this study had four primary goals. First, this study investigated prevalence rates of these conditions within non-clinical college student and community samples in order to better understand their impact within the general population. Second, the clinical characteristics and psychological correlates of DST conditions were studied to better conceptualize and distinguish these conditions. Third, mechanisms of action and individual difference factors likely to explain or exacerbate the symptoms of these conditions were explored. Fourth, and finally, a DST assessment instrument, the DST Scale, was developed and subjected to psychometric scrutiny in order to advance assessment of these conditions.

Review of the Literature

Epidemiology and Clinical Characteristics

Not surprisingly given their recent emergence, overall prevalence rates for DST conditions have not been well-documented. One study reported prevalence rates around 15% for all types of DST conditions in a randomly selected sample of 10,349 people surveyed in Poland (Fabijanska et al., 1999). Rates as high as 40-60% have been reported among patients in audiology and tinnitus specialty centers (Jastreboff & Jastreboff, 2004, 2006), with prevalence rates for tinnitus in the United States estimated at 20% (Møller et al., 2011). The clinical characteristics and epidemiology of hyperacusis are better understood than other DST conditions, although two recent studies help shed light on the rates of misophonia (Wu et al., 2014) and auditory and tactile intolerance (Taylor et al., 2014) in the general population. Several factors, including the novelty of the misophonia construct, the conflation of phonophobia with the clinical characteristics of both hyperacusis and misophonia, and the overall lack of research specifically aimed at understanding these conditions, have all contributed to uncertainty about the nature and impact of these conditions within the population.

Hyperacusis. Individuals with hyperacusis present with an unusually high sensitivity to ordinary environmental sounds (Baguley & McFerran, 2011; Katzenell & Segal, 2001), such that they find sounds as low as 40 dB (equivalent to quiet talking) to be uncomfortable (Schwartz et al., 2011). Reduced loudness tolerance in general, and hyperacusis in particular, are commonly reported across a number of medical conditions, including migraine, Lyme disease, William's syndrome, multiple sclerosis, Addison's disease, and fibromyalgia (Baguley, 2003; Baguley & McFerran, 2011; Katzenell & Segal, 2001). However, cases of central hyperacusis, where the underlying pathology is at least partially understood as in the conditions mentioned above, are less common than non-syndromic hyperacusis, in which an underlying medical condition cannot be identified (Baguley, 2003; Katzenell & Segal, 2001). Knowledge of the mechanisms involved in these more well-understood conditions has led to the proposal of potential mechanisms for the development of hyperacusis, but little concrete evidence has emerged in support of physiological or neurological causes for hyperacusis (Baguley & McFerran, 2011; Katzenell & Segal, 2001).

Although hyperactivity of the auditory pathways is often cited in audiology as the primary diagnostic criteria for hyperacusis, self-report of discomfort at low sound level thresholds is the primary method by which diagnosis of hyperacusis is made (Baguley & McFerran, 2011). Important behavioral features include sound avoidance and the use of ear protection (Baguley & McFerran, 2011; Blaesing & Kroener-Herwig, 2012). Specialists in the area differentiate hyperacusis from other conditions of DST based on the intolerance to sounds in general rather than to specific sounds (Baguley & McFerran, 2011). Hyperacusis is also distinct from loudness recruitment, a phenomenon experienced by hearing-impaired individuals in which the contrast between a barely audible sound and a slightly louder sound is exaggerated due to abnormal loudness growth (Baguley, 2003). Consistent with this distinction, hyperacusis has been reported equally across normal hearing and hearing-impaired populations (Andersson et al., 2002; Baguley & McFerran, 2011; Blaesing, Goebel, Flotzinger, Berthold, & Kroner-Herwig, 2010).

Few epidemiological studies have thoroughly examined the prevalence or incidence of hyperacusis in the general population. An online and postal survey conducted in Sweden found overall rates of between 8-9% of respondents (Andersson et al., 2002). The researchers also provided a metric of hyperacusis severity by evaluating rates of those requiring the use of ear protection and identified a subset of about 3% of those surveyed who could be considered to have clinically significant hyperacusis (Andersson et al., 2002). This data converges with estimates synthesized by other researchers who calculated an overall 2% prevalence rate for significant hyperacusis based on reported comorbidity rates between hyperacusis and tinnitus of 50-70% (Baguley & McFerran, 2011; Hoffman & Reed, 2004). Similarly, a medical and audiological evaluation of over 500 Brazilian school children 5-12 years old found a prevalence rate of 3.2% (Coelho, Sanchez, & Tyler, 2007). Problematic noise sensitivity and tinnitus symptoms following traumatic brain injury (TBI) have also been reported and have recently received attention in the TBI literature as under-recognized symptoms (Eskridge et al., 2013; Landon, Shepherd, Stuart, Theadom, & Freundlich, 2012). Although it has not yet been supported with research, the high rate of comorbidity between tinnitus and hyperacusis likely compounds their individual effects and would be anticipated to cause greater distress and impairment among individuals affected by both. Indeed, high rates of anxiety are reported in people with hyperacusis (Blaesing & Kroener-Herwig, 2012; Jüris et al., 2013), with 47% meeting criteria for an anxiety disorder in one study (Jüris et al., 2013).

Autism spectrum disorders (ASDs) are also related to hyperacusis and other DST conditions, including phonophobia and misophonia. A recent review (Stiegler & Davis, 2010) asserts that DST symptoms have been inconsistently defined in the autism literature and, as a result, are often under-recognized or mistreated among individuals with ASDs. The authors concluded that the presence of DST is an important diagnostic consideration in evaluating individuals suspected of an ASD, and that in these individuals symptoms are more likely to be related to emotion regulation difficulties in response to specific sounds than to physiological abnormalities in the auditory system (Stiegler & Davis, 2010). Thus, the symptoms and underlying processes of DST in ASDs appears to mirror what has been observed in the general population, suggesting that communication across these areas of research will be important in appropriately defining and diagnosing these clinical phenomena.

Misophonia. The term misophonia was proposed to describe a cluster of symptoms surrounding a strong adverse reaction to specific sounds (Jastreboff & Jastreboff, 2003). Misophonia is differentiated from hyperacusis by the aversion to certain sounds rather than to all sounds above a particular loudness level (Jastreboff & Jastreboff, 2004). The aversive sound stimuli mentioned most often involve noises made by other humans, particularly chewing food, lip smacking, nail picking, and speaking (Collins, 2010; Edelstein et al., 2013; Hadjipavlou et al., 2008; Neal & Cavanna, 2013; Schroder et al., 2013).

Given the nascence of the construct, it is little surprise that epidemiological and other population-based descriptive studies for misophonia were lacking until very recently. The researchers who originally proposed the term misophonia have reported that 57% of the patient population at tinnitus specialty clinics also suffers from misophonia or some other DST problem (Jastreboff & Jastreboff, 2003; 2004; 2006). However, these researchers did not systematically distinguish between misophonia and phonophobia, and these estimates include individuals with and without concurrent hyperacusis and/or tinnitus. Within this sample, the researchers found that 28.9% presented with pure misophonia, and 32.9% suffered from hyperacusis with or without concurrent misophonia (Jastreboff & Jastreboff, 2004). Outside of audiology clinics, a more widespread general prevalence is suggested in that nearly 50 misophonia patients self-referred to a Department of Psychiatry in Amsterdam within 2.5 years after posting an announcement on a Dutch misophonia internet group and the hospital website (Schroder et al., 2013). A recent study examined prevalence rates of both auditory intolerance (i.e., those who experience heightened distress in response to everyday sounds) and tactile intolerance (i.e., those who are unusually sensitive to certain tactile sensations such as sticky or greasy substances, or the feeling of clothing tags) within a large community sample recruited through Amazon's Mechanical Turk program (Taylor et al., 2014). The authors found that a substantial portion of participants reported both auditory and tactile intolerance, indicating that there may be a more general sensory intolerance syndrome (Taylor et al., 2014). This study did not rule out loudness as a source of auditory intolerance (as in hyperacusis) and did not assess the interpersonal aspects of the sounds that are key to understanding misophonia; thus auditory intolerance as defined in this study may be broader than the misophonia construct. Another recent study found a 20% incidence rate of clinically significant misophonia symptoms within a large college student sample (Wu et al., 2014). This study, like Taylor et al. (2014), reported strong associations between misophonia symptoms and general sensory sensitivity. Importantly, the available case reports and empirical studies consistently find onset of misophonia during early adolescence (Edelstein et al., 2013; Hadjipavlou et al., 2008; Neal & Cavanna, 2013; Schroder et al., 2013) and a potentially greater rate in girls (Schwartz et al., 2011), suggesting that future studies should not be limited to adult populations. The recent emergence of the misophonia construct and the lack of consensus in defining it shed some doubt on the reliability of these prevalence rates. However, it is clear that a strong aversive reaction to specific human sounds is not an uncommon clinical problem in otolaryngology and audiology clinics, and is also found with some frequency within the general population.

Misophonia has been proposed as a new psychiatric disorder (Schroder et al., 2013). In one of the first studies specifically aimed at studying misophonia, researchers performed clinical interviews and gathered self-report questionnaire data on 42 patients who self-referred to the psychiatry department of an academic medical center in The Netherlands in response to advertisements posted on the hospital website and a Dutch misophonia online support network (Schroder et al., 2013). Based on the clinical profile of these patients, the following diagnostic criteria were proposed:

> A) The presence or anticipation of a specific sound, produced by a human being (e.g. eating sounds, breathing sounds), provokes an impulsive aversive physical reaction which starts with irritation or disgust that instantaneously becomes anger. B) This anger initiates a profound sense of loss of self-control with rare but potentially aggressive outbursts. C) The person recognizes that the anger or disgust is excessive, unreasonable, or out of proportion to the circumstances or the provoking stressor. D) The individual tends to avoid the misophonic situation, or if he/she does not avoid it, endures encounters with the misophonic sound situation with intense discomfort, anger, or disgust. E) The individual's anger, disgust, or avoidance causes significant distress (i.e. it bothers the person that he or she has the anger or

disgust) or significant interference in the person's day-to-day life. For example, the anger or disgust may make it difficult for the person to perform important tasks at work, meet new friends, attend classes, or interact with others. F) The person's anger, disgust, and avoidance are not better explained by another disorder, such as obsessive-compulsive disorder (e.g. disgust in someone with an obsession about contamination) or post-traumatic stress disorder (e.g. avoidance of stimuli associated with a trauma related to threatened death, serious injury or threat to the physical integrity of self or others) (Schroder et al., 2013).

Individuals meeting these criteria did not tend to display consistent co-occurrence with most mood and anxiety disorders or hearing impairments. However, 73% met criteria for one or more of the obsessive-compulsive spectrum disorders (OCSDs), including attention deficit hyperactivity disorder, hypochondria, Tourette syndrome, obsessive-compulsive disorder (OCD), obsessive compulsive personality disorder (OCPD), skin picking, and trichotillomania, leading to the conclusion that misophonia might be tentatively classified as a new OCSD (Schroder et al., 2013). However, because these proposed criteria were developed based on symptom patterns observed in individuals who self-referred for a study of misophonia, it is important to note that threats to external validity such as selection bias may limit the generalizability of the clinical profile identified in this study. Furthermore, the authors did not comment on the degree of inter-rater reliability reached across the five different psychiatrists in applying the proposed diagnostic criteria. Finally, ongoing debate about the validity of the OCSD label in describing a heterogeneous group of clinical problems (Castle & Phillips, 2006) should be a further caution against automatically assigning the label to any condition characterized by compulsive-impulsive symptoms.

A second study of the clinical characteristics and physiological responses of individuals with misophonia provided support for the proposed diagnostic criteria and for the distinct nature of misophonic symptoms (Edelstein et al., 2013). This investigation involved semi-structured clinical interviews and assessment of skin conductance response (SCR) to aversive and non-aversive auditory and visual stimuli in a sample of eleven individuals who self-identified as having misophonia through an online misophonia support group. In addition to corroborating the original classification of misophonia, the authors found that misophonic symptoms are modulated by the social context. Nine of 11 participants reported their misophonic responses were more extreme when the sound was produced by certain individuals, usually close friends, co-workers, or family members. Further, self-produced sounds or sounds produced by children or animals rarely caused misophonic reactions. The authors also collected qualitative data regarding the types of thoughts frequently endorsed by individuals with misophonia, such as “I want to punch this person” and “Don’t you know what you sound like?” (Edelstein et al., 2013). Finally, misophonics, compared to non-misophonic controls, exhibited significantly greater SCR and ratings of aversiveness in response to aversive auditory stimuli (e.g., lips smacking), but not to aversive visual stimuli. Although limited by a small self-identified sample, the use of both qualitative and quantitative methodology contributes additional support for the misophonia construct as a distinct and relevant clinical phenomenon.

Another recent study (Schroder et al., 2014) built on the physiological findings of Edelstein and colleagues (2013) by comparing the N1 auditory event-related potentials (ERPs) response (a measure of early attention) of misophonia patients and healthy controls during an oddball paradigm (deviant sounds presented in the context of repetitive sounds while watching a silent movie). The authors selected this task because attenuated N1 response has been demonstrated in other pathologies, including schizophrenia, PTSD, and antisocial personality disorder, and they hypothesized that an underlying neurobiological deficit in auditory processing might be present in misophonia. The results supported their hypothesis, with diminished N1 peak evoked by oddball tones within the misophonia group, with no differences in other measured ERPs or in response to the repetitive tones. However, as the authors acknowledge, although this study differentiates individuals with misophonia from healthy controls in terms of their auditory processing, it does not distinguish misophonia from other pathology where similar patterns have been observed (Schroder et al., 2014).

Two recent studies have explored the relationship between misophonia and other psychiatric conditions, particularly OC spectrum disorders. Wu and colleagues (2014) surveyed 483 undergraduates and found moderate associations between misophonia symptoms and obsessive-compulsive, general anxiety, and depression symptoms. Similarly, Taylor and colleagues (2014) confirmed that general psychopathology, and especially OC disorder caseness, OC symptom severity, and OC related phenomena were elevated among individuals reporting auditory and tactile intolerance. Furthermore, the Wu et al. study showed that anxiety mediates the relationship between misophonia symptoms and anger outbursts, suggesting that OC spectrum disorders and misophonia may share common maintaining factors.

So far, investigations of misophonia have revealed a consistent and clinically distinct pattern, with the greatest similarity and overlap to OCD and related disorders. Converging evidence for a relationship between misophonia and the OC spectrum comes from case reports of misophonic patients presenting with comorbid OCSDs (Neal & Cavanna, 2013), and with OC symptoms such as preoccupation with and compulsive mimicry of the aversive sounds (Hadjipavlou et al., 2008). However, given small sample sizes, few experimental studies, and limitations in research design, the reliability, validity, and clinical utility of misophonia remains in question (Ferreira et al., 2013). Therefore, classifying it as a new psychiatric disorder is premature. At the same time, the proposed diagnostic criteria, clinical and physiological data, documented comorbidity with OCSDs, and associations between symptoms in the general population provide a promising foundation for future researchers to build upon in conceptualizing misophonia.

Phonophobia. Phonophobia is a term sometimes mentioned in conjunction with hyperacusis and misophonia. Little has been published on it, and the term suffers a significant lack of conceptual clarity. For these reasons, the current study will not seek to measure this construct. Appendix B includes an overview of the research to date on this topic and a more detailed rationale for its exclusion from the current study. Although phonophobia will not be explicitly investigated in this study, we will examine the relationship of DST conditions to other specific phobias, in an effort to rule out a specific phobia with a strong sound component (e.g., fear of thunder) from the distinct patterns of sound sensitivity and avoidance associated with hyperacusis and misophonia.

Summary of DST classification. The defining characteristics for each DST condition were synthesized from a comprehensive review of the available literature. However, it should be noted that definitions and terminology for these conditions continue to evolve. For example, a recent report released from the "first international conference on hyperacusis" during which prominent audiology and ENT researchers and clinicians met, suggested classification of three types of hyperacusis, including "loudness hyperacusis", "annoyance hyperacusis", and "fear hyperacusis" (Aazh, McFerran, Salvi, Prasher, Jastreboff, & Jastreboff, 2014). These sub-classifications for hyperacusis appear to map onto descriptions for hyperacusis, misophonia, and phonophobia, respectively. Within the same report and in a recent commentary on treatment of DST conditions, Jastreboff and Jastreboff proposed an alternative classification that better matches with the definitions provided above: that DST is an umbrella term, which can be subdivided into hyperacusis (negative reactions to sounds based on their physical characteristics, i.e., spectrum and intensity), misophonia (negative reactions to sounds with a specific pattern and meaning), and phonophobia (a subtype of misophonia in which fear is the dominant emotional response) (Aazh et al., 2014; Jastreboff & Jastreboff, 2014). Dozier (2015), who founded the Misophonia Treatment Institute, recently proposed renaming misophonia "Conditioned Aversive Reflex Disorder", based primarily on unpublished case reports describing the development of conditioned responses to specific auditory triggers. Meanwhile, among behavioral medicine researchers, misophonia seems to be the accepted term and a fairly consistent definition as sensitivity to select sounds has emerged (e.g., Schroder et al., 2013; Webber & Storch, 2015), but its association with other types of DST phenomenology and with tinnitus has largely been ignored. Thus, at present, it appears that the strongest empirical basis exists to support investigation of hyperacusis and misophonia as distinct clinical entities, with the understanding that there is likely to be overlap in their occurrence, clinical characteristics, mechanisms of action, assessment strategies, and treatment approaches.

Theoretical Perspectives

Research on the DST conditions has so far failed to identify and test specific theories to explain the etiology and maintenance of these issues. Success in conceptualizing tinnitus from a bio-psychosocial perspective, with an emphasis on psychological factors in predicting its severity and in developing effective treatment options, suggests that psychosocial theories are likely to be useful in understanding DST conditions as well. We anticipate that psychosocial models similar to those applied in tinnitus as well as those used to describe anxiety, depression, and somatization will be most relevant in conceptualizing DST conditions.

Normal auditory functioning. Some degree of sound sensitivity and avoidance are part of the normal functioning of the auditory system (Møller, Langguth, De Ridder, & Kleinjung, 2011). Explaining the presence of these phenomena in healthy individuals can help elucidate how these normal processes can go awry and result in clinically significant problems. In particular, the neural wiring and adaptive function of the auditory system can help to explain how auditory sensitivity and abnormal sound perception emerge. The auditory system is linked to the body's stress systems, including the limbic system, the hypothalamus, and the reticular system (Mazurek et al., 2010). These linkages are hypothesized to have important implications for the ways in which auditory stimuli are perceived and interpreted (Møller et al., 2011).

The association between auditory processing and stress has been supported by experimental research. Recent experimental studies have demonstrated that inducing negative affect through writing about a frightening life experience (Siegel & Stefanucci, 2011) or through pairing a neutral sound with an aversive vibration (Asutay & Vastfjall, 2012) can lead to increased loudness perception. These studies illustrate the ease with which neutral sounds can gain emotional salience through conditioning. In addition, certain sounds have affective value on their own, which was demonstrated in a study that measured response latency to environmental sounds (Bertels, Kolinsky, Coucke, & Morais, 2013). In this study, participants exposed to emotionally neutral (e.g., scissors), negative (e.g., growling dog), positive (e.g., laughter), and taboo (e.g., farting) sounds showed attentional bias to negative and taboo sounds but not positive or neutral sounds (Bertels et al., 2013). The authors conceptualized this attentional bias as an avoidance response, characterized by individuals shifting their attention away from aversive stimuli (Bertels et al., 2013). Loud sound can be inherently aversive; in fact the iconic report of fear conditioning employed a loud sound as the unconditional stimulus (Watson & Rayner, 2000). Finally, strong aversive reactions to specific sounds, as seen in misophonia and phonophobia, have been documented in the general population in response to certain sounds (e.g., fingernails on a chalkboard; Kumar, von Kriegstein, Friston, & Griffiths, 2012; Zald & Pardo, 2002). These findings highlight the automaticity of sound fear learning and the emotional salience of sounds within a normally functioning auditory system. As will be discussed in the next section, the importance of behavioral learning principles in predicting healthy responses to auditory stimuli implies that these same models may be involved in the pathological auditory sensitivity characteristic of DST conditions.

Cognitive and learning models. Cognitive and learning concepts are crucial in explaining how internal and external stimuli can become associated with negative affect and behavior, and maintain longstanding dysfunctional outcomes. Cognitive-behavioral therapy (CBT) draws upon classical and operant learning principles and cognitive theory (Beck & Clark, 1997) to explain and treat mental disorders (Persons, 2008). These models have been quite successful in conceptualizing the etiology and maintenance of tinnitus (Andersson, 2002; Andersson et al., 2005; Greimel & Kroner-Herwig, 2011a), chronic pain (De Peuter, Van Diest, Vansteenwegen, Van den Bergh, & Vlaeyen, 2011), somatoform disorder (Brown, 2004), migraine (Buse & Andrasik, 2009; Holroyd & Drew, 2006) and other somatic phenomena that are seemingly related to DSTs (Cuijpers, van Straten, & Andersson, 2008).

Researchers have also suggested that conditions of DST can be described from a cognitive-behavioral perspective (Baguley & McFerran, 2011; Greimel & Kroner-Herwig, 2011a; Webber & Storch, 2015; Schneider & Arch, 2015). However, research examining these psychological mechanisms in hyperacusis and misophonia is only just emerging. Furthermore, despite the established comorbidity of DST conditions with tinnitus, many of the studies investigating psychological mechanisms in tinnitus excluded individuals reporting DST (Blaesing & Kroener-Herwig, 2012; Kleinstauber et al., 2012). Thus, while the mechanisms hypothesized below are consistent with DST phenomena and have been verified as operative in disorders including tinnitus, anxiety disorders, and chronic pain, it should be emphasized that little or no research has yet been conducted to provide evidence for them in the etiology of DST conditions.

There are numerous mechanisms by which a person can become oversensitive to sound, either temporarily or for a longer period, though in most cases of hyperacusis no underlying medical condition or physiological mechanism can be found (Baguley, 2003). For example, particular cases of hyperacusis have been associated with serotonin receptor disturbance or auditory efferent dysfunction (Baguley, 2003; Marriage & Barnes, 1995). Several studies have established a link between emotional exhaustion, stress, and reduced tolerability for sound (Hasson, Theorell, Bergquist, & Canlon, 2013; Wallen, Hasson, Theorell, & Canlon, 2012). It may be that increased sensitivity to sound is relatively common in the way, for example, panic attacks have numerous etiologies and are relatively common in the general population (Barlow, 2002). While most people who experience panic attacks interpret them benignly, others interpret the attacks as evidence of a dangerous physical or psychological problem, and come to fear the attacks and develop panic disorder; agoraphobic avoidance of places and activities that become associated with the attacks may also develop (Barlow, 2002), which maintains the symptoms. A similar process may play out with hyperacusis. For many, sound loudness tolerance may be reduced for any number of reasons, including transient stress. Whereas a benign interpretation ("that was loud!") may be most common, some may interpret the stimulus as intolerable and perhaps as an indication of a physical problem. Anxious thoughts and feelings about sound, as well as sound avoidance, were more elevated among individuals with both hyperacusis and tinnitus compared to those with tinnitus alone (Blaesing & Kroener-Herwig, 2012). Indeed, although many mechanisms are hypothesized, the primary symptom is the patient's self-report of discomfort at sounds below the typical discomfort threshold. People who make such negative attributions about sounds may begin to avoid loud sounds—by wearing ear protection or avoiding situations in which high sound levels may occur—even though sound avoidance and wearing ear protection exacerbates hyperacusis (Vernon, 1987).

Misophonia has been characterized by an aversion to specific sounds. Unlike specific phobia, in which the aversive response is fear, in misophonia the response is more diverse. The response can include fear, but sometimes includes an obsessive impulse to respond aggressively to the sound source, and compulsive efforts to reduce distress surrounding the obsession (Hadjipavlou et al., 2008; Schroder et al., 2013), and thus it has been conceptualized as a potential OCSD. Drawing on a cognitive-behavioral explanation for OCD, the sound aversion observed in misophonia might be conceptualized to emerge through an initial association between a mildly annoying stimulus (e.g., a person chewing) and an aggressive impulse (e.g., wanting to throw something at the person), leading to attempts to suppress the ego dystonic impulse by avoiding the stimulus or attempting to neutralize it through compulsive behaviors (e.g., mimicking the sound), and resulting in a paradoxical increase in the frequency of the obsession and the distress surrounding it (Barlow, 2002; Schroder et al., 2013). This conceptualization appears to fit with the current clinical characteristics of misophonia, and recent empirical evidence confirms an association between misophonia and OC related phenomena (Taylor et al., 2014; Webber & Storch, 2015; Wu et al., 2014). However, theorists have also recently argued that misophonia should be considered distinct from OCD because the prominent emotional response is anger, whereas obsessions in OCD primarily cause distress, anxiety, and sometimes disgust (Schneider & Arch, 2015), and that these differences may have important treatment implications for misophonia.

Individual differences. Specific personality traits and comorbid psychological disorders have been identified as associated with DST, suggesting particular predispositions to developing these conditions. As might be expected from the proposed DST conceptualizations above, many of these predispositions overlap considerably with those found in individuals with anxiety disorders. Compared to a normative sample, individuals with hyperacusis endorsed higher trait neuroticism, particularly on subscales assessing susceptibility to stress and somatic trait anxiety (Jüris et al., 2013). Given that the DST conditions all involve exaggerated emotional responses to stimuli that are reported as benign by most people, it is further anticipated that these conditions will be associated with high anxiety sensitivity and low distress and discomfort tolerance. Deficits in emotion regulation and higher levels of hostility and anger are also theoretically consistent with the conceptualization of misophonia in particular. Other characteristics that may distinguish individuals at risk for developing DST conditions include synesthesia (Edelstein et al., 2014) and higher overall sensitivity to sensory stimuli (Wu et al., 2014). Furthermore, it is unclear whether individuals with sound intolerance problems are also more sensitive to pleasurable sounds, like music, or conversely, whether they are less able to appreciate pleasant auditory experiences. Therefore, a newly established construct—music reward—which taps individual differences in the enjoyment of music (Mas-Herrero, Marco-Pallares, Lorenzo-Seva, Zatorre, & Rodriguez-Fornells, 2013), may also be related to DST issues.

Quality of life and functional impairment. Tinnitus research has consistently shown that the psychological aspects (e.g., emotional distress, depression) are most predictive of the impact of tinnitus on quality of life and functional impairment (Andersson, 2002; Cima, Crombez, & Vlaeyen, 2011). Within the tinnitus literature, sleep impairment, concentration problems, and difficulties fulfilling major social roles are commonly reported, particularly among those experiencing high levels of tinnitus-related distress or comorbid depression (Budd & Pugh, 1995; 1996). Studies to date have failed to examine the impact of DST symptoms on individuals' functioning. Based on their overlap with tinnitus and their conceptualization as similar to anxiety and somatoform disorders, substantial emotional distress and impairment in functional status are expected to be associated with DST symptoms.

In sum, preliminary research and parallels to tinnitus suggest that DST issues can be conceptualized using existing bio-psychosocial theories of psychopathology. Mechanisms of fear conditioning, cognitive distortion, and behavioral avoidance may be common pathways through which external auditory stimuli generate and perpetuate clinically debilitating conditions. The importance of psychological factors in determining the clinical significance of these conditions implies that psychological factors should be a key target of assessment and treatment.

Assessment of DST Conditions

In order to make progress in identification, conceptualization, and developing treatments for DST conditions, reliable and valid assessment methods and instruments are needed. However, assessment procedures for conditions of DST have received little attention within the medical and psychological research literatures, and so few tools are available for either researchers or clinicians.

Clinically, individuals with DST conditions are most likely to first show up in the office of an otologist, otolaryngologist, or audiologist (Wackym & Friedland, 2004). Conditions of DST are rarely evaluated during routine otologic examinations; however, once a primary diagnosis of tinnitus has been made, patients are often referred to audiologists for further evaluation where it is more likely that they will be assessed for hyperacusis (Henry, 2004). Mention of misophonia assessment as part of routine audiology exams is less common, perhaps due to its recent emergence in the literature. Because of the involvement of the auditory system and the observation that patients suffering from these conditions often present to audiology clinics, audiological exams are recommended for individuals presenting with conditions of DST in order to capture the auditory characteristics of the presenting problem and rule out hearing damage or other auditory system disorders (Henry, 2004). Assessment of uncomfortable loudness levels (ULL), or the threshold at which sound tested at various frequency levels becomes uncomfortable, is considered a crucial step in identifying hyperacusis (Baguley, 2003; Henry, 2004). Although the use of the ULL suggests a degree of objectivity, it is important to note that the results of the ULL rely upon a patient's subjective report. Research indicates that stress and emotional distress can interact to alter perception of ULLs (Hasson et al., 2013; Wallen et al., 2012), and discomfort thresholds can also be influenced by test instructions (Bornstein & Musiek, 1993). Thus it seems likely that a questionnaire could be developed that would be as reliable and valid as audiometric testing at identifying hyperacusis. As a general point, there are no definitive audiological or medical assessment tools available for any DST condition, and any audiometric or medical data used to identify and describe DST conditions must be considered within the context of psychosocial factors.

In contrast to the large literature on psychosocial assessment of tinnitus (Greimel & Kroner-Herwig, 2011b), few resources are available for assessment of DST conditions. Three questionnaires to evaluate psychosocial aspects of hyperacusis have been developed (Baguley, 2003).

The Hyperacusis Questionnaire (HQ) is a 14-item, self-report scale designed to quantify the behavioral/adaptive consequences and cognitive and emotional aspects of hyperacusis (Khalfa, Dubal, Veuillet, Perez-Diaz, Jouvent, & Collet, 2002). An initial psychometric study showed that the total score was normally distributed in a general population sample. A principal components analysis identified three factors, labeled attentional, social, and emotional by the authors, that together accounted for 48.4% of the total variance (Khalfa et al., 2002). One recent Swedish study assessed the relationship between scores on the HQ, Hospital Anxiety and Depression Scale (HADS), and loudness discomfort levels (LDLs) in a sample of 62 individuals diagnosed with hyperacusis based on a clinical interview (Jüris, Ekselius, Andersson, & Larsen, 2013b). Lower LDL levels were associated with higher scores on the HQ and on the anxiety subscale of the HADS, but scores on the

HQ and HADS were not related. The authors recommended using both the HQ and the HADS to aid in diagnosing hyperacusis (Jüris et al., 2013b).

A second self-report instrument, developed for assessing negative emotional response to loud sounds, is the 15-item Questionnaire on Hypersensitivity to Sound (abbreviated as the GUF from its original German-language version). The GUF was evaluated in a clinical sample of individuals reporting both chronic tinnitus and hypersensitivity to sound (Nelting, Rienhoff, Hesse, & Lamparter, 2002). As with the Hyperacusis Questionnaire, the authors identified three factors, which they termed cognitive reactions, behavioral responses, and emotional reactions to external noises, that explained a majority of the variance in questionnaire scores (Nelting et al., 2002). The GUF also has good internal reliability and demonstrated convergent validity based on correlation with other self-report and audiometric measures of hyperacusis (Blaesing et al., 2010). The three factors emerging from these questionnaires map closely on to the cognitive, behavioral, and physiological systems that have long been used to organize research on emotion (Lang, 1977), suggesting similarities between oversensitivity to sound and an emotional response.

More recently and based on the conceptualization of sound avoidance as an exacerbating factor in hyperacusis, the Noise Avoidance Questionnaire (NAQ) was developed and demonstrated to be a reliable and valid tool (Blaesing & Kroener-Herwig, 2012). The NAQ was normally distributed, with a Cronbach's alpha of 0.90. It assisted in distinguishing individuals with hyperacusis and tinnitus both from controls and from those with tinnitus alone, and was also associated with higher levels of hyperacusis-related distress, as measured by the GUF (Blaesing & Kroener-Herwig, 2012). In sum, several useful questionnaires are available to evaluate distress and cognitive-behavioral components of hyperacusis; however, many questions about the reliability and validity of these measures remain unaddressed. It should be noted that although English-language translations are available for all three instruments, no published data on English versions were found.

Two self-report tools have been developed to measure the occurrence and severity of misophonia (Schroder et al., 2013; Wu et al., 2014). In conjunction with the proposed diagnostic criteria described in the clinical characteristics section above, the Amsterdam Misophonia Scale (A-MISO-S) was adapted from the Yale-Brown Obsessive Compulsive Scale (Y-BOCS), based on prior success in adapting the scale to assess other OCD-related impulse control disorders including pathological gambling and body dysmorphic disorder (Schroder et al., 2013). The A-MISO-S is a 6-item clinician-administered scale that asks individuals to indicate their amount of time preoccupied daily with the misophonic stimulus, their degree of social impairment, the intensity of their anger, their effort to cognitively resist or avoid the misophonic sounds, the amount of control experienced over their thoughts about the stimulus, and the amount of time they spend avoiding misophonic situations (Schroder et al., 2013). Severity ranges are proposed to classify misophonia symptoms as subclinical, mild, moderate, severe, and extreme (Schroder et al., 2013), though no basis for this proposal is presented. The psychometric properties of the A-MISO-S have not been adequately evaluated; however, the researchers who proposed the scale have suggested that the scale conformed to their proposed diagnostic criteria for misophonia, captured a unique clinical phenomenon, and provided a useful metric for categorizing the range of severity of individuals in their sample (Schroder et al., 2013). As with the three hyperacusis scales, although an English translation is available for the A-MISO-S, no data are available on it to date. A newer instrument is the Misophonia Questionnaire (MQ), a three-part self-report questionnaire that assesses for the presence of misophonia (Misophonia Symptom Scale), associated emotions and behaviors (Misophonia Emotions and Behaviors Scale), and overall severity of sound intolerance (Misophonia Severity

Scale) (Wu et al., 2014). In its initial validation within a large college student sample, adequate internal consistency, and convergent and discriminant validity were demonstrated (Wu et al., 2014), indicating that the MQ is likely to be a useful tool for assessing misophonia within the general population.

Although promising assessment tools are emerging to measure DST conditions and their associated sequelae, there is a lack of empirical evidence to support use of these scales. Specifically, little is known about the relationships among the different putative DST diagnostic categories and whether they can be validly differentiated from one another and from other related psychiatric diagnoses. Therefore, a goal of this study is to evaluate the relationships among these scales and other valid measures of related psychiatric diagnoses and psychological mechanisms. In addition, development of a self-report scale based on the proposed differences between misophonia, hyperacusis, and normal sound sensitivity is warranted. These steps will add to our understanding of existing assessment tools and will address an important gap in the assessment of DST conditions.

Conceptualizing Treatment of DST Conditions

A small literature exists to support the application of biopsychosocial principles in the treatment of hyperacusis, while only a few case studies to date have explored treatment of misophonia. To briefly summarize the hyperacusis treatment literature, in one study (Peiro et al., 2009) simple noise exposure successfully treated hyperacusis, in another study (Hiller & Haerkotter, 2005) adding noise exposure to psychological treatment for tinnitus was beneficial only for comorbid hyperacusis sufferers, and in a third study (Jüris et al., 2014) CBT including systematic exposure successfully treated hyperacusis. There otherwise appears to be no other evidence-based treatments available for hyperacusis (Jüris et al., 2014). Based on efficiency, simplicity, treatment effect size, and cost-effectiveness, the simple exposure-only approach (Peiro et al., 2009) appears to be preferable. Although in this study 100% of the patients were successfully treated, it is cautioned that the exposure-only approach has not yet been compared to any type of control group. Additionally, the literature suggests that hyperacusis is a chronic condition, and thus longer follow-up data is recommended. It should also be noted that these three studies were all conducted in Europe, and therefore generalization to US populations cannot be determined as of yet. Still, successful treatment of hyperacusis symptoms using simple exposure and more comprehensive CBT provide additional support for conceptualization of hyperacusis using learning and cognitive theory.

The misophonia treatment literature is even less well developed than that of hyperacusis. Indeed, it is noteworthy that, in seven published case reports describing 15 patients with misophonia, none of them reported on treatment, and most of the articles declared a need for treatment research. In the past two years, two case reports have been published documenting, for the first time, successful treatment of misophonia using short-term cognitive-behavioral therapy (Bernstein, Angell, & Dehle, 2013; McGuire, Wu, & Storch, 2015). In the first case example, the authors described use of cognitive restructuring, behavioral exposures and problem-solving techniques, and exercise over the course of six sessions to address a 19-year-old's debilitating aversion to the sounds of other people's eating (Bernstein et al., 2013). Positive change in GAF scores and subjective reports of distress in response to triggers were noted, and the authors concluded that CBT represents a promising approach for misophonia treatment, with the caveat that further studies are needed to replicate these results and clarify the active ingredients contributing to therapeutic change (Bernstein et al., 2013). Building on this work, McGuire and colleagues (2015) reported successful application of CBT to address misophonia in two adolescents and documented symptom change using direct measures of misophonia symptom improvement, including the previously-validated Misophonia Questionnaire and Severity Scale (Wu et al., 2014), and a newly-developed Parent-Report

Misophonia Questionnaire and Severity Scale (McGuire et al., 2015). These initial reports of CBT's effectiveness in treating misophonia are promising, although there is a need for further research to replicate these findings in a larger, randomized, clinical trial. Finally, as several researchers have suggested, it is important to continue to consider the unique aspects of misophonia, including its potential association with tinnitus (McGuire et al., 2015) as well as the prominent role of anger (Schneider & Arch, 2015) to ensure that treatment approaches are comprehensive in addressing this bio-psychosocial condition. In this vein, additional research into the clinical correlates, mechanisms of action, and assessment strategies for both misophonia and hyperacusis should be prioritized.

Aims and Hypotheses

The field of DST research is wide open, and most questions about these conditions remain unanswered. Thus, in developing a research strategy, it is important to delineate priorities for initial investigations on this topic. Based on review of the existing literature, several important gaps were identified.

Prevalence and associated characteristics of DST. The best epidemiological study of hyperacusis thus far suggests a prevalence of 8-9% in a Swedish community sample reporting hyperacusis symptoms, with 3% reporting clinically significant symptoms, based on a postal and online survey (Andersson et al., 2002). An estimated 20% incidence rate of misophonia in a U.S. college student sample (Wu et al., 2014) suggests that DST may be common among young adults. Further investigation of DST conditions and their relationships with other types of psychopathology and sensory sensitivities will greatly add to the existing literature. More broadly, information about associated characteristics of DST conditions—age of onset, gender/race distribution, psychiatric and physical health comorbidities, functional impairment, personality traits, etc.—will help to better understand these conditions and direct future investigation.

In sum, little is known about the prevalence of DST conditions in the general population, as most studies have examined them within clinical populations. The few prevalence studies that have explored these conditions within the general population have used imprecise definitions, leading to ambiguity about their actual occurrence and the degree of comorbidity across DST conditions. Thus, this study aimed to establish prevalence and comorbidity rates for hyperacusis, misophonia, and tinnitus in large, general college student and community samples, using clear definitions drawn from the research literature. Specific research questions and hypotheses included:

1. What are the prevalence rates of misophonia and hyperacusis in the general adult population? Recent studies suggest a prevalence rate of 20% in a college student sample for misophonia (Wu et al., 2014), but no studies to date have examined prevalence of hyperacusis in the general population of the United States. Hyperacusis rates of 8-9% were found in a Swedish sample of community adults (Andersson et al., 2002), therefore similar rates might be expected within undergraduate and community samples in the United States. We hypothesized that approximately 20% of an undergraduate sample and approximately 20% of an adult community sample will endorse some level of misophonia symptoms, based on evidence that college students experience mental health problems at roughly the same rate as their non-college attending same age peers (Blanco et al., 2008). We also predicted that approximately 9% of our undergraduate and community samples would endorse some degree of hyperacusis symptoms.

2. To what extent do misophonia and hyperacusis occur comorbidly with one another and with tinnitus? Studies in audiology and otolaryngology clinics have reported high rates of comorbidity between misophonia and tinnitus (28.9%) and between hyperacusis and tinnitus (32.9%) (Jastreboff, 2004), but overlap across these conditions has not been explored in the general population. Based on known comorbidity rates between tinnitus and DST conditions, it was

anticipated that approximately 25% of individuals reporting misophonia and/or hyperacusis would also report tinnitus symptoms.

3. Are DST conditions more represented within certain demographic categories (i.e., gender, racial/ethnic, or age differences)? There is some indication that misophonia occurs more frequently among women (Edelstein et al., 2013; Hadjipavlou et al., 2008; Neal & Cavanna, 2013; Schroder et al., 2013; Schwartz et al., 2011), but the demographic features of hyperacusis are unknown. It was hypothesized that misophonia would affect women at a higher rate than men. No specific hypotheses were made regarding the demographic features of hyperacusis.

Clinical correlates. A second important gap in the DST literature is the lack of knowledge about the phenomenology and clinical correlates of misophonia and hyperacusis. A limited number of studies investigating misophonia have demonstrated a link with OCD and other obsessive-compulsive spectrum disorders (Schroder et al., 2013; Edelstein et al., 2013; Wu et al., 2014; Taylor et al., 2014). Hyperacusis and tinnitus and have been tied to anxiety (Hesser & Andersson, 2009) and somatoform disorders (Hiller, Janca, & Burke, 1997).

4. What known psychiatric conditions are most closely related to misophonia and hyperacusis? Are these relationships strong enough to suggest they are the same construct or more moderate to suggest similar, but distinct phenomena? Prior research has shown moderate correlations between misophonia and OC related conditions (Wu et al., 2014; Schroder et al., 2013) or OCD caseness (Taylor et al., 2014). Therefore, it was anticipated that individuals in our samples who report misophonia symptoms would endorse OCD symptoms at a higher rate than those who do not report any misophonia symptoms. Hyperacusis has been shown to occur in conjunction with anxiety disorders, at a rate of 47% in one study (Jüris et al., 2013). We anticipated that individuals endorsing hyperacusis symptoms in our sample would also report anxiety symptoms more often than

those who did not report any hyperacusis symptoms. Furthermore, research has established a relationship between depression and tinnitus severity (Hebert, Canlon, Hasson, Hanson, Westerlund, &Theorell, 2012), suggesting that depression also may be elevated among individuals with misophonia and/or hyperacusis. We predicted a positive correlation between depression symptoms and the severity of misophonia and hyperacusis symptoms. Finally, a relationship between autism spectrum disorders and DST conditions has also been proposed (Stiegler & Davis, 2010). Therefore, we screened for autism spectrum traits and evaluated their relationship with misophonia and hyperacusis, with the expectation that these characteristics would occur more frequently in those reporting DST symptoms than those who did not report any DST symptoms.

5. A link between mild TBI, generalized sensory sensitivity, and tinnitus has been established (Landon, Shepher, Stuart, Theadom, & Freundlich, 2012). Thus, we also explored the relationship between the neurobehavioral symptoms of mild TBI and the DST conditions of interest. We hypothesized a positive correlation between hyperacusis and tinnitus and the neurobehavioral symptoms seen in post-concussive syndrome. No significant relationship between misophonia and neurobehavioral symptoms was anticipated.

6. Finally, several studies have shown an association between somatic symptoms and medical conditions and tinnitus and hyperacusis (Baguley, 2003; Ganz-Sanchez & Bezerra-Rocha, 2011), but these studies have been limited to medical patients seeking treatment in ENT or audiology clinics. The relationship between somatization and medical illness with DST conditions is unknown in the general population. We hypothesized that there would be a positive correlation between report of tinnitus and hyperacusis symptoms and report of somatic symptoms as well as specific medical conditions, particularly report of hearing loss and head injury.

Mechanisms of etiology and maintenance. It has been suggested that theories of psychopathology, especially those used to understand and treat anxiety and somatoform disorders, such as cognitive-learning models and individual difference factors, can be applied to conceptualize DST conditions. In order to examine individual differences and mechanisms of action in misophonia and hyperacusis, we included measures of anxiety sensitivity, distress and discomfort tolerance, and personality. Research on characteristics associated with DST conditions will assist in describing the mechanisms of etiology and maintenance. For example, do people reporting DST also report more general anxiety, greater anxiety sensitivity, or reduced distress and discomfort tolerance? Do individuals with these conditions report greater sensitivity to interoceptive and/or exteroceptive stimuli in general? Are these individuals more sensitive to sensory stimuli in general? Do misophonics report higher levels of generalized anger or hostility? What are the personality characteristics of individuals with misophonia and hyperacusis? What other types of characteristics may be linked to misophonia and hyperacusis?

7. Based on similarities to other types of psychopathology, hypothesized individual difference or mechanisms for hyperacusis and misophonia included maladaptive personality traits (higher levels of neuroticism), increased anxiety sensitivity, higher general sensory intolerance, increased generalized anger and hostility, greater difficulties with emotion regulation, and greater intolerance for distress and discomfort. Positive correlations between neuroticism, anxiety sensitivity, sensory sensitivity, difficulties with emotion regulation, and distress and discomfort intolerance and misophonia and hyperacusis symptoms were anticipated.

8. Outside the realm of psychopathology, other factors have been proposed to be relevant in the conceptualization of DST conditions. For instance, recent research has shown that individuals differ in the extent to which they experience emotional and physiological rewards from listening to

music (Mas-Herrero, Marco-Pallares, Lorenzo-Seva, Zatorre, & Rodriguez-Fornells, 2013). This construct presents an important question in the study of sound sensitivity: Do individuals with DST also experience reduced rewards from pleasurable sounds? Or, are these individuals particularly sensitive to sounds in general and therefore experience heightened reward from certain, pleasurable sounds? We hypothesized that individuals with hyperacusis would show reduced music reward based on the generalized nature of their sound intolerance, but individuals with misophonia would show average levels of music reward, based on the selective nature of their sound sensitivity.

9. Researchers have also posited that misophonia symptoms may be partially explained by synesthesia (Edelstein et al., 2013), a neurological phenomenon in which stimulation of one sensory or cognitive pathway triggers involuntary experiences in a second, often unrelated sensory or cognitive pathway. One commonly-reported example is when individuals experience certain numbers or letters as inherently colored. No research to date has actually explored whether misophonia symptoms and synesthesia experiences are related; therefore, we included a measure of general absorption in sensory experiences, which includes a synesthesia subscale. We hypothesized that sensory absorption and especially synesthesia experiences would be positively correlated with symptoms of misophonia.

Developing and validating assessment tools. Three self-report questionnaires are available that assess the cognitive, behavioral, and emotional consequences of hyperacusis; additionally, hyperacusis is identified through self-reported discomfort to sounds in audiological exams. However, there are no data regarding estimated reliability or construct or criterion-related validity on the English translation of any of these questionnaires. The assessment literature on misophonia is even less well-developed. One of only two available self-report instruments, the A-MISO-S, asks respondents in interview format to list sounds that elicit an emotional response, and then follows with six questions that assess functional impairment. No reliability or validity information on the instrument has been presented, either in English or the original Dutch. The recently developed MQ shows more promise in that it evaluates the many symptoms of importance for understanding or treating the disorder in individuals, such as type of noise(s) found aversive, behavioral and emotional specifics of the response, and the degree of severity.

Given the recent emergence of these conditions within the field of psychology and the apparent lack of diagnostic clarity, a DST assessment instrument should be developed to aid in identifying individuals with misophonia, hyperacusis, and normal sound sensitivity based on the types of sounds that cause distress or discomfort. Based on the need for more comprehensive assessment of DST conditions, a fourth goal of this study was to address the lack of valid assessment tools available for diagnosing hyperacusis and misophonia and differentiating pathological sound sensitivity from normal sound sensitivity. In particular, we aimed to develop a scale to assist clinicians and researchers in identifying individuals with primary hyperacusis, primary misophonia, or normal sound sensitivity. Although several scales have been developed to assess for the presence and severity of hyperacusis and for misophonia symptoms, none of these scales assists in distinguishing between these diagnostic categories. Our scale development focused on identifying the types of sounds that validly distinguish between these DST conditions. This approach was based on a review of the literature, which suggested that DST conditions share many common symptoms, clinical correlates, and mechanisms, but could best be differentiated based on the types of sounds that cause discomfort and distress.

10. In developing the DST Scale, a three-factor solution was predicted with distress reported to items related to misophonia (e.g., eating sounds, foot tapping, consonant/vowel sounds), hyperacusis (e.g., whispering, traffic noise, radio playing at moderate volume), and normal sound

sensitivity (e.g., nails on a chalkboard, gunshot, passing gas), respectively, clustering into three distinct factors.

Method

Participants

Participants were drawn from two different populations. The first sample was recruited through the Virginia Commonwealth University undergraduate participant pool using an online system that allows students to participate in research for extra credit in psychology courses. The other sample was drawn from community-dwelling English speaking adults located in the United States participating in research for compensation through Amazon's Mechanical Turk (MTurk) program. MTurk is an online marketplace where "requestors" (increasingly, behavioral researchers) post human intelligence tasks or jobs (including experimental and cross-sectional survey research) and "workers" (in this case, research participants) choose jobs to complete for pay. Mason and Suri (2012) have elaborated the advantages and procedures for conducting behavioral research using MTurk. Their experience and review of studies employing MTurk indicates that MTurk workers come from a more diverse background than the typical undergraduate participant pool sample. Furthermore, replications of laboratory research studies suggest that MTurk workers behave in a manner consistent with laboratory subjects, lending support for the validity of this research platform. Recent research has also demonstrated that MTurk offers a viable option for collecting data on clinical populations (Shapiro, Chandler, & Mueller, 2013). In sum, MTurk is an emerging and useful research tool that was employed in this study to expand the potential sample size, sample diversity, and external validity of this survey study.

We aimed to collect data from approximately 400 students and 400 community adults. Participants were required to be 18 years of age and older and capable of providing informed consent. There were no other exclusion criteria for participation in this study. Select measures were administered only to a subset of participants in order to shorten the survey to ease time burden for participants (see “Changes in measures administered during data collection” sub-heading at the end of Method section for more details). For a large scale assessment of prevalence of several conditions with a potentially low base rate in the population, a large sample size was needed. Based on review of the literature (e.g., Wu et al., 2014; Taylor et al., 2014), a sample size of approximately 300-500 for each sample was deemed sufficient to adequately sample the diagnoses of interest and perform factor analysis on the 41-item DST Scale (see *Measures* section). Demographic data on gender, age, race and ethnicity, household income, and hometown setting was also collected. The selection of two different, non-clinical samples was appropriate, given the study’s aims to clarify prevalence rates, evaluate clinical correlates and mechanisms, and validate a DST scale for use in the general population. Final sample sizes and sample characteristics are presented below in the Results subsection “Preliminary Data Screening and Participant Characteristics”.

Design

This was a cross-sectional survey study in which participants provided responses to a variety of questions through a secure online survey.

Procedure

The survey was administered through the undergraduate participant pool and Amazon’s MTurk with a link to take the survey at an external, secure electronic data storage system, Research Electronic Data Capture (REDCap). The survey was made available until approximately 400 students and 400 community adults completed it. The student sample was collected continuously between July and December 2014. The community sample was collected using Amazon’s MTurk within approximately ten hours on a single day in April 2015. Community sample participants spent an average of 46 minutes completing the survey and received $1 upon completion. Completion time data were not available for the student sample collected through the undergraduate participant pool.

At the beginning of the survey, all participants answered a series of screening questions about tinnitus, sound intolerance, and hearing problems. Based on responses to some of these questions, participants were directed to answer additional questions about their experiences with these problems. All participants answered questionnaires in the same order, beginning with demographic and screening items and continuing on to assessment of DST conditions, assessment of relevant psychiatric diagnoses, and assessment of mechanisms of action and functional status. The order of these questionnaires was established to group related constructs together to allow for ease of comprehension by participants.

Measures. Participants were asked to complete a number of different measures that are either valid and reliable self-report questionnaires or experimental questions created by the research team when no standard measures were available. Measures were selected to evaluate and screen for tinnitus, DST symptoms, mental health symptoms, physical health problems, quality of life, and individual differences and mechanisms of action. A demographics questionnaire and a set of control items buried within the survey to detect random responding were also included. A complete set of assessment tools is included in Appendix A, and all measures are described briefly below.

DST and related measures. The DST and tinnitus screening items were developed based on existing tinnitus and DST screening questions used by audiologists in research and clinical practice (Møller et al., 2011). Slight modifications were made only when necessary in order to be consistent with the current literature or to allow for greater variation in responding. These screening items were presented first. Only participants who responded affirmatively to questions about tinnitus, DST in general, or misophonia specifically were asked to complete the A-MISO-S and the Mini Tinnitus

Questionnaire. These questionnaires presuppose some level of misophonia or tinnitus symptoms, respectively; therefore, only participants endorsing these symptoms were asked to complete these measures.

The Decreased Sound Tolerance Scale (DST Scale) asks individuals to rate their level of discomfort (1=*no discomfort*, 4=*extreme discomfort*) in response to a range of environmental and human-produced sounds. The DST Scale was created for this study by a panel of researchers with expertise in the DST conditions. The sounds included on the scale range from those considered to be distressing for those with misophonia (i.e., human-produced sounds at close range such as chewing, breathing, or clicking), hyperacusis (i.e., common sounds above a certain low volume such as a television playing in the background, a truck driving by, or an audience applauding), and for those in the general population (i.e., uncomfortably loud, disgusting, or otherwise distressing sounds such as nails on a chalkboard, ambulance sirens, a gunshot, or fart sounds). For all sounds rated a 2 or higher on discomfort, a drop-down menu appeared asking participants to select and rate the intensity of the most prominent emotion(s) experienced in response to the sound on a 1 (*low intensity*) to 10 (*highest intensity possible*) scale. Emotion response options included anger/rage, fear, anxiety, sadness, disgust, and other (*please specify*). The emotion response and intensity rating parts of the scale were not included in the reliability and validity analyses of the scale.

The Amsterdam Misophonia Scale (A-MISO-S; Schröder, Vulink, & Denys, 2013) is a six-item clinician-administered screening tool developed to assess the severity of misophonia symptoms among individuals with misophonia. Based on its initial purpose and mode of administration, only individuals who responded affirmatively to misophonia or DST screening items were asked to complete this scale. According to the authors who developed the scale, scores from 0 to 4 are considered subclinical misophonic symptoms, 5 to 9 are mild, 10 to 14 are moderate, 15 to 19 are severe, and 20 to 24 are extreme (Schröder et al., 2013).

The Misophonia Questionnaire (MQ) is a three-part, 20-item, self-report questionnaire that assesses for the presence of misophonia (Misophonia Symptom Scale), associated emotions and behaviors (Misophonia Emotions and Behaviors Scale), and overall severity of sound intolerance (Misophonia Severity Scale) (Wu et al., 2014). Convergent and discriminant validity were demonstrated in a large college student sample (Wu et al., 2014). For the Misophonia Severity Scale (range=0-15), individuals that reported a 7 or higher on the MQ Misophonia Severity Scale were considered to have clinically significant misophonia symptoms (Wu et al., 2014). The average score reported from a college student sample on the MQ Total Score, which includes both the Misophonia Symptom Scale and the Misophonia Emotions and Behaviors Scale, was 31.21 (*SD*=7.64) for those above the clinical cutoff and was 17.81 (*SD*=9.17) for those falling below the clinical cutoff (Wu et al., 2014).

The Hyperacusis Questionnaire (HQ) is a 14-item self-report scale (range=14-56) designed to quantify the behavioral/adaptive consequences and cognitive and emotional aspects of hyperacusis (Khalfa, Dubal, Veuillet, Perez-Diaz, Jouvent, & Collet, 2002). It has good psychometric properties, and provides information about hyperacusis symptoms within attentional, social, and emotional domains (Khalfa et al., 2002). A mean score of 15 has been reported in the general population, with a score greater than 28 indicating likely clinical level hyperacusis symptoms (Khalfa et al., 2002).

The Mini Tinnitus Questionnaire (Mini TQ; Hiller & Goebel, 2004) is a 12-item self-report questionnaire adapted from the longer, 52-item Tinnitus Questionnaire (Hiller & Goebel, 1992) to rapidly assess tinnitus-related psychological distress. The Mini TQ was found to be an adequate substitute for the longer scale, with a strong correlation to the original TQ, good test-retest reliability, and associations with other measures of psychological distress. The authors recommended interpretation guidelines to consider patients scoring 1 to 7 as having no clinically relevant distress due to the tinnitus, those scoring 8 to 12 as moderately distressed, those scoring 13 to 18 as severely distressed, and those scoring 19 to 24 as most severely distressed (Hiller & Goebel, 2004).

The Hearing Handicap Inventory-Adult Version (HHIA; Newman, Weinstein, Jacobson, & Hug, 1991) is a 25-item self-report questionnaire on a 0 to 4 Likert-style scale evaluating an individual's degree of hearing-related functional impairment in overall (total score ranging from 0-100), social (HHIA-S; range 0-48), and emotional (HHIA-E; range 0-52) domains. It was validated in a sample of hearing-impaired adults (Newman et al., 1991), but has been widely used in hearing research to assess the social and emotional impact of hearing problems.

Clinical correlate measures. The Neurobehavioral Symptom Inventory (NSI; Cicerone & Kalmark, 1995) is a 22-item self-report questionnaire assessing the perceived frequency and degree of interference of various neurological and behavioral symptoms, such as "Feeling dizzy" and "Slowed thinking, difficulty getting organized, can't finish things" in the past month. It was originally validated within a sample of patients diagnosed with TBI (Cicerone & Kalmark, 1995) and is also used by the Department of Veteran's Affairs to assess post-concussive symptoms following mild TBI in combat veterans (King et al., 2012). To our knowledge, it has not been used within the general population but its brevity and the face validity of its items suggest that it may be well suited for this use.

The Obsessive Compulsive Inventory-Revised (OCI-R; Foa et al., 2002) is an 18-item short version of the OCI (Foa, Kozak, Salkovskis, Coles, & Amir, 1998) used to assess symptoms of OCD within clinical and non-clinical samples. Individuals rated the degree of distress and impairment caused by various obsessive-compulsive symptoms in the past month on a 5-point Likert scale. The mean score for individuals with OCD is 28.0 (*SD*=13.53), and 21 is the recommended cutoff score suggesting likely presence of OCD (Foa et al., 2002).

The Fear Survey Schedule (FSS-III; Wolpe & Lang, 1964; Arrindell, Emmelkamp, & Van der Ende, 1984) is a 52-item self-report scale assessing for different types of specific phobias, ranging from “Open wounds” to “Looking foolish”. Respondents are asked to rate “how disturbed you feel” by each feared thing or experience from “Not at all” to “Very much”. Although it was developed for assessment of specific phobia among anxiety patients, the FSS has been used to assess the frequency of different types of phobias within several large college student samples (e.g., Bernstein & Allen, 1969; Landy & Gaupp, 1971). Only the Social Phobia subscale (FSS-S) portion was administered to the entire student and community samples.

The Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983) is a 14-item self-report scale that assesses common symptoms of anxiety and depression. It was developed to avoid conflation of the somatic symptoms of anxiety and depressive disorders with those of physical illness. As such, it is commonly used in medical settings to screen for anxiety and depression. Interpretative ranges are available for overall and separate anxiety (HADS-A) and depression (HADS-D) levels.

The Autism Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) is a 50-item self-report instrument used to measure the extent of autistic traits in adults. In its initial validation study, eighty percent of individuals meeting criteria for an ASD scored 32 or higher, while normal controls had a mean score of 16.4. The authors emphasized that the scale should not be used on its own to make a diagnosis and that many individuals scoring above 32 reported no major functional impairment (Baron-Cohen et al., 2001). It has been used within community samples to capture the prevalence of autistic traits among working adults, and adequate reliability and validity have been demonstrated (Baron-Cohen et al., 2001).

The Medical Questionnaire consists of two parts, a 12-item medical diagnosis section and a 22-item health problem section. The medical diagnosis section asks participants to check off whether they have been diagnosed with specific medical conditions such as “Head Injury” and “Allergies”. The health problem section provides a checklist to assess how many common somatic complaints such as “Headaches” and “Nausea” participants have experienced. Medical checklists of this nature have been used extensively in behavioral research to efficiently capture health information (e.g., in expressive writing studies; Fratarolli, 2006). The Medical Questionnaire used in this study was developed for use in psychological research within Veteran’s Administration hospitals.

Mechanisms and individual difference measures. The Multidimensional Anger Inventory (MAI; Siegel, 1986) is a 30-item self-report questionnaire that captures trait level anger along a variety of dimensions. It was validated within a sample of adult factory workers and found to have adequate reliability and validity.

The Anxiety Sensitivity Inventory-3 (ASI-3; Taylor et al., 2007) is a widely used, 18-item self-report instrument that asks individuals to rate their degree of anxiety in response to various social, cognitive, and physiological situations, such as “It scares me when my heart beats rapidly” and “When I feel "spacey" or spaced out I worry that I may be mentally ill”. The degree of anxiety sensitivity is captured with a total score and three domain scores: Cognitive concerns, Social concerns, and Physical concerns.

The Distress Tolerance Scale (DTS; Simons & Gaher, 2005) is a 15-item self-report tool that assesses beliefs about feeling emotionally distressed or upset. Individuals rate the veracity of a series of statements such as “Feeling distressed or upset is unbearable to me” and “I’ll do anything to avoid feeling distressed or upset". Good psychometric properties were demonstrated for the DTS, including an association with maladaptive coping behaviors in its initial validation (Simons & Gaher, 2005).

The Discomfort Intolerance Scale (DIS; Schmidt, Richey, & Fitzpatrick, 2006) is a 7-item self-report scale that captures an individual's tolerance for discomfort and pain and tendency to avoid physical discomfort. In its initial validation, it was shown to be related to the pathogenesis of panic disorder. The factor structures and inter-associations among the ASI-3, DTS, and DIS have been examined to develop a model of affect tolerance and sensitivity within the general population (Bernstein, Zvolensky, Vujanovic, & Moos, 2009).

The Ten Item Personality Inventory (TIPI; Gosling, Rentfrow, & Swann 2003) is a brief, face valid, self-report questionnaire that assesses personality functioning according to the Five Factor model. Two items correspond to each of the five personality factors which include, Openness to Experience (TIPI-O), Conscientiousness (TIPI-C), Extraversion (TIPI-E), Agreeableness (TIPI-A), and Emotional Stability/Neuroticism (TIPI-N). The Emotional Stability subscale is scored with higher scores indicating lower levels of neuroticism and higher levels of emotional stability for ease of interpretation alongside the other subscales. Good psychometric properties have been demonstrated, and the TIPI is considered an appropriate substitute for longer personality assessments within the general population (Ehrhart, Holcombe-Ehrhart, Roesch, Chung-Herrera, Nadler, & Bradshaw, 2009).

The Absorption Scale (AS; Tellegen & Atkinson, 1974) is a 29-item true or false style scale that was developed to assess openness to self-altering experiences, considered an aspect of hypnotic susceptibility. It includes factors that assess synesthesia and enhanced awareness, which may be relevant to DST conditions. Only the synesthesia subscale (AS-S) was administered to both of the full samples.

The Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004) is a 36-item self-report questionnaire designed to assess multiple dimensions of emotional dysregulation. The measure yields a total score and six sub-scale scores, which include non-acceptance of emotional responses (DERS-ACCEPT), difficulties engaging in goal directed behavior DERS-GOAL), impulse control difficulties (DERS-IMPULSE), lack of emotional awareness (DERS-AWARE), limited access to emotion regulation strategies (DERS-STRATEGIES), and lack of emotional clarity (DERS-CLARITY). Validation of the DERS was performed with an undergraduate student population and good internal reliability and construct and predictive validity were demonstrated (Gratz & Roemer, 2004).

The Adult Sensory Questionnaire (ASQ; Kinnealey, Oliver, & Wilbarger, 1995) is a 26-item self-report tool used to assess sensory defensiveness. Cutoff scores for levels of sensory defensiveness are provided to aid interpretation (Kinnealey & Oliver, 2002). It was used to assess general sensory sensitivity in a recent study of misophonia's epidemiology and clinical correlates in a college student population (Wu et al., 2014).

The Barcelona Music Reward Questionnaire (BMRQ- English version; Mas-Herrero et al., 2013) was developed to evaluate individual differences in how people experience reward from music. Its psychometric properties and relationship to other psychological measures have been demonstrated within both Spanish and English speaking populations. Factor analysis revealed four factors of music reward including Musical Seeking (e.g. "I'm always looking for new music"), Sensory-Motor (e.g. "Music often makes me dance"), Mood Regulation (e.g., "Music calms and relaxes me"), Emotion Evocation (e.g., "I sometimes feel chills when I hear a melody that I like"), and Social Reward (e.g., “Music makes me bond with other people”). An overall total score can also be calculated by summing the four factors. This measure was included to investigate whether positive reactions to music are positively or negatively correlated with the negative reactions to sounds found in DST conditions.

The Somatosensory Amplification Scale (SSAS; Barsky, Wyshak, & Klerman, 1990) is a ten-item self-report scale designed to assess sensitivity to mild bodily experiences which are uncomfortable but not typical symptoms of disease. It was validated in a medical outpatient clinic and demonstrated to distinguish patients with a DSM-III-R hypochondriasis diagnosis from patients without hypochondriasis in a comparison sample. Acceptable test-retest reliability and internal reliability were also established for the scale.

Functional impact measures. The SF-12 Short Form Health Survey (SF-12; Ware, Kosinski, & Keller, 1996) was developed using items from the SF-36 Health Survey that capture the most variance in physical and mental health outcomes. It is used to efficiently assess health-related quality of life and the impact of health-related problems on daily functioning. The SF-12 is widely used within medical and epidemiological research to evaluate the impact of various health conditions and to assess the efficacy of health interventions.

The Linear Analogue Self Assessment (LASA; Locke et al., 2007) is a 5-item self-report scale that assesses dimensions of well-being using single items. Overall, cognitive, emotional, physical, and spiritual dimensions of well-being are included. It was originally developed for rapid and holistic assessment of quality of life within oncology samples (Locke et al., 2007), and it has also been used to assess well-being among medical students (Thomas et al., 2007).

Effort measure. The Directed Questions Scale (Maniaci & Rogge, 2014) consists of 7 questions that were embedded within the survey to assess how carefully participants read items.

Items include "This is a control question. Mark 'Mostly True' and move on”. Participants who answered incorrectly on 3 or more of these items were removed from the dataset based on established criterion from prior research (Maniaci & Rogge, 2014).

Changes in measures administered during data collection

The undergraduate participant pool sample data was collected between July and December 2014. Slight modifications were made to the survey after August 2014, including the replacement of two general quality of life measures (SF-12 and the LASA) with the HHIA, to allow for more focused evaluation of the influence of sound and hearing related conditions on quality of life and daily functioning. In addition, the BMRQ, the full FSS-III except the Social Phobia subscale, the AS except the synesthesia subscale, the AQ, and the NSI were eliminated after collecting data from a subset of participants (*N*=103) in order to shorten the survey to ease time burden for participants. No analyses were performed examining the SF-12 and the LASA. The BMRQ, FSS-III total, AQ, AS, and NSI are included in analyses, with the reduced sample size noted for these measures.

Results

Preliminary Data Screening and Participant Characteristics

In Table 2, results of data cleaning are presented, including the number of participants initially recruited and the criteria by which participants were eliminated from analyses. As noted in the table, fewer than 10% of participants who completed the survey were eliminated from analyses for making too many errors on distraction questions (see Effort Measures), and the vast majority of participants in both samples provided valid responses to these questions. Responses in the incomplete/not submitted category appear to represent individuals who initiated the survey but then decided not to complete it, creating a survey record but providing no data.

Table 2.

Data Cleaning Results for Student and Community samples

	Student sample	Community sample
Total number of participants who initiated survey	653	612
Number of incomplete/not submitted survey responses in REDCap	161	212
Number of remaining participants making 3 or more errors on distraction questions	41 (8.30% of submitted responses)	25 (6.27% of submitted responses)
Total number of participants included in final analyses	451	375
Percentage of final analysis participants making 0 errors on distraction questions	85.43%	89.04%

In Table 3, sample characteristics of the student, community, and combined samples are presented. Significant differences on demographic variables across the two samples are noted. In general, community sample participants were older, less racially/ethnically diverse but more gender-balanced, lower income, more educated, and reported more of certain medical diagnoses than student sample participants. The significant difference in age and educational attainment across the two samples is most likely explained by the restricted range of an undergraduate college student sample, where the majority of individuals have recently graduated high school but have not yet completed college. Nearly 8% of the combined sample identified as 'Other' on race/ethnicity screening, and space was provided to write-in other racial/ethnic identities. Of this 8%, roughly half (54.7%) provided a write-in response, with the largest number identifying as "Asian" or coming from a specific region of Asia or having a specific Asian nationality (e.g., "Southeast Asian", "Japanese") (38.2%), the second largest group identifying as "Multiracial, Mixed, or Bi-racial" (22.9%), followed by a number of individuals identifying as “Hispanic” (11.8%), and smaller numbers identifying partially or completely as African (e.g., “Ethiopian” “African and White”) (8.8%), Caribbean (e.g., “West Indian”, “Puerto Rican”) (5.9%), Middle Eastern (e.g., “Caucasian/Middle Eastern, “Half-white non-Hispanic and Turkish”) (5.9%), or Native American (2.9%).

Demographics and Prevalence Rates (Aim 1: Hypotheses 1-3)

Descriptive statistics were used to calculate prevalence rates for the different DST conditions. Overall prevalence rates were estimated by assessing the percentage of participants answering affirmatively to screening items for general DST issues, tinnitus, misophonia, hyperacusis, hearing problems, and general sensory sensitivity. These estimates are likely to be over-inclusive because they rely on single item screening measures. Prevalence rates were also assessed by evaluating the percentage of individuals that fell within certain ranges of symptom severity for tinnitus, misophonia, and hyperacusis, using the specific symptom measures for these scales. Established cut-off points were used to categorize severity ranges when available. Otherwise, the distribution of responses was evaluated, and degree of severity was estimated based on a normal distribution. Prevalence rates based on both single-item screening measures and severity ranges of specific scales were also examined in the context of demographic factors, including age, gender, race/ethnicity, educational attainment, household income, and geographic region.

Table 3.

Sample Characteristics

	Student sample	Community sample	Combined sample
Demographic items			
Age, Mean (SD)	19.58 (3.60)	37.04 (12.54)*	27.49 (12.41)
(Range)	(17-67)	(17-77)	(17-77)
Gender*			
Female	71.2%	54.6%	63.6%
Male	28.4%	44.6%	35.7%
No response	.4%	.8%	.6%
Ethnic identity*			
African American or Black	23.5%	6.9%	15.9%
Asian American	14.9%	13.5%	14.3%
White-Non-Hispanic	42.8%	61.0%	51.1%
White-Hispanic	8.4%	10.3%	9.3%
Middle Eastern	2.9%	0.0%	1.6%
Other	7.5%	8.0%	7.7%
No response	0.0%	.3%	.1%
Family Income*			
Under $20,000	9.3%	20.4%	14.4%
Between $20,000 and $39,000	13.1%	27.3%	19.6%
Between $40,000 and $69,000	22.6%	32.1%	26.9%
Between $70,000 and $99,000	20.4%	11.4%	16.3%
Between $100,000 and $149,000	20.8%	5.0%	13.6%
$150,000 or greater	12.0%	2.7%	7.7%
No response	1.8%	1.1%	1.4%
Geographic location			
Rural	12.4%	15.6%	13.9%
Small Town	15.5%	25.2%	19.9%
Suburban	57.6%	34.5%	47.1%
Urban	14.4%	24.4%	19.0%
No response	0.0%	.3%	.1%
Education*			
Less than high school	0.0%	.8%	.4%
High school/GED	32.8%	11.7%	23.2%
Some college	52.3%	22.8%	38.9%
2 Year college degree (Associate's)	10.6%	10.6%	10.6%
4 Year college degree (BA/BS)	4.2%	35.5%	18.5%
Master's Degree	0.0%	15.4%	7.0%
Doctoral Degree	0.0%	1.3%	.6%
Professional Degree (MD/JD)	0.0%	1.6%	.7%
No response	0.0%	.3%	.1%

Table 3 continues

Table 3 continued

Medical diagnoses			
Diabetes	.9%	8.0%	4.1%
Epilepsy	.9%	1.9%	1.3%
Head Injury	3.5%	7.4%	5.3%
Ulcer	1.1%	4.8%*	2.8%
Heart Problems	3.3%	6.4%	4.7%
Kidney Disorder	.4%	1.6%	1.0%
Liver Problems	.7%	1.9%	1.2%
Hypertension	1.6%	11.9%*	6.3%
Hearing Loss	.2%	4.5%*	2.2%
Cancer	.9%	2.7%	1.7%
Allergies	25.5%	24.4%	25.0%
Respiratory Disease	2.2%	4.8%	3.4%

Note: *Designates a statistically significant difference between the student and community samples. Because of the large number of comparisons made, a two-tailed alpha level of $p<.001$was employed.

In Table 4a frequencies of responses to DST screening items and frequency of clinical level symptoms on standardized DST measures within the combined sample are displayed (see Appendix C, Table 4b for data presented in each sample separately, with significant differences across the two samples noted). Rates of tinnitus, hyperacusis, misophonia, and general sensory and auditory intolerance based on screening items were equivalent across the two samples. College students reported more difficulty detecting or hearing sounds, while community adults had a higher frequency of hearing aid use. The status of specific hypotheses related to prevalence rates are reported below. Unless the two samples significantly differed, prevalence rates reported below are for the combined sample.

Prior research reported a 15% prevalence rate for DST problems in a (Polish) general population sample (Fabijanska et al., 1999) and 40-60% within audiology and tinnitus clinics in the United States (Jastreboff & Jastreboff, 2004, 2006). Hyperacusis rates of 8-9% were found in a Swedish community sample, with only 3% identified as having clinically significant symptoms. Misophonia rates of nearly 20% were documented in a large college student sample (Wu et al., 2014), while somewhat more elevated rates (28.9%) have been reported in audiology clinics (Jastreboff & Jastreboff, 2004). The prevalence rate for misophonia based on screening was 16.2% responding with a definite affirmative and an additional 44.7% reporting at least occasional sensitivity to certain sounds made by other people, meaning that a total of 60.9% of all participants reported at least occasional misophonia symptoms. Anger and disgust were the most frequently reported emotional reactions. Fewer than 1% of community adults reported a misophonia diagnosis. Based on the MQ severity score, 15.6% of participants reported clinically significant misophonia symptoms. Categorization by AMISO-S severity ranges revealed that among individuals screened for reporting some level of misophonia symptoms, severity ranged from mild (43.0%) to moderate (19.4%) to severe (3.3%). Hyperacusis prevalence based on screening was 16.9%, but only .8% of community adults reported having ever received a hyperacusis diagnosis. Clinically significant hyperacusis symptoms were reported by 26.3% of participants. About a quarter of both samples reported tinnitus, with nearly 15% of all participants experiencing tinnitus symptoms for longer than one year. General sensory intolerance and general auditory intolerance were endorsed by 30.3% and 34.9% of participants, respectively.

Table 4a.

Percent of Combined Sample Endorsing DST and Tinnitus on Screening Items and Standardized Measures

DST screening item or measure	% in combined sample
Tinnitus screening: *Do you experience ringing, roaring, or buzzing in your ears or head?*	25.5%
If yes, How long have you experienced this symptom?	
Less than 3 months	5.3%
3-6 months	3.1%
6 months-1 year	2.2%
Longer than 1 year	14.5%
Hyperacusis screening: *Do sounds cause you pain or physical discomfort?*	16.9%
Misophonia screening: *Compared to other people, are you sensitive to certain sounds made by other people?*	
Sometimes	44.7%
Yes	16.2%
Please select the specific emotion(s) that you most often experience in response to sounds that bother you:	
Anger	29.3%
Disgust	29.6%
Fear	4.5%
Anxiety	22.8%
Sadness	2.2%
Guilt	1.2%
Other ("annoyance", "irritability", "nausea", "pain" "surprise", "alertness", "apathy")	10.0%
Hearing difficulty screening:	
Do you have difficulty detecting sounds in your environment and/or understanding the speech of others?	17.0%
Have you ever worn hearing aids or have ever had hearing aids recommended to you?	5.3%

Table 4a continues

Table 4a continued

Percentage of participants reporting having received sound-related diagnoses (community sample only)	.7%
Misophonia	.8%
Hyperacusis	.5%
Phonophobia	4.2%
Tinnitus	1.6%
Selective sound intolerance	1.8%
Decreased sound tolerance	1.0%
Recruitment	1.9%
Other sound-related diagnosis	
Treatment screening: *Have you ever sought or received treatment for a hearing or sound sensitivity problem (including hyperacusis, misophonia, or any other issue related to decreased sound tolerance or selective sound intolerance)?* (community sample only)	2.5%
General sensory intolerance screening: *Are you very bothered by certain tactile sensations, such as clothing textures or tightness; substances that feel sticky, greasy, or wet, or activities like haircuts or cutting your nails?*	30.3%
General auditory intolerance screening: *Are you very bothered by certain auditory sensations, such as the sounds of alarms sirens, appliances, or background noises like people talking or ticking clocks?*	34.9%
Misophonia Questionnaire Severity Score= 7 or higher	15.6%
#Amsterdam Misophonia Scale Total Score (*N*=542)	
No symptoms	34.3%
Mild (5 to 9)	43.0%
Moderate (10 to 14)	19.4%
Severe (15 to 19)	3.3%
Extreme (20 to 24)	0.0%
Hyperacusis Questionnaire Total Score=28 or higher	26.3%
#Mini Tinnitus Questionnaire Total Score (*N*=214)	
No symptoms	66.7%
Moderately distressed (8 to 12)	18.0%
Severely distressed (13 to 18)	12.6%
Most severely distressed (19 to 24)	2.7%

#Denotes that percentage is taken from the subset of participants responding to these items

In Table 5a, the conditional probability of screening positively for a DST condition based on screening for tinnitus or another DST condition is shown. (See Table 5b in Appendix C for raw data of overlap across conditions in each sample). Consistent with expectation, the probability of screening positively for tinnitus or for another DST condition was increased when an individual had already screened positively for one of the other conditions. Chi-square tests were performed for each of these conditional probabilities to determine whether these relationships were statistically significant. The conditional probability of screening positively for misophonia based on a positive tinnitus screen (72.2% reporting sometimes or definitely having misophonia symptoms, $\chi^2(1,821)=15.47$, $p<.001$) or a positive hyperacusis screen (84.2% reporting occasional or definitive misophonia symptoms $\chi^2(1,821)=37.70$, $p<.001$) was significant. The probability of a positive tinnitus screening was also significantly enhanced by a positive screen for hyperacusis (24.2%) and vice versa (36.7%), $\chi^2(1,817)=10.86$, $p=.001$.

Table 5a.

Conditional Probabilities of Positive Screen for Hyperacusis, Misophonia, and Tinnitus

	Probability of positive tinnitus screen	Probability of positive misophonia screen	Probability of positive hyperacusis screen
Positive tinnitus screen (*N*=208)	--	20.7% (definitive); 51.4% (sometimes)	24.0%
Positive misophonia screen (*N*=132 definitive; *N*=364 sometimes)	32.6% (definitive); 29.4% (sometimes)	--	34.9% (definitive); 19.2% (sometimes)
Positive hyperacusis screen (*N*=138)	36.2%	37.4% (definitive); 56.9% (sometimes)	--

Note: Data presented are for combined sample as conditional probabilities did not significantly differ across samples.

Responses to DST screening items and DST standardized measures significantly differed by gender. While males (*M*=1.63, *SD*=.68) were more likely than females (*M*=1.86, *SD*=.71) to endorse misophonia symptoms on a screening item (lower scores indicate a more definite positive screen for misophonia), $F(1,821)=21.27$, $p<.001$, females ($M=18.09$, $SD=10.94$) had a significantly higher mean MQ Total Score than males ($M=14.18$, $SD=12.00$), $F(1, 821)=22.49$, $p<.001$. Male participants were also more likely than females to endorse general sensory intolerance, (Males: $M=.25$, $SD=.43$) (Females: $M=.34$, $SD=.47$), $F(1,821)=7.57$, $p=.006$, and auditory intolerance (Males: $M=.28$, $SD=.45$) (Females: $M=.39$, $SD=.49$), $F(1,819)=8.69$, $p=.003$, on screening items (lower scores indicate a positive screen). Finally, though no significant gender difference was found on tinnitus screening, males ($M=6.77$, $SD=5.62$) reported more functional impairment related to tinnitus symptoms on the Mini-TQ than females ($M=5.01$, $SD=4.74$), $F(1,212)=5.86$, $p=.016$.

Differences on DST screening items and DST measures were also found based on ethnic/racial identity. Individuals identifying as 'Other' on race/ethnicity screening reported significantly more hyperacusis symptoms on the HQ ($M=27.14$, $SD=7.40$) than all other race/ethnicity categories, $F(5, 825)=4.66$, $p<.001$. Similarly, this group also reported more severe misophonia symptoms on the AMISO-S, ($M=8.45$, $SD=4.21$), $F(5, 541)=4.44$, $p=.001$.

Age was positively correlated with tinnitus screening ($r=.10$), the HQ Total Score ($r=.07$), and the Mini-TQ ($r=.15$), all $ps<.05$. There were no significant associations between education level and DST screening items or symptom measures, $ps>.05$. Participant responses to DST screening items or standardized measures did not differ based on geography or household income, $ps>.05$.

In Table 6a, the means and standard deviations for all DST, clinical correlate, and individual difference/mechanism of action measures within the combined sample are presented. Table 6b (Appendix C) provides means and standard deviations within the student and community samples separately. Significant differences between the two samples were calculated with a conservative alpha level of $p<.001$ to adjust for multiple comparisons. The two samples were equivalent in their level of DST symptoms, but a significantly higher level of tinnitus symptoms on the Mini TQ and greater impact of hearing related problems on daily functioning on the HHIA were reported within the community sample compared to the student sample. Community sample participants also reported slightly higher levels of depression symptoms on the HADS and a greater number of medical diagnoses. However, higher levels of anxiety on the HADS-A and anger on the MAI were reported within the student sample. On the TIPI, college students rated themselves as significantly more extraverted, while community sample participants rated themselves as higher in agreeableness. The student sample also reported greater difficulties with emotion regulation on the DERS.

Table 6a.

Means and Standard Deviations of Survey Measures in Combined Sample

	N	Mean (SD)
DST and related measures		
Amsterdam Misophonia Scale	542	6.30 (4.12)
Misophonia Questionnaire Total	826	16.66 (11.48)
Symptom scale	826	6.73 (5.26)
Emotions and behaviors scale	699	11.74 (6.37)
Severity scale	817	2.94 (2.62)
Hyperacusis Questionnaire	826	23.83 (6.89)
Mini Tinnitus Questionnaire	214	5.63 (5.11)
Hearing Handicap Inventory-Adult Total	732	8.54 (16.72)
Social subscale		3.77 (7.90)
Emotional subscale		4.77 (9.12)
Clinical correlate measures		
Obsessive Compulsive Inventory-Revised	826	12.53 (11.13)
Fear Survey Schedule-III		
Social subscale	467	32.21 (12.26)
Hospital Anxiety and Depression scale total	826	10.98 (6.78)
Anxiety subscale		6.74 (4.22)
Depression subscale		4.24 (3.53)
Medical Questionnaire	828	
# Diagnoses endorsed		.59 (.90)
# Somatic symptoms endorsed		2.20 (2.65)
Individual difference and mechanism of action measures		
Multidimensional Anger Inventory	826	71.84 (19.24)
Table 6a continues		
Table 6a continued		
Anxiety Sensitivity Index-3	826	18.36 (13.53)
Distress Tolerance Scale	826	49.94 (12.78)
Discomfort Tolerance	826	21.15 (5.55)
Ten Item Personality Inventory	826	
Extraversion		7.95 (3.23)
Agreeableness		10.34 (2.47)
Conscientiousness		11.03 (2.47)
Emotional stability		9.48 (3.04)
Openness to experience		10.45 (2.42)
Absorption Scale- Synesthesia subscale	826	4.28 (2.47)
Difficulties with Emotion Regulation Scale Total	826	79.87 (24.25)
Non-acceptance of emotional responses		12.81 (5.83)
Difficulties engaging in goal-directed*		13.53 (5.02)
Impulse control difficulties		11.21 (4.70)

Table 6a continues

Table 6a continued

Lack of emotional awareness		15.10 (5.17)
Limited access to emotion regulation strategies		16.65 (7.07)
Lack of emotional clarity		10.57 (4.28)
Adult Sensory Questionnaire	826	8.18 (4.82)
Somatosensory Amplification Scale	732	25.94 (6.14)

Bivariate correlations were calculated to assess the relationships between DST measures and clinical correlate measures. Correlations reaching statistical significance were examined to determine the direction and magnitude of the relationship, with .10 considered a small effect size, .30 a medium effect size, and .50 a large effect size (Cohen, 1992). Table 7a displays the correlations of the DST measures across the two samples (see Table 7b in Appendix C for differences in correlations in the community and student samples). Medium to large, positive relationships were found between the A-MISO-S, MQ, HQ, and Mini TQ, with some significantly stronger associations within the community sample compared to the student sample.

Table 7a.

Decreased Sound Tolerance Measures Correlation Matrix for Combined Sample

	MQ Total	MQ SS	MQ EBS	MQ Severity	HQ	Mini-TQ	HHIA Total	HHIA-SOC	HHIA-EMO
A-MISO-S	.62	.46	.60	.60	.55	.68	.35	.33	.35
MQ Total		.89	.91	.62	.66	.59	.37	.34	.38
MQ SS			.53	.51	.54	.47	.29	.27	.30
MQ EBS				.55	.63	.58	.35	.33	.36
MQ Severity					.58	.52	.35	.34	.34
HQ						.60	.48	.45	.48
Mini-TQ							.67	.61	.68

Notes: All correlations are significant at $p<.01$
N=826, except for the following: A-MISO-S (n=542), MQ EBS (n=699), MQ Severity (n=817), Mini-TQ (n=214), HHIA and HHIA-SOC/EMO (n=732)
Measure abbreviations:
A-MISO-S= Amsterdam Misophonia Scale total score
MQ Total= Misophonia Questionnaire total score
MQ SS= Misophonia Questionnaire Symptom Scale
MQ EBS= Misophonia Questionnaire Emotions and Behaviors Scale
MQ Severity= Misophonia Questionnaire Severity item
HQ= Hyperacusis Questionnaire
Mini-TQ= Mini Tinnitus Questionnaire
HHIA= Hearing Handicap Inventory-Adult Version
HHIA-SOC= Hearing Handicap Inventory-Adult Version Social Subscale
HHIA-EMO= Hearing Handicap Inventory-Adult Version Emotional Subscale

Clinical Correlates (Aim 2: Hypotheses 4-6)

Hypothesized clinical correlates of DST conditions included neurobehavioral symptoms, OCD, Specific Phobia, anxiety and depression, and ASDs. The relationship between measures capturing these clinical symptoms and the presence of DST symptoms were examined using bivariate Pearson correlations with an alpha level of .01. A correlation matrix showing the associations between all DST measures and hypothesized clinical correlates is shown in Table 8a. Significant positive correlations were found between the DST measures and the hypothesized clinical correlates, with few significant differences in these correlations across the two samples (see Table 8b in Appendix C for these correlations separated by sample). No comparisons across the two samples were able to be made for the NSI, FSS-III total score, and AQ; however, these measures showed positive, medium to large sized associations with DST symptoms within the student sample. There was a particularly strong association between the AQ and the Mini TQ. The direction and magnitude of correlations between DST measures and clinical correlates was fairly consistent across DST conditions, with the exception that the AQ was not significantly associated with the MQ SS or MQ Severity scales.

Table 8a.

Decreased Sound Tolerance and Clinical Correlate Measures Correlation Matrix

	Clinical correlate measures									
	NSI	OCI-R	FSS-III	FSS-III S	HADS	HADS-A	HADS-D	AQ	Med DX	SOM
Decreased sound tolerance measures										
A-MISO-S	.39	.39	.11~	.33	.39	.38	.30	.42	.19	.19
MQ Total	.47	.44	.26	.46	.39	.45	.22	.25	.23	.29
MQ SS	.37	.33	.24	.38	.29	.33	.16	.10~	.20	.24
MQ EBS	.48	.47	.19	.45	.46	.47	.32	.34	.20	.25
MQ Severity	.40	.40	.15	.36	.34	.36	.22	.19~	.22	.27
HQ	.51	.44	.18	.44	.43	.43	.31	.40	.25	.32
Mini-TQ	.37	.53	-.04~	.36	.50	.41	.46	.71	.41	.27
HHIA	--	.42	--	.26	.39	.34	.34	--	.29	.20
HHIA SOC	--	.40	--	.23	.36	.31	.33	--	.30	.18
HHIA EMO	--	.42	--	.28	.39	.35	.34	--	.27	.21

Notes: All correlations are significant at $p<.01$, except where $\sim p>.05$

N=826, except for the following: A-MISO-S (n=542), MQ EBS (n=699), MQ Severity (n=817), Mini-TQ (n=214), HHIA and HHIA-SOC/EMO (n=732), NSI (n=94), FSS-III (n=94), FSS-III-SOC (n=467), AQ (n=82)

Measure abbreviations:

A-MISO-S= Amsterdam Misophonia Scale total score

MQ Total= Misophonia Questionnaire total score

MQ SS= Misophonia Questionnaire Symptom Scale

MQ EBS= Misophonia Questionnaire Emotions and Behaviors Scale

MQ Severe= Misophonia Questionnaire Severity item

HQ= Hyperacusis Questionnaire total score

Mini TQ= Mini Tinnitus Questionnaire total score

HHI-A= Hearing Handicap Inventory-Adult Version total score

HHI-A SS= Hearing Handicap Inventory-Adult Version Social Subscale

HHI-A ES= Hearing Handicap Inventory-Adult Version Emotional Subscale

NSI=Neurobehavioral Symptom Inventory total score

OCI-R=Obsessive Compulsive Inventory-Revised total score

FSS-II= Fear Survey Schedule-III total score

FSS-III SOC= Fear Survey Schedule-III social phobias subscale

HADS=Hospital Anxiety and Depression Scale total score

HADS-A=Hospital Anxiety and Depression Scale anxiety scale

HADS-D=Hospital Anxiety and Depression Scale depression scale

AQ= Autism Quotient total score

MedDX=Total number of medical diagnoses endorsed on Medical Questionnaire Part 1

SOM= Number of somatic symptoms endorsed on Medical Questionnaire Part 2

Based on substantial evidence of a clinical association between OCD and misophonia (e.g., Schroder et al., 2013; Taylor et al., 2014; Wu et al., 2014), additional analyses were performed to examine the frequency of OCD and misophonia caseness and rates of co-occurrence. As previously mentioned, approximately 15.6% of participants reported clinically significant misophonia symptoms based on an MQ Severity Score greater than 7. Using an OCI-R clinical cut-off score of 21, 21.2% of participants were found to have clinically significant OCD symptoms. Cross-tab analyses were performed to identify the conditional probability of having clinically significant misophonia symptoms based on the presence of clinically significant OCD symptoms (and vice versa). Table 9 displays the rates of overlap in clinically significant symptoms based on the presence of the other condition. In both cases, the presence of misophonia or OCD significantly increased the likelihood of clinically relevant symptoms of OCD (45.7%) or misophonia (34.1%), respectively, $\chi^2(1,817)=55.37$, $p<.001$. These rates did not differ between the student and community samples.

Table 9.

Conditional Probabilities of OCD and Misophonia

	Probability of clinically significant OCD symptoms	Probability of clinically significant misophonia symptoms
Clinically significant OCD symptoms present (*N*=173)	--	34.10%
Clinically significant misophonia symptoms present (*N*=129)	45.74%	--

Individual Differences and Mechanisms of Action (Aim 3: Hypotheses 7-9)

Hypothesized individual difference measures and proposed mechanisms of action were first examined using bivariate Pearson correlations. Individual difference measures that were predicted to correlate with higher levels of DST symptoms included measures of personality functioning, generalized sensory sensitivity, sensory absorption and synesthesia. Proposed mechanisms of action included anxiety sensitivity, distress tolerance, discomfort tolerance, and difficulties in emotion regulation.

In Table 10a, associations between all DST measures and hypothesized individual difference and mechanism of action measures are shown (see Appendix C for Table 10b displaying these correlations separately by sample). Moderate associations were found between DST symptoms and anger (MAI), anxiety sensitivity (ASI-3), distress tolerance (DTS), emotion regulation difficulty (DERS), and sensitivity to bodily sensations (SSAS), with some stronger associations among community adults compared to college students. The strongest associations were found between the ASQ and the MQ Total Score, the Mini-TQ and the ASI-3, and the HQ and the ASQ. The DS, TIPI-O, AS, and BMRQ showed few, small magnitude associations with the DST measures. Among the personality domains of the TIPI, the emotional stability (neuroticism) domain showed the strongest association with DST symptoms.

Table 10a.

Decreased Sound Tolerance and Mechanisms/Individual Difference Measures Correlations Matrix

	Decreased sound tolerance measures							
	A-MISO-S	MQ Total	MQ SS	MQ EBS	MQ Severity	HQ	Mini TQ	HHIA
Mechanisms and individual difference measures								
MAI	.38	.47	.35	.48	.34	.39	.42	.26
ASI-3	.35	.40	.30	.47	.31	.37	.54	.38
DTS	-.26	-.32	-.23	-.37	-.26	-.31	-.31	-.23
DIS	.03~	.02~	.00~	.00~	.07*	.00~	-.04~	-.02~
TIPI-O	-.01~	-.05~	-.06~	-.07~	-.05~	-.05~	-.15*	-.14
TIPI-C	-.06~	-.09~	-.06~	-.15	-.11	-.13	-.21	-.19
TIPI-E	-.11*	-.06~	-.05~	-.09*	-.04~	-.19	-.17*	-.06~
TIPI-A	-.18	-.22	-.16	-.25	-.19	-.19	-.30	-.20
TIPI-N	-.35	-.35	-.24	-.41	-.31	-.34	-.41	-.21
AS	.05~	.14	.12	.10*	.09*	.13	.04~	.20
AS-S	.18	.20	.13	.23	.20	.22	.25	.20
DERS	.31	.35	.25	.40	.26	.35	.39	.29
DERS-NA	.25	.30	.22	.33	.20	.30	.29	.24
DERS-G	.27	.34	.28	.33	.27	.41	.27	.21
DERS- I	.25	.27	.16	.37	.21	.26	.41	.28
DERS-A	.06~	.08*	.04~	.09*	.09	.04~	.09~	.11
DERS-S	.32	.33	.24	.39	.23	.35	.42	.27
DERS-C	.19	.22	.15	.28	.17	.19	.24	.20
ASQ	.43	.55	.45	.49	.49	.57	.51	.41
BMRQ	-.04~	.00~	.02~	.00~	-.14~	-.15~	-.05~	--
SSAS	.27	.39	.33	.34	.36	.37	.28	.14

Notes: All correlations are significant at $p<.01$, except where $\sim p>.05$ and $*p<.05$
N=826, except for the following: A-MISO-S (n=542), MQ EBS (n=699), MQ Severity (n=817), Mini-TQ (n=214), HHIA (n=732), AS (n=92), BMRQ (n=92), SSAS=(n=732)
Measure abbreviations:
A-MISO-S= Amsterdam Misophonia Scale total score
MQ Total= Misophonia Questionnaire total score
MQ SS= Misophonia Questionnaire Symptom Scale
MQ EBS= Misophonia Questionnaire Emotions and Behaviors Scale
MQ Severe= Misophonia Questionnaire Severity item
HQ= Hyperacusis Questionnaire total score
Mini TQ= Mini Tinnitus Questionnaire total score
HHI-A= Hearing Handicap Inventory-Adult Version total score
MAI= Multidimensional Anger Inventory total score

Table 10a continues

Table 10a continued

ASI-3= Anxiety Sensitivity Index-3 total score
DTS=Distress Tolerance scale total score
DIS=Discomfort Tolerance scale total score
TIPI-O=Ten Item Personality Inventory-Openness to Experience scale
TIPI-C= Ten Item Personality Inventory-Conscientiousness scale
TIPI-E= Ten Item Personality Inventory-Extraversion scale
TIPI-A= Ten Item Personality Inventory-Agreeableness scale
TIPI-N= Ten Item Personality Inventory-Emotional Stability/Neuroticism scale
AS=Absorption Scale
AS-S= Absorption Scale-Synesthesia subscale
DERS=Difficulties with Emotion Regulation Scale total score
DERS-NA=DERS Nonacceptance of emotional responses subscale
DERS-G= DERS Difficulties engaging in goal-directed behavior subscale
DERS-I=DERS Impulse control difficulties subscale
DERS-A= DERS Lack of emotional awareness subscale
DERS-S=DERS Limited access to emotion regulation strategies subscale
DERS-C= DERS Lack of emotional clarity subscale
ASQ= Adult Sensory Questionnaire total score
BMRQ=Barcelona Music Reward Questionnaire total score
SSAS=Sensory Amplification Scale total score

Given that moderate to large, significant correlations were found between nearly all hypothesized individual difference/mechanism of action measures with DST measures, mediation and moderation analyses were performed based on a priori theory. Because there were few significant differences in correlations between the two samples, mediation and moderation analyses were performed using the combined sample to maximize statistical power.

Mediation analyses. Mediation analyses were performed using PROCESS, a computational tool developed by Hayes (2013) that allows the user to test simple and multiple mediator models with bootstrap confidence interval methodology, the preferred statistical approach for mediation analyses (Preacher & Hayes, 2008; Hayes, 2013). PROCESS was used as an add-on to SPSS Version 21 through the regression analysis function. For each of the mediation analyses below, model summary statistics (R^2 for the overall model and for each variable, p values, and upper and lower limit confidence intervals) and estimates of the total, direct, and indirect effects are provided.

Bootstrapping was performed with 10,000 samples to produce bias-corrected bootstrap confidence intervals with 95% level of confidence. All effects reported below are unstandardized, where path coefficients are defined as follows: "a" path (independent variable to mediating variables), “b” path (mediating variables to dependent variable, controlling for the IV), “c” path (IV to DV without the mediating variables, aka the total effect), “c’” path (IV to DV, controlling for the mediating variables, aka the Direct effect), and R square (amount of variance in the DV accounted for by the IV and mediating variables). The *ab* path is the coefficient for the indirect effect, which is estimated using the bootstrap confidence interval method. If the confidence interval does not contain zero, then the null hypothesis can be rejected, and mediation has occurred.

Mediation model #1: Relationship between misophonia symptoms and symptom severity mediated by psychological mechanisms. In the first mediation model, mediation of the relationship between misophonia symptoms (MQ Total Score) and their severity (MQ Severity Score, which is a single item severity rating, completed independently of the MQ Total Score) was assessed using a parallel multiple mediator model, with emotion regulation (DERS), somatosensory amplification (SSAS), anxiety sensitivity (ASI-3), and distress tolerance (DTS) as mediators presumed not to be causally related to one another. This model was selected based on the theory that misophonia operates similarly to other behavioral medicine phenomena in that the severity of the condition (i.e., level of functional impairment and emotional distress) was expected to be influenced by psychological mechanisms that exacerbate symptoms (which can exist at varying levels of severity), leading to worse outcomes. In parallel multiple mediator models of this nature, it is permissible (and indeed often predicted) that the mediators are correlated with one another, but it is assumed that they are not causally related to one another (Hayes, 2013).

From this parallel multiple mediator analysis, misophonia symptom severity was directly and indirectly explained by the presence of misophonia symptoms through a pathway of amplifying bodily sensations. The total effect model was significant, R^2=.39, F(1, 723)=462.30, p<.001, indicating that misophonia symptoms and the hypothesized mediators accounted for about 39% of the variance in misophonia severity. As can be seen in Figure 1, the presence of misophonia symptoms was associated with greater somatosensory amplification (a_1=.21), and amplification of bodily sensations was associated with higher misophonia symptom severity (b_1=.05). A bias-corrected bootstrap confidence interval (CI) for the indirect effect (ab_1=.01) based on 10,000 bootstrap samples was entirely above zero (.0053-.0174). Because this CI does not include zero, the null hypothesis that ab_1=0 can be rejected. The direct effect of misophonia symptom presence on misophonia symptom severity was maintained independent of its relationship with somatosensory amplification (c'=.13, p<.001). None of the other mediators were shown to be significant intervening variables in the relationship between misophonia symptoms and their severity (e.g., all the *b* paths were nonsignificant).

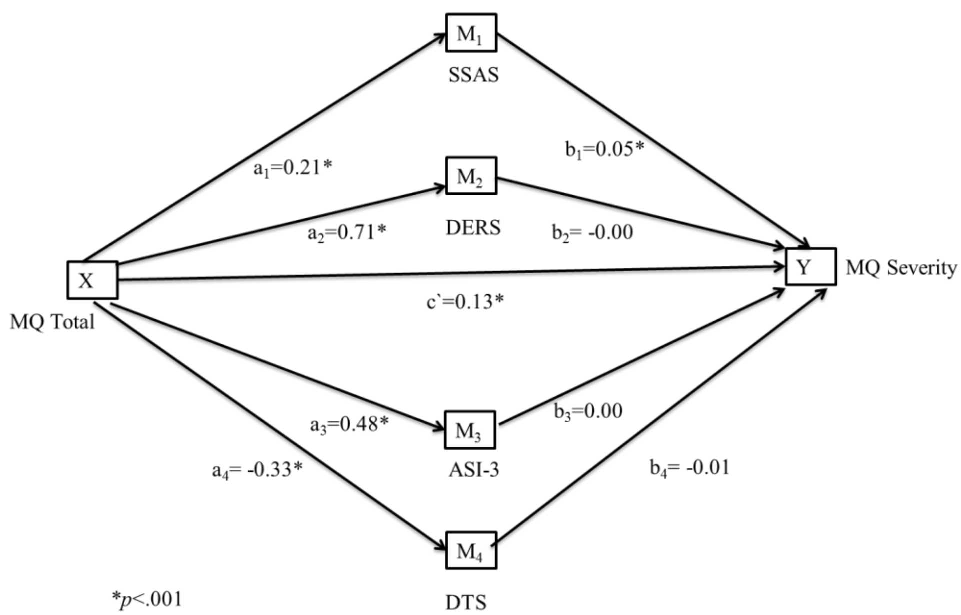

Figure 1. Parallel Mediation of Misophonia Symptom Severity by Somatosensory Amplification

Mediation model #2: Relationship between misophonia symptoms and hearing-related functional impairment mediated by psychological mechanisms. A second mediation model tested the same mediators as above in a parallel multiple mediator model to explain the relationship between the presence of misophonia symptoms (MQ Total Score) and hearing-related functional impairment (HHI-A Total Score). Similar to the above model, it was hypothesized based on proposed similarity of misophonia to other behavioral medicine conditions that hearing-related functional impairment resulting from the presence of misophonia symptoms would be explained through psychological pathways. From this parallel multiple mediator analysis, hearing-related functional impairment was directly and indirectly explained by the presence of misophonia symptoms through anxiety sensitivity and amplification of bodily sensations (see Figure 2). The total effect model was significant, R^2=.16, F(1, 730)=142.82, p<.001, indicating that misophonia symptoms and the hypothesized mediators accounted for about 16% of the variance in hearing-related functional impairment. The presence of misophonia symptoms was associated with greater somatosensory amplification (a^1=.21) and anxiety sensitivity (a^2=.48), and amplification of bodily sensations and anxiety sensitivity were related to misophonia symptom severity (b^1= -.20, b^2=.32). Bias-corrected bootstrap confidence intervals for the indirect effects through bodily amplification (ab^1= -.04) and anxiety sensitivity (ab^2=.15) based on 10,000 bootstrap samples did not include zero ($CI^{1=}$ -.0898- -.0007) (CI^2=.0960-.2265). Pairwise comparison of anxiety sensitivity and somatosensory amplification determined that the two indirect effects were significantly different from one another (CI=.1149-.2898). This difference can be explained by the opposing directions of the path coefficients: bodily amplification was inversely related to misophonia symptom severity, whereas anxiety sensitivity was positively associated with misophonia symptom severity. The direct effect of misophonia symptom presence on hearing-related handicap was maintained independent of its effect on somatosensory amplification and anxiety sensitivity (*c*'=.40, *p*<.001).

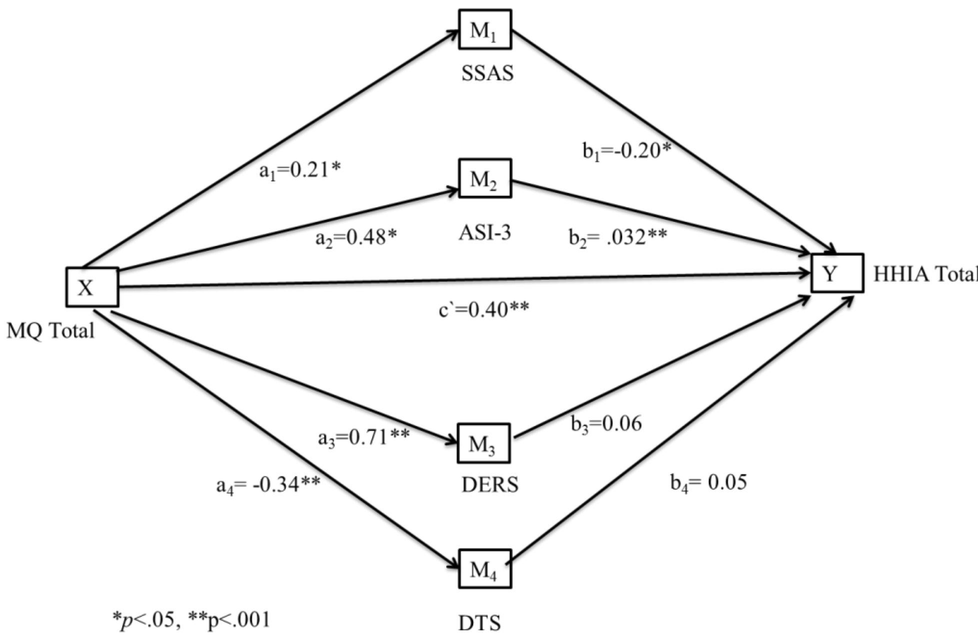

Figure 2. Parallel Mediation of Hearing-Related Handicap by Somatosensory Amplification and Anxiety Sensitivity

Mediation model #3: Relationship between misophonia symptoms and resulting anger response mediated by anxiety sensitivity. Finally, a third, simple mediation model was tested to replicate and extend the mediation model reported by Wu and colleagues (2014), in which anxiety was shown to mediate the relationship between misophonia symptoms and rage reactions. Our replication of this model assessed whether anxiety sensitivity (ASI-3) mediated the relationship between misophonia symptoms (MQ Total Score) and anger (MAI). The total effect model was significant, R^2=.16, *F*(1, 824)=154.53, *p*<.001, indicating that misophonia symptoms and anxiety sensitivity accounted for about 16% of the variance in anger. From this simple mediation analysis, anger was directly and indirectly explained by misophonia symptoms through the pathway of anxiety sensitivity (see Figure 3). The presence of misophonia symptoms was associated with increased anxiety sensitivity (*a*=.47), and anxiety sensitivity was related to higher levels of anger (*b*=.60). A bias-corrected bootstrap confidence interval for the indirect effect (*ab*=.28) based on 10,000 bootstrap samples was entirely above zero (.2199-.3476). The direct effect of misophonia symptom presence on anger was maintained independent of its relationship with anxiety sensitivity (*c*'=.51, *p*<.001).

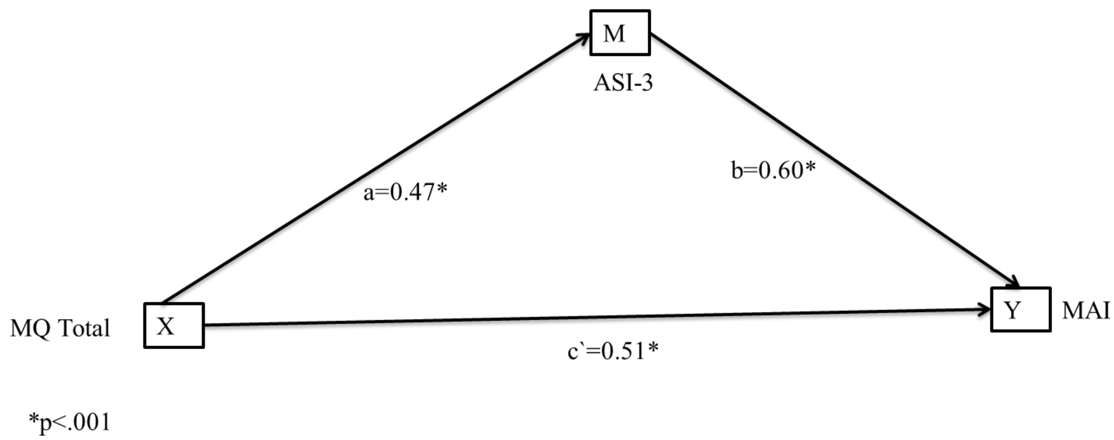

Figure 3. Simple Mediation of Misophonia-Related Anger by Anxiety Sensitivity

Moderation analyses. Moderation models were selected to evaluate characteristics or individual difference variables that have been proposed to make individuals more susceptible to develop clinically significant misophonia symptoms. Hypothesized moderators included synesthesia (AS-S), emotional stability (neuroticism) (TIPI-N), and sensory sensitivity (ASQ).

Moderation analysis #1: Relationship between misophonia symptoms and misophonia symptom severity moderated by individual difference measures. In the first set of moderation models, the impact of each moderator on the relationship between misophonia symptoms (MQ Total Score) and misophonia severity (MQ Severity Score) was tested. For each model, the dependent variable was the MQ Severity Score, and the MQ Total Score and the moderator were entered as independent variables in the first step, followed by an interaction term multiplying the MQ Total Score by the moderator in the second step. Synesthesia ($F\Delta$ (1,813)=.18, *p*=.175), neuroticism ($F\Delta$

(1,813)=.58, p=.448), and sensory sensitivity ($F\Delta$ (1,813)=.81, p=.369), were not significant moderators of the association between misophonia symptoms and their severity.

Moderation analysis #2: Relationship between misophonia symptoms and hearing-related functional impairment moderated by individual difference measures. The same procedure for moderation analysis described above was repeated to examine potential moderators of the relationship between misophonia symptoms (MQ Total) and hearing-related functional impairment (HHIA). In three separate models, synesthesia ($F\Delta$ (1,728)=5.04, p=.025, β=.20), emotional stability (neuroticism) ($F\Delta$ (1,728)=5.15, p=.024, β=-.22), and sensory sensitivity ($F\Delta$ (1,728)=19.62, p=<.001, β=.43), were each found to significantly moderate the association between misophonia symptoms and hearing-related functional impairment. See Figures 4-6 for graphical representations of the moderating effects of these variables on the association between misophonia symptoms and hearing handicap. The three levels of high, medium, and low for both moderator and for the MQ Total were computed using the mean as the medium value, one standard deviation above the mean as the high mean, and one standard deviation below the mean as the low mean (in accordance with Aiken & West, 1991). As shown in Figure 4, at higher levels of misophonia symptoms, individuals reporting greater experience of synesthesia had worse hearing-related functional impairment, whereas there were no differences in functional impairment across levels of synesthesia among individuals with lower levels of misophonia symptoms.

Similarly, in Figure 5, it is evident that at higher levels of misophonia symptoms, lower levels of emotional stability (higher neuroticism) are related to worse hearing-related functional impairment, whereas there were no differences in functional impairment across levels of emotional stability among individuals with lower levels of misophonia symptoms.

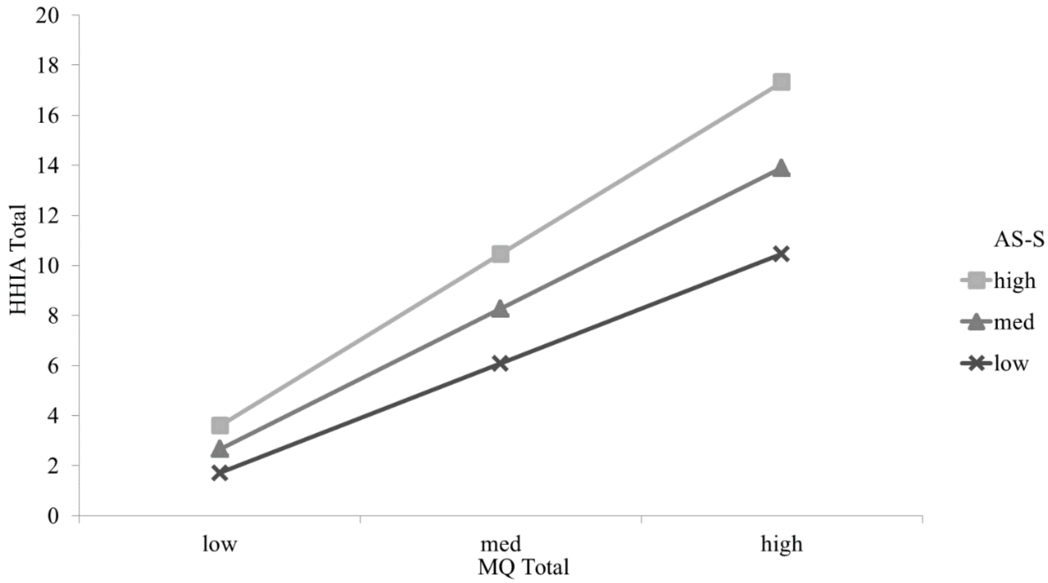

Figure 4. Synesthesia Exacerbates the Relationship between Misophonia and Hearing-Related Handicap

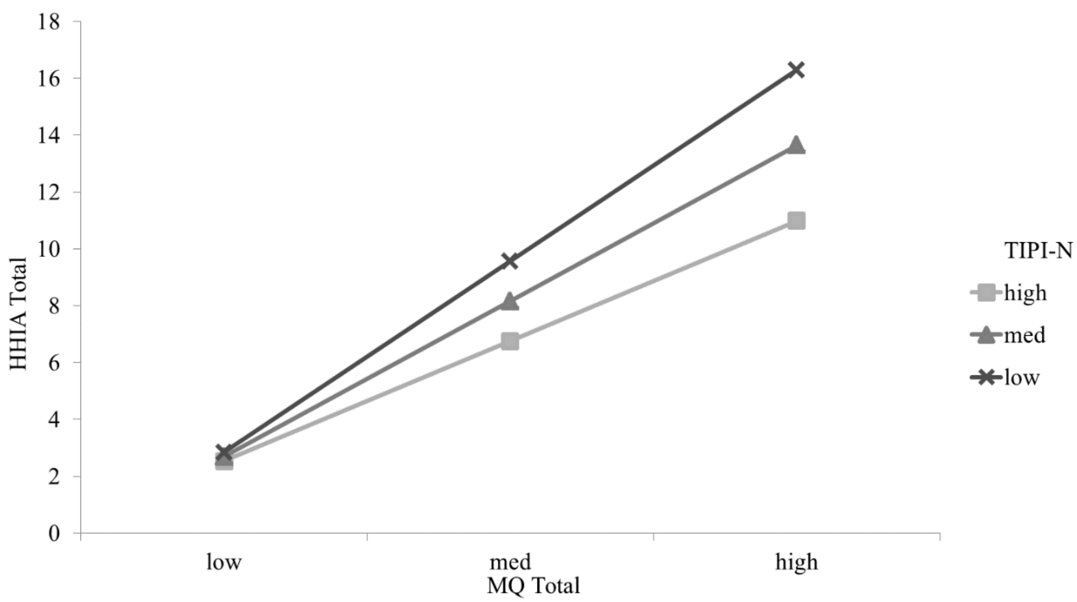

Figure 5. Emotional Instability Exacerbates the Relationship between Misophonia and Hearing-Related Handicap

A slightly different pattern is seen in Figure 6, where the positive relationship between misophonia symptoms and hearing-related functional impairment is seen most strongly for those at high levels of sensory sensitivity compared to those at medium and low levels of sensory sensitivity.

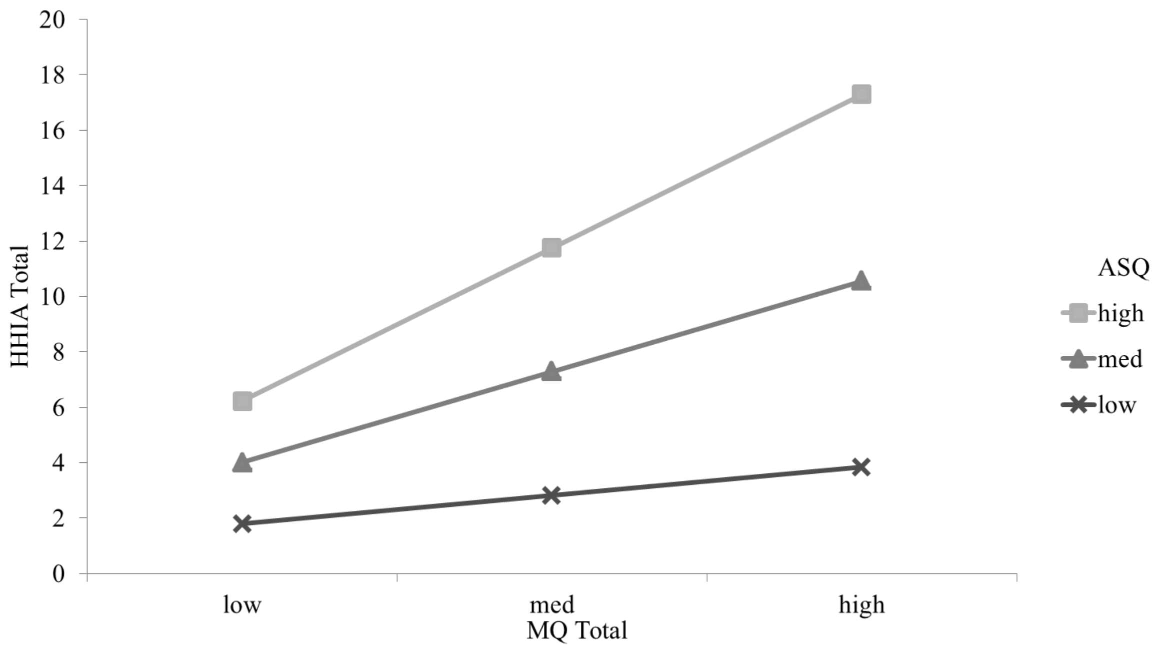

Figure 6. The Relationship between Misophonia Symptoms and Hearing-Related Handicap is Strongest for those with High Sensory Sensitivity

Scale Development (Aim 4: Hypothesis 10)

The DST Scale was developed with the aim to address the need for an assessment tool that can differentiate DST conditions from one another and from normal sound sensitivity. The 41 original items asked respondents to rate their degree of discomfort/aversion to various sounds, with sound items included that were hypothesized to assess three types of sound sensitivity: misophonic sound sensitivity (e.g., eating, breathing, pen clicking), hyperacusis-type sound sensitivity (e.g., hum of a vacuum running in the other room, traffic noise from inside a car), and normal sound sensitivity (e.g., ambulance siren, nails on a chalkboard, gunshot). As such, a three factor solution was hypothesized for the scale. Scale development was completed in four stages: (1) Initial exploratory factor analysis (EFA) with all 41 items in the full student sample; (2) Second EFA with winnowed items and factor structure on half of the community sample (randomly selected); (3) Final confirmatory factor analysis (CFA) on second randomly selected half of the community sample; (4) Evaluation of estimated internal reliability and construct validity of scores on final items and scale with the student and community samples.

Stage 1: Initial EFA in student sample. First, an EFA was performed using the original 41 items of the DST Scale (see item development description in Method section) within the full student sample (N=451). The recommended minimum of ten cases per item was met with approximately 11 subjects per item. Assumptions of normality and linearity were tested by assessing the skewness and kurtosis of each item and examining scatterplots for each item. A large number of items were found to be positively skewed and/or leptokurtotic, indicating a non-normal distribution. Natural log and square root transformations were performed in an attempt to normalize these items; however, the transformations were not successful in addressing the problem. In addition, the ratio of the standard error of skewness to the degree of skewness exceeded the critical value of 2, suggesting that these variables are likely to be positively skewed in the overall population and not just within this particular sample (Cramer, 1997). Therefore, no further transformations were attempted, and the items were subjected to factor analysis in their original form.

An EFA using the maximum likelihood method performed on the original 41 items showed adequate factorability, with the Kaier-Meyer-Olkin measure of sampling adequacy of .79, above the recommended value of .7, and Bartlett's test of sphericity was significant (χ^2 (820) = 3645.78, p<.001). Examination of the scree plot and amount of variance explained by each additional factor indicated that a two-factor solution best fit the data; therefore, the EFA was limited to a two-factor solution. Initial factor loadings were examined. Criteria for retaining items were as follows: the item had to load higher than .300 on a primary factor and no greater than .225 on another factor. Using these criteria, only 17 of the original 41 items were retained because they cleanly loaded on one of the two factors. The EFA was repeated with these 17 items using both Varimax and oblique rotations to determine which best described the data. The factor correlation matrix showed that the two factors were only loosely correlated, r=.165; therefore, a Varimax rotation, which assumes that the factors are not correlated, was used to generate the final factor loadings for the EFA. The final items and their factor loadings and communalities are presented in Table 11 below.

Table 11.

Rotated Factor Matrix Loadings and Communalities for Two Factor Solution in Student Sample

	Factor 1	Factor 2	Communalities
Eating sounds (e.g., chewing, lip smacking, crunching, slurping, swallowing, etc.)	-.104	**.538**	.301
Breathing/nose sounds	.019	**.480**	.231
Finger/hands sounds (e.g., finger snapping, finger tapping, fingers drumming on table, knuckle cracking)	.095	**.529**	.289
Pen clicking	-.022	**.433**	.188
TV or radio playing at a moderate volume while you are in the room.	**.330**	-.031	.110
Large truck or bus driving by while you are on the sidewalk	**.507**	.058	.261
Traffic noise you can hear from inside your home or other building	**.467**	.155	.242
Car horn while you are inside of a car or other vehicle	**.498**	.110	.261
Loud music at a concert	**.415**	-.056	.176

Table 11 continues

Table 11 continued

	Factor 1	Factor 2	Communalities
Vacuum that you are operating	**.403**	-.090	.171
Vacuum running in the next room	**.306**	.111	.106
Children laughing nearby	**.365**	.033	.134
Fire/smoke alarm	**.498**	.151	.271
Ambulance sirens	**.571**	.087	.334
Nails on a chalkboard	.128	**.328**	.124
Screeching tires	**.411**	.067	.174
Vomiting sounds	.156	**.388**	.175

Stage 2: Second EFA in first community subsample. A second EFA was performed on a randomized subsample of the community sample (*N*=188) using the winnowed items and factor structure described above. The rule of thumb of 10:1 cases per items was maintained. Factorability was fair, with KMO=.67, and Bartlett's test of sphericity was significant (χ^2 (136)=712.15, p<.001). The same item selection criteria were applied to further refine the factor structure and evaluate whether the original EFA could be replicated. Eleven of the 17 items conformed to the student EFA factor structure, with six items showing mixed or low factor loadings within the community subsample 1 (see Table 12 for rotated factor matrix and communalities in second EFA in community subsample 1). One item (vacuum that you are operating) met criteria for inclusion; however, its factor loading and communality values were substantially lower than other included items, suggesting that this item was weaker than the others. Therefore, this item was also cut, leaving ten final items, with five items loading cleanly on each of the two factors.

Table 12.

Rotated Factor Matrix and Communalities for Two Factor Solution in Community Subsample 1

	Factor 1	Factor 2	Communalities
Eating sounds (e.g., chewing, lip smacking, crunching, slurping, swallowing, etc.)	.103	**.558**	.322
Breathing/nose sounds	.216	.254	.111
Finger/hands sounds (e.g., finger snapping, finger tapping, fingers drumming on table, knuckle cracking)	.214	**.352**	.170
Pen clicking	-.045	**.558**	.313
TV or radio playing at a moderate volume while you are in the room.	.222	.013	.050
Large truck or bus driving by while you are on the sidewalk	**.733**	.050	.540
Traffic noise you can hear from inside your home or other building	**.736**	-.082	.549
Car horn while you are inside of a car or other vehicle	**.523**	.199	.313
Loud music at a concert	**.489**	.081	.245

Table 12 continues

Table 12 continued

Vacuum that you are operating	.317	.119	.115
Vacuum running in the next room	.278	.143	.098
Children laughing nearby	.207	.023	.044
Fire/smoke alarm	.399	.481	.390
Ambulance sirens	**.554**	.238	.364
Nails on a chalkboard	-.094	**.624**	.399
Screeching tires	.338	.267	.186
Vomiting sounds	.198	**.506**	.295

Note: The ten items retained are shown in **bold**.

Stage 3: CFA in second community subsample. Finally, a CFA using the further winnowed ten items from the second EFA was performed in MPlus Editor on the second randomized subsample of the community sample (*N*=187) to determine whether the factor structure and item loadings could be replicated a third time using structural equation modeling (SEM). The hypothesized model was estimated using maximum likelihood estimation with robust standard errors (MLR). MLR provides mean-adjusted estimates for non-normally distributed continuous data to account for minor violations of parametric assumptions (Muthén & Muthén, 2012). Model fit was assessed using the χ^2 value, the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), the Root Mean Square Error of Approximation (RMSEA), and the Standardized Root Mean Square Residual (SRMR), where values of .90 or above for the CFI and TLI (Tucker & Lewis, 1973), .08 or below for the RMSEA (Browne & Cudeck, 1993) and the SRMR (Kline, 2005) indicate that a model adequately fits the data. Based on these criteria, model fit was adequate for the hypothesized two factor solution, with $\chi^2(34)=59.57$, $p=.004$, CFI=.92, TLI=.90, RMSEA=.06 (90% Confidence Interval= .04-.09, $p=.193$), and SRMR=.06. The model results (using the STDYX standardization as is appropriate for continuous data) for the final ten item scale are presented in Table 13.

Table 13.

Means (SD) and Factor Loadings for CFA in Community Subsample 2

Item	Mean (SD)	Factor 1 (LSS)	Factor 2 (HSS)
Eating sounds (e.g., chewing, lip smacking, crunching, slurping, swallowing, etc.)	2.03 (.94)		0.45
Finger/hands sounds (e.g., finger snapping, finger tapping, fingers drumming on table, knuckle cracking)	1.55 (.79)		0.71
Pen clicking	1.41 (.63)		0.65
Nails on a chalkboard	2.32 (1.12)		0.41
Vomiting sounds	2.04 (.99)		0.32
Large truck or bus driving by while you are on the sidewalk	1.21 (.48)	.61	
Traffic noise you can hear from inside your home or other building	1.29 (.62)	.74	
Car horn while you are inside of a car or other vehicle	1.33 (.66)	.71	
Loud music at a concert	1.41 (.75)	.41	
Ambulance sirens	1.50 (.88)	.60	

Note: All loadings were significant at $p<.001$. Factor 1 was named the Loudness Sensitivity Subscale (LSS), and Factor 2 was named the Human Sounds Subscale (HSS).

In sum, factor analysis yielded a robust two factor solution. Factor 1 appeared to consist of items measuring sensitivity to loud sounds, assessing discomfort in response to the following sounds: truck, traffic, horn, concert, and siren. Therefore, Factor 1 was named the "Loudness Sensitivity Subscale" (LSS). In contrast, Factor 2 seemed to capture sensitivity to low to medium volume sounds produced by other humans, assessing aversion to the following sounds: eating, hand sounds, pen clicking, fingernails on a chalkboard, and vomit. Thus, Factor 2 was named the "Human Sounds Subscale" (HSS). Total scores were calculated for the sum of the five items from each of the two subscales. A total score for the entire scale was also calculated and named the "DST -10".

Stage 4: Reliability and validity analyses. In the final scale development step, estimated internal reliability and validity were assessed for the two subscales and the DST-10 within the student and community samples separately.

***Estimated internal reliability*.** Estimated internal reliability was assessed using Cronbach's alpha coefficient, which measures the degree of inter-correlations among test items and is considered an indirect measure of how much a scale captures a single unidimensional latent construct. Commonly accepted interpretative ranges for Cronbach's alpha are as follows: $\alpha \geq 0.9$=Excellent, $0.7 \leq \alpha < 0.9$= Good, $0.6 \leq \alpha < 0.7$= Acceptable, $0.5 \leq \alpha < 0.6$=Poor, $\alpha < 0.5$= Poor. Cronbach's alpha was calculated for the DST -10, LSS, and HSS within the community and student samples. In the community sample, for the DST -10, α=.72, indicating 'good' internal consistency for the sum score of all ten scale items. Internal consistency for the items making up the LSS (α=.74) and the HSS (α=.64) fell between 'good' and 'acceptable' ranges, respectively, in the community sample. However, in the student sample, internal consistency of the DST -10 was poor (α=.58), the LSS was acceptable (α=.62), and the HSS was poor (α=.53).

Content validity. Content validity of the DST Scale subscales was assessed in the student and community samples separately with additional EFAs, which were performed to examine the factor loadings of the items of the DST Scale with other scales measuring similar constructs. The same high and low criteria as before (.225 low, .300 high) were used to evaluate the factor loadings. To assess the content validity of the LSS factor, an EFA was performed with the five items of the LSS and the 14 items of the HQ, based on the assumption that the LSS items should factor with items of the HQ, particularly those assessing sensitivity and avoidance of loud sounds. For the HSS factor, an EFA was performed with the five items of HSS and the eight items of the MQ-SS because it was hypothesized that items on both scales measured sensitivity to human-produced sounds.

Contrary to expectation, the LSS and HQ items showed inconsistent factorability in both the student and community samples. In part, the lack of correspondence in factor loadings appeared to be due to mixed factor loadings for many of the HQ items, suggesting that the scale's established psychometric properties may not have been reproduced in these samples. There were three HQ items ("use earplugs or earmuffs to reduce your noise perception"; "find noise unpleasant in certain social situations"; "think about the noise you are going to have to put up with") that factored with the LSS items in the community sample. In the student sample, the factorability of the LSS and HQ items was difficult to interpret due to mixed loadings for many of the items on both scales. Again, somewhat unexpectedly, there was a lack of overlap in factor loadings for the HSS and MQ-SS items in both the student and community samples. Only one of the MQ-SS items ("people eating, e.g., chewing, swallowing, lips smacking, slurping, etc.") loaded cleanly with the HSS items in the community sample. Similar to the HQ, many of the MQ-SS items showed mixed factor loadings. In sum, content validity of the HSS and LSS were not supported by examining the factorability of these items with items anticipated to measure similar constructs from other, more established scales.

Convergent and discriminant validity. Correlations of the final DST Scale and its subscales with other validated measures were performed as an evaluation of evidence supporting construct validity within the student and community samples. The DST -10 and the LSS and HSS factor subscale scores were examined independently. Scales used to evaluate the convergent validity of the DST -10 included the ASQ and the HHIA. Convergent validity of the LSS was tested by evaluating its association with the HQ. Convergent validity of the HSS was assessed by examining its association with the A-MISO-S and the MQ. Discriminant validity was assessed by evaluating the strength of correlations between the DST -10 and LSS and HSS subscale scores with the Mini TQ, the OCI-R, and the TIPI-Emotional Stability scale. Table 14 shows the correlations of the DST -10, LSS, and HSS with convergent and discriminant validity measures in each sample.

Table 14.

Correlation Matrix of Convergent and Discriminant Validity Measures for the DST Scale in Student/Community Samples

	DST-10	DST -LSS	DST -HSS
Convergent validity measures			
MQ	.62/.64	.32/.46	.59/.56
A-MISO-S	.37/.45	.16/.37	.37/.31
HQ	.53/.60	.43/.51	.40/.44
ASQ	.44/.51	.29/.41	.37/.41
HHIA	.18/.32	.23/.36	.07^/.16
Discriminant validity measures			
Mini-TQ	.18^/.40	.19*/.38	.10^/.25
OCI-R	.28/.31	.25/.35	.19/.16
TIPI-N	-.20/-.27	-.12*/-.15	-.19/-.27

Note: Correlation coefficients are presented as student sample *r* value/community sample *r* value, all correlations are significant at $p<.01$, except where indicated: ^$p>.05$, *$p<.05$
Student sample (*N*=451), except A-MISO-S (*n*=314), HHIA (*n*=357), Mini-TQ (*n*=109)
Community sample (*N*=375), except A-MISO-S (*n*=228), Mini-TQ (*n*=105)

Some evidence for convergent and discriminant validity of the DST -10, LSS, and HSS was demonstrated. In particular, a significantly stronger correlation for the HSS with the MQ compared to the correlation of this scale with the LSS provides convergent evidence that the HSS also appears to measure misophonic-type sound sensitivity. However, contrary to prediction, the LSS did not correlate more strongly with the HQ than the HSS. Evidence for discriminant validity was supported in the generally lower correlations found between discriminant validity measures and the DST -10 and its subscales compared to the magnitude of correlations with the convergent validity measures.

Criterion validity. Finally, criterion validity of the two subscales was assessed by evaluating the hit rate of distinguishing individuals meeting clinical criteria for hyperacusis on the HQ or misophonia on the MQ using their scores on the LSS and HSS, respectively. In order to perform these sensitivity and specificity analyses, continuous scores on the LSS and HSS were first converted to categorical scores using an iterative process to determine the most useful cutoff scores for each subscale. Then, cross-tab analyses were performed to identify the conditional probability of correctly identifying an individual with clinically significant hyperacusis or misophonia based on LSS and HSS cut-off scores, respectively. An overview of these analyses can be seen in Tables 14 and 15.

For the LSS, a cutoff score of 5 was identified as providing the highest levels of both sensitivity and specificity. With large numbers of false positives and few false negatives, a positive screen on the LSS is in itself inadequate to confirm the condition (PPV = 38%). It did, however, correctly identify 81% of all cases (the sensitivity). As a screening test, a negative result on the LSS is also very good at reassuring that a patient does not have the disorder (NPV = 88%) but this initial screen only correctly identifies those who do not have hyperacusis at a rate a little higher than chance (53% specificity).

Table 15.

Sensitivity, Specificity, and Predictive Value of the LSS Subscale

		Patients with clinically significant hyperacusis (as confirmed by HQ >28)		
		Condition positive	Condition negative	
LSS subscale score > 5	Test outcome positive	True positive (TP)=176	False positive (FP)=283	Positive predictive value= TP/ (TP +FP)= 176/ (176+283)=**38%**
	Test outcome negative	False negative (FN)=42	True negative (TN)=322	Negative predictive value= TN/ (FN +TN)= 322/(42 +322)=**88%**
		Sensitivity=TP/(TP+FN)= 176 (176+42)=**81%**	Specificity=TN /(FP + TN)=322/ (283+322)=**53%**	

Note: Data presented are for the combined student and community sample (*N*=823) as values were roughly equivalent across samples.

For the HSS, a cutoff score of 10 was selected to optimize clinical utility of the scale. Similar to the LSS, there was a high rate of false positives and few false negatives, indicating that a positive screen on the HSS is in itself poor at confirming the disorder (PPV = 28%). However, it did correctly identify 65% of all cases (the sensitivity). As a screening test, a negative result on the LSS is also very good at ruling out the condition (NPV = 91%) and this initial screen correctly identifies those who do not have misophonia at a rate of 68% (the specificity).

Table 16.

Sensitivity, Specificity, and Predictive Value of the HSS Subscale

		Patients with clinically significant misophonia (as confirmed by MQ Severity >7)		
		Condition positive	Condition negative	
HSS subscale score > 10	Test outcome positive	True positive (TP)=84	False positive (FP)=218	Positive predictive value= TP/ (TP +FP)= 84/ (84+218)=**28%**
	Test outcome negative	False negative (FN)=45	True negative (TN)=470	Negative predictive value= TN/ (FN +TN)= 322/(42 +322)=**91%**
		*Sensitivity=TP/(TP+FN)= 84 (45+84)=**65%**	#Specificity=TN /(FP + TN)=470/ (218+470)=**68%**	

Note: *Sensitivity values differed, with 78% in the student sample and 48% in the community sample, #Specificity values differed, with 94% for the student sample, and 89% in the community sample

Discussion

This large scale survey study investigated emerging conditions of decreased sound tolerance (DST), including misophonia and hyperacusis, as well as tinnitus, with the aims of clarifying prevalence and comorbidity rates, identifying clinical correlates and underlying mechanisms, and developing a scale to assist in identifying these conditions. Adding to a small but growing literature on the DST conditions, misophonia and hyperacusis, this study is the first to investigate these two conditions simultaneously as well as in relation to tinnitus and a wider range of other clinical problems. Most of the prior research on these conditions had been limited to relatively small clinical samples (e.g., Edelstein et al., 2013; Jüris et al., 2013; Schroder et al., 2013), case studies (e.g., Bernstein et al., 2013; Webber et al., 2014), or book chapters or narrative reviews (Andersson et al., 2005; Baguley, 2003; Baguley & McFerran, 2011). Few large scale survey studies investigating the nature of misophonia and hyperacusis within the general population have been conducted, and these studies were limited by reliance on a college student sample (Wu et al., 2014), measurement of a limited range of clinical correlates and potential mechanisms (Taylor et al., 2014; Wu et al., 2014), or use of un-validated measures to assess the presence of misophonia and/or hyperacusis (Andersson et al., 2002; Taylor et al., 2014). This study aimed to address a number of these gaps in the DST literature by assessing the prevalence of DST conditions using well-validated measures in large student and community samples and investigating a number of theories regarding the etiology and maintenance of these conditions to advance understanding, prevention, assessment, and treatment of these emerging behavioral medicine conditions.

Prevalence

We sought to clarify the prevalence rates for misophonia and hyperacusis, explore comorbidity rates across DST conditions and with tinnitus, and examine whether DST conditions differ based on demographic variables.

Based on prior research (Wu et al., 2014), a prevalence rate of approximately 20% was hypothesized for misophonia. In the present study, 15.6% of participants reported clinically significant symptoms on a validated measure of misophonia. There was not a significant difference between students' (16.2%) and community members' (14.9%) report of misophonia symptoms, and the rates of misophonia for students found in this study are roughly equivalent to those previously reported in a large U.S. student sample (95% margin of error is +/- 3.41%) using the same measure (Wu et al., 2014). However, a much larger percentage (60.9%) identified some level of misophonia symptoms when more inclusive screening items are used to classify misophonia. These data provide evidence that a large percentage of the general population experiences non-clinical misophonic-type sound sensitivity, while a smaller, but still substantial, subset of individuals is affected by more clinically significant misophonia symptoms. Such a finding suggests that misophonia occurs along a dimensional spectrum, similar to what has been proposed with regards to other mental health conditions (Brown & Barlow, 2005; Widiger & Samuel, 2005).

It was predicted based on a general population survey conducted in Sweden (Andersson et al., 2002) that hyperacusis symptoms would be present in about 9% of individuals sampled, with 3% having clinically significant symptoms. In contrast with expectations (95% margin of error for prevalence rates in our sample is +/- 3.41%), nearly 17% of all participants reported that sounds cause them pain or physical discomfort on a screening item, and over a quarter of the total sample (26.3%) reported clinically significant hyperacusis symptoms on a validated hyperacusis questionnaire. These rates of hyperacusis are markedly higher than those documented in a Swedish survey study (Andersson et al., 2002), which may be explained by methodological differences between the two studies. In particular, the main item used to classify hyperacusis in the Swedish study was “Do you consider yourself to be sensitive to everyday sounds?”, whereas, in the current study, the hyperacusis screening item was “Do sounds cause you pain or physical discomfort?” It is noteworthy that a larger percentage of individuals responded affirmatively to our screening item, which focuses on a physical reaction to sound, than to the item used in the Swedish study, which asks participants to make a subjective assessment about their degree of sensitivity to sounds. It is possible that individuals with hyperacusis are more likely to attribute their symptoms to physical processes (e.g., pain, physical discomfort) than to abnormal sound sensitivity. The current study was also the first to rely on a standardized measure of hyperacusis (the HQ) to document prevalence rates in both college student and community samples. Future studies should continue to assess multiple aspects of hyperacusis (e.g., physical, emotional, and behavioral components) using established measures to better understand its prevalence and impact across different populations.

Studies in clinical audiology and otolaryngology clinic settings have shown high comorbidity rates between misophonia and hyperacusis as well as with tinnitus (Jastreboff, 2004); therefore, we anticipated elevated but somewhat lower rates of comorbidity within our general population samples. This hypothesis was confirmed, with the likelihood of screening positively for another DST condition or tinnitus based on a positive screen for one of these conditions ranging from 19 to 56%. Positive screenings for tinnitus or for hyperacusis were both particularly predictive of a positive screen for misophonia (20.7% and 37.4%, respectively). These findings are consistent with reports in clinical settings of overlap between these conditions when tinnitus is present (57% for general DST problems, 28.9% misophonia only, 32.9% hyperacusis with or without misophonia; Jastreboff, 2004; Jastreboff & Jastreboff, 2014) and are the first to empirically demonstrate that DST conditions and tinnitus have elevated comorbidity rates in the general population. Consistent with screening, all DST questionnaire measures were found to be significantly correlated with one another as well as with a measure of tinnitus symptoms.

Finally, the role of demographic variables in predicting the presence of DST symptoms was explored. Little research was available to inform our hypotheses in this regard, with the exception that some prior studies and case reports had reported greater frequency of misophonia among women (Edelstein et al., 2013; Hadjipavlou et al., 2008; Neal & Cavanna, 2013; Schroder et al., 2013; Schwartz et al., 2011). Somewhat paradoxically, in this study, males were more likely to screen positively for misophonia, yet females reported greater misophonia symptoms on a validated measure of misophonia. Males also reported more sensory sensitivity and more tinnitus symptoms than females. From these data, it appears that prior studies finding higher rates in women could be explained by two related factors. First, there appears to be a greater severity of misophonia symptoms in females, which may spur more women to seek treatment for their sound sensitivity symptoms, and helps to explain why studies conducted in clinical settings (e.g., Schroder et al., 2013) have found higher rates of misophonia among women. Relatedly, females are more likely in general to seek help for mental health problems than are males (Chandra & Minkovitz, 2006), also potentially leading to the perception that women are more frequently affected by misophonia symptoms. Conversely, no gender differences in misophonia rates or severity were found in a survey study of unscreened college students (Wu et al., 2014). The inclusion of a community adult sample, in which the representation of gender was more balanced than is typical of college student samples, may be the reason that some gender differences were detected in the current study.

Few other demographic variables were related to DST or tinnitus screening and questionnaire responses. Individuals identifying their race/ethnicity as ‘Other’ reported more hyperacusis symptoms and more severe misophonia symptoms. Only half of these respondents provided further information about their racial/ethnic identity, and of those, the largest number identified as Asian, followed by multiracial or biracial, with many other backgrounds represented. Due to the small numbers and diversity in responding, it is difficult to draw any definitive conclusions about why these individuals reported more DST symptoms. Older age was also associated with positive tinnitus screening, more hyperacusis symptoms, higher numbers of health problems and somatic symptoms, and more functional impairment from tinnitus symptoms. These findings are consistent with the conceptualization of tinnitus and hyperacusis in audiology as conditions that can increase in older age due to hearing loss or damage but can also occur across the age spectrum independent of hearing status (Andersson et al., 2002; Baguley & McFerran, 2011; Blaesing, Goebel, Flotzinger, Berthold, & Kroner-Herwig, 2010). Given mostly equivalent prevalence rates across various demographic variables and the lack of systematic differences in symptom endorsement within specific race/ethnicity and/or socioeconomic categories, it appears that DST conditions are not particularly "culturally-bound", at least based on current definitions.

Clinical Correlates

Positive associations for misophonia and hyperacusis with several mental health conditions, including OCD, anxiety, autism spectrum disorders (ASD), and depression, were anticipated based on prior research or theory (e.g., Hesser & Andersson, 2009; Jüris et al., 2013a;b; Schroder et al., 2013; Stiegler & Davis, 2010; Taylor et al., 2014; Wu et al., 2014). The hypothesis that misophonia would show at least a moderate correlation with OCD symptoms was confirmed; however, there was a lack of specificity for this relationship in that hyperacusis and tinnitus also showed equally strong positive associations with OCD. This finding may be explained by the covariance of these other conditions with misophonia, or it could be indicative of a broader association of OCD, tinnitus, and DST. In further support of a specific link between OCD and misophonia, a prior study showing overlap in OCD and auditory sensitivity caseness (Taylor et al., 2014) was replicated using more rigorous criteria for misophonia caseness. Positive medium-sized correlations were also found for misophonia and hyperacusis with general anxiety symptoms, social phobia, and depression. The anticipated link between autism spectrum traits and DST conditions was also supported (Stiegler & Davis, 2010), but the strongest association was detected between autistic traits and tinnitus symptoms.

The overlap in clinical caseness between OCD and misophonia was consistent with prior research (Schroder et al., 2013; Taylor et al., 2014), and this study built upon previous investigations in that these phenomena were assessed in the general population rather than in a psychiatric clinic (e.g., Schroder et al., 2013) and the methods for assessing the presence and clinical significance of misophonia were more rigorous than those previously employed (e.g., Taylor et al., 2014).

The strong relationship between ASD traits and tinnitus was unexpected, and to our knowledge, no studies have examined the association between these conditions, nor have researchers predicted that they would be highly correlated. As predicted, there were also significant positive associations between ASD traits and misophonia and hyperacusis symptoms. One prior clinical opinion article (Stiegler & Davis, 2010) had predicted a strong association between ASD, hyperacusis, and misophonia, noting that strong reactions and aversions to sounds (as well as other sensory stimuli) are commonly reported in children with ASDs and that they appear to be emotionally and behaviorally manifested rather than the product of an anatomical auditory problem related to the ASD.

A positive association was also predicted between hyperacusis and tinnitus with neurobehavioral/concussive symptoms (tinnitus and hyperacusis only; Landon et al., 2012), and medical diagnoses/somatic symptoms (hyperacusis and tinnitus only; Baguley, 2003; Ganz-Sanchez & Bezerra-Rocha, 2011). Similar to many of the hypothesized clinical correlates, neurobehavioral/concussive symptoms showed medium to large associations with misophonia, tinnitus, and hyperacusis symptoms, with no reliable differences in the strength of these relationships. Finally, the hypothesized relationship between medical diagnoses/somatic symptoms and hyperacusis and tinnitus was confirmed, but only within the community sample. This finding is likely explained by the association of these symptoms with increased age, a relationship that could not be detected due to the limited age range represented in the student sample.

In sum, this study provided additional support for previously identified clinical correlates of DST conditions (e.g., anxiety, OCD; Jüris et al., 2013; Taylor et al., 2014; Wu et al., 2014), while confirming other correlates that had been previously hypothesized (e.g., ASDs, depression, post-concussive syndrome, medical conditions; Stiegler & Davis, 2010; Jüris et al., 2013a; Landon et al., 2012; Baguley, 2003; Ganz-Sanchez & Bezerra-Rocha, 2011) but had not yet been confirmed with research. However, there was a lack of specificity in the relationships between DST symptoms and hypothesized clinical correlates, suggesting that common mechanisms of action and/or overlap in the way that these constructs are evaluated could account for some of these unexpected relationships. Future research will be needed to better disentangle the extent to which these relationships are explained by true clinical comorbidity or by covariance in assessment tools.

Mechanisms of Action and Individual Differences

Mechanisms by which symptoms of misophonia and hyperacusis were hypothesized to cause more serious functional problems included anxiety sensitivity, emotion regulation difficulties, distress and discomfort intolerance, and amplification of bodily sensations. Correlational analyses provided support for anxiety sensitivity, anger, emotion regulation difficulties, distress intolerance, and somatic amplification as potential mechanisms involved in misophonia and hyperacusis. Contrary to expectation, no associations with discomfort intolerance were found.

In order to better model some of these hypothesized pathways, three mediation models were tested. The first two models assessed anxiety sensitivity, emotion regulation, distress intolerance, and somatosensory amplification as potential mediators of the relationship between misophonia symptoms (i.e., sensitivity to specific sounds) and two dependent variables: 1) misophonia severity (i.e., the degree of distress and interference caused by these symptoms) and 2) hearing-related functional impairment (i.e., general social and emotional distress and impairment associated with a hearing-related problem). These first two models sought to evaluate and compare mechanisms of action that have been implicated in the etiology and maintenance of other behavioral medicine conditions (e.g., panic disorder, chronic pain, tinnitus) (e.g., Andersson, 2002; Andersson et al., 2005; Barlow, 2002; 2005; Brown, 2004; Cuijpers et al., 2008; De Peuter et al., 2011; Greimel & Kroner-Herwig, 2011a) that are proposed to be theoretically similar to misophonia (Schroder et al., 2013; Webber & Storch, 2015; Wu et al., 2014).

In the first model, only somatosensory amplification was found to intervene in the association between misophonia symptom presence and their severity, indicating that misclassification of benign auditory sensations (e.g., detecting loud chewing) as threatening may be an important explanatory variable in the pathology of misophonia. The second model supported both somatosensory amplification and anxiety sensitivity as mediators of the relationship between misophonia symptoms and hearing-related handicap. However, somatosensory amplification showed an inverse association with hearing-related handicap, while the opposite pattern was seen for anxiety sensitivity. No evidence for emotion regulation or distress intolerance as intervening variables was found. Although a robust literature exists to support the role of emotion regulation in various forms of psychopathology (e.g., depression, anxiety disorders, somatoform disorders) (for review, see Berking & Wupperman, 2012), it may be that dysregulation of emotion is too broad a concept to account for variance in misophonia symptom severity. Similarly, a review of the distress tolerance construct noted that a non-linear relationship between distress tolerance and psychopathology might be anticipated, based on the emerging hypothesis that both extremely high and low levels of distress tolerance may be maladaptive (Leyro, Zvolensky, & Bernstein, 2010). Thus, while emotion regulation and distress tolerance do not appear to act as amplifying variables in the process by which misophonia symptoms become functionally impairing, a more complex role for these factors in the etiology and/or maintenance of misophonia (as well as hyperacusis) may be identified in future research. Future studies should examine emotion regulation and distress tolerance as potential moderators in misophonia's pathogenesis, given that some researchers have argued that these factors should be conceptualized as more stable traits (Berking & Wupperman, 2012; Leyro et al., 2010).

The third mediation model attempted to replicate and extend a model demonstrated in prior research (Wu et al., 2014) in which anxiety mediated the association between misophonia symptom presence and rage reactions. This temporal sequence of anxiety leading to anger reactions has also been proposed as an explanation for rage reactions observed in adolescents with obsessive-compulsive symptoms in Tourette's syndrome (Budman et al., 2008) and has been documented in adolescent misophonia patients (Johnson et al., 2013). In Wu and colleagues' model, anxiety was measured using a symptom scale, whereas in this study, a measure of anxiety sensitivity was employed as the mediator, and a general measure of anger substituted for the measure of rage reactions. As predicted, anxiety sensitivity mediated the relationship between misophonia symptoms and anger. This finding further bolsters existing theory proposed by Wu and colleagues (2014) for anxiety as an important maintaining factor in misophonia and lends support for using evidence-based anxiety disorder treatment strategies to address misophonia symptoms.

It was also anticipated that individuals with misophonia or hyperacusis might differ from other individuals in certain ways, based on similarity and overlap with tinnitus and theoretical similarity to other behavioral medicine conditions. Proposed individual difference variables of interest included neuroticism/emotional stability, music reward (Mas-Herrero et al., 2013), and synesthesia (misophonia only; Edelstein et al., 2013). Neuroticism was positively related to DST conditions and to tinnitus. No association between music reward and DST symptoms was detected; however, the measure of music reward was only administered to a limited number of subjects in the student sample. Synesthesia was related to misophonia symptoms and severity, but this was most consistently shown within the community sample. Unexpectedly, hyperacusis and tinnitus were also positively associated with synesthesia experiences, suggesting that this proposed individual difference factor is not unique to misophonics.

Moderation analyses with select individual difference measures were performed to more closely examine risk factors for developing clinically significant misophonia symptoms. None of the proposed moderators (synesthesia, neuroticism, sensory sensitivity) significantly impacted the association between misophonia symptoms and their severity, but these variables did have an influence on the association between misophonia symptoms and hearing-related functional impairment.

Taken together with the mediation results, it is interesting to note that the only variable found to contribute to the association between misophonia symptoms and their severity was amplification of bodily sensations, while a broader range of mechanisms and individual difference variables were implicated in the relationship between misophonia symptom presence and the degree of hearing-related handicap. This discrepancy may be due to the more general nature of the hearing-related handicap construct, compared to the specificity and more direct linkage between misophonia symptoms and their severity. More complex process models, which include moderators, mediators, and moderated mediation, should be tested in future studies in order to fully explain the multifactorial pathways by which misophonia develops and is maintained. These models should also be extended to test their relevance for the etiology and maintenance of hyperacusis, which is anticipated to have similar risk factors and mechanisms. The predominant hypothesis in audiology that hyperacusis results from abnormally strong reactivity of the auditory pathways, while misophonia results from abnormally strong functional connections between the auditory, limbic and autonomic systems for specific patterns of sound (Baguley, 2003; Jastreboff & Jastreboff, 2003; 2004; 2006) was not directly evaluated in this study. Findings from this study supporting the role of somatosensory amplification and anxiety sensitivity in the development of clinically significant misophonia support the notion that the interpretation or meaning of the sound is paramount in misophonia. However, the strong correlations shown in this study for hyperacusis with these same factors and prior research highlighting the role of emotional stress in predicting hyperacusis symptoms (Hasson et al., 2013; Jüris et al., 2013a;b) suggest that the underlying mechanisms involved in hyperacusis and misophonia are likely to be more similar than different.

Scale Development

This study aimed to develop and provide initial evidence of reliability and validity for an assessment tool that could aid in identifying and differentiating hyperacusis and misophonia. A collection of initial items was generated by a panel of behavioral medicine researchers, based on a review of the DST literature, with the goal of differentiating hyperacusis and misophonia based on the types of sounds that are aversive/cause distress. Forty-one items were generated that were intended to capture three types of sound sensitivity: hyperacusis-type (i.e., medium and low volume environmental sounds), misophonic-type (i.e., human-produced, repetitive or potentially annoying/disgusting sounds), and normal-type (i.e., startling or extremely disgusting sounds likely to be aversive to most individuals).

A three-factor structure based on these delineations was hypothesized. EFA and CFA procedures were followed to identify a suitable factor structure and determine appropriate factor loadings for the strongest items. Through this iterative process, the scale was winnowed down to ten items with a two-factor solution, with five items loading cleanly onto each factor. The factors were named the Loudness Sensitivity Scale (LSS; Factor 1) and Humans Sounds Scale (HSS; Factor 2), with loud sound items loading on the LSS (truck, traffic, concert, siren, horn) and human-produced sounds loading on the HSS (eating, hand sounds, pen clicking, nails on a chalkboard). Although a three-factor solution was not supported, this two-factor solution aligns with the hypothesis that hyperacusis-type and misophonia-type sound sensitivities would load on distinct factors. These items are also very consistent with the sound sensitivity profiles reported in previous studies and case reports describing hyperacusis and misophonia triggers (Aazh et al., 2014; Jastreboff & Jastreboff, 2014; Wu et al., 2014).

Analyses of internal consistency lent initial support for the reliability of the two subscales, as well as the overall total scale, the DST -10. Evidence supporting construct validity based on additional EFAs with items from other validated measures of similar constructs was mixed. However, higher correlations found with convergent validity measures than with discriminant validity measures provided some support for the scale and subscales' construct validity. Finally, criterion validity for the two subscales was assessed by examining the sensitivity and specificity values for each subscale in predicting the presence or absence of clinically-significant symptoms based on an established scale. These analyses revealed that the LSS and HSS are primarily suitable for "ruling out" hyperacusis and misophonia, respectively, but perform less well in definitively identifying the presence of these conditions. An important caveat to these results is that the established scales used in our validation efforts are themselves relatively new and have not been widely used. The MQ was previously validated in a college student sample and showed adequate internal reliability and some support for convergent validity with the auditory items of the ASQ, but the authors did not examine its association with the A-MISO-S, the only other misophonia assessment tool available to date. Similarly, the HQ has also been shown to have adequate psychometric properties, but the authors of a recent study examining its association with anxiety symptoms and the ULL (Jüris et al., 2013b) proposed lowering the clinical cut-off score, at least within Swedish samples. Furthermore, as a general note, evidence for the reliability and validity of current working definitions for misophonia and hyperacusis as underlying latent constructs is in its early stages of accrual, and these definitions may continue to evolve as additional research is completed. Taken in sum, we conclude that the DST -10 and its subscales, the LSS and HSS, appear best suited to be used as a screening tool in the general population to identify and rule out hyperacusis-type or misophonic-type sound sensitivity.

Summary, Implications, and Future Research Directions

This study is the first to investigate two emerging behavioral medicine conditions—misophonia and hyperacusis— in two large, representative general population samples. These data are the first to provide comprehensive coverage of prevalence rates, clinical correlates, individual difference variables, and mechanisms of action, and pave the way for many future investigations of DST conditions. Within each of the four aims of this study, significant progress was made towards gaining a better understanding of DST. In Table 17, an overview of the knowledge base for DST and related conditions to date is provided, integrating prior empirical data with the results of this study. Information that was added based on the current study is displayed in bold italics, and information that remains consistent from prior research is shown in regular text.

Establishing prevalence rates for misophonia and hyperacusis within the general population is an important contribution of this study. Multi-method assessment of these constructs, including basic screening items as well as more comprehensive measures with clinical ranges, strengthens our knowledge about the impact of these conditions within the population, their interaction with various demographic variables, and the spectrum of severity along which they occur. This study is also the first to collect data simultaneously on DST conditions, tinnitus, and relevant mental health conditions within the general population, providing the first empirical data in support of their theorized clinical overlap and comorbidity. The broad range of prevalence rates reported in this

Table 17.

Updated Classification of DST and Related Conditions Based on Current Study

Diagnostic label	Defining symptoms	Typical emotional and behavioral responses	Prevalence rates	Clinical correlates	Mechanisms and individual difference variables	Assessment tools
Decreased sound tolerance	Term used to encompass conditions related to increased sensitivity to sound or specific sound triggers, that occurs not only in the context of another diagnosed medical or psychiatric illness (e.g., not only during migraine attacks)	General emotional distress, anxiety, depression, avoidance	***34.9% general auditory intolerance, 1.8% receive diagnosis, 2.5% receive treatment*** (15% Polish general population, 40-60% tinnitus clinic samples)	Tinnitus, ***other DST conditions, anxiety and depression, ASD, medical diagnoses, post-concussive symptoms***	Anger, ***anxiety sensitivity, neuroticism, emotion dysregulation, sensory sensitivity, somatosensory amplification***	***DST -10 for general screening, HHIA for functional impact***
Hyperacusis	Sensitivity to sounds below normal sound sensitivity thresholds that is not primarily explained by a hearing problem or another medical issue	Anxiety, fear, general emotional distress, physical pain	***16.9% positive screen, 26.3% clinically significant symptoms, <1% diagnosed*** (8-9% Swedish general population, 32.9% tinnitus clinics)	***Misophonia,*** tinnitus, ***OCD,*** depression, anxiety, ***ASD, medical diagnoses and post-concussive symptoms***	Same as above, not explored further in this study	***DST -LSS,*** HQ, GUF, NAQ

Table 17 continues

Table 17 continued

Misophonia	Extreme aversion to specific sound triggers, usually produced by other humans	Annoyance/irritation, disgust, anger, anxiety	***16.2% screen positive and 15.6% clinically significant symptoms, <1% diagnosed*** (20% U.S. college students, 28.9% tinnitus clinics)	***Hyperacusis, tinnitus, OCD, ASD,*** anxiety, ***depression***, ***social anxiety, medical diagnoses, and post-concussive symptoms***	***Somatosensory amplification, anxiety sensitivity (mediators), neuroticism, synesthesia, sensory sensitivity (moderators)***	***DST -HSS,*** MQ, A-MISO-S
Tinnitus	Intermittent or continuous ringing, roaring, or buzzing in the ear(s) or head that has lasted 3 months or longer in the past year	Emotional distress, anxiety, anger, depression	***26% general population, 15% for more than 1 year, 4% diagnosed*** (20% U.S. general population)	***ASD,*** anxiety, depression, medical diagnoses, post-concussive symptoms	Same as DST, not explored further in this study	Mini-TQ

study (e.g., misophonia prevalence ranging from 60.9% on screening to 16.2% for clinically significant symptoms) suggests that experiences of auditory sensitivity are commonly experienced in the general population, but symptoms that cause emotional distress and impairment occur less frequently. Given high rates of comorbidity for other mental health and behavioral medicine conditions, an important next step is to examine rates of misophonia and hyperacusis in mental health treatment seeking and adult and pediatric primary care samples, because it is anticipated that rates of clinically significant symptoms would be elevated in these groups. Since DST result in social and behavioral withdrawal, their symptoms may increase functional impairment among people with other mental health conditions.

Similarly, the assessment of proposed clinical correlates lends the first empirical evidence for some hypothesized associations (e.g., ASD, depression) and bolsters existing data for previously identified relationships (e.g., OCD, anxiety, anger). However, the causal direction of these relationships remains unclear, and longitudinal data is needed to reveal the clinical course of DST within the context of other relevant mental and physical health problems. For example, many case studies have reported onset of misophonia in adolescence (Bernstein et al., 2014; Johnson et al., 2013; McGuire et al., 2015), but many of these cases had other comorbid diagnoses, raising the question of which condition came first and to what extent addressing the symptoms of one might generalize to another. Overall, the correlational findings indicate that DST conditions, tinnitus, and several mental health conditions (i.e., OCD, anxiety, ASD, depression) are closely linked, but additional research will be needed to disentangle the nature of these associations. Specifically, future treatment studies should prioritize inclusion of individuals with relevant comorbid conditions (e.g., OCD, tinnitus) and should document change in symptom presence and severity for these conditions as well as DST symptoms.

The assessment of proposed individual difference variables and mechanisms of action involved in the etiology and maintenance of DST also makes a substantial contribution to the nascent literature on these conditions and has important treatment implications. In particular, the finding that amplification of bodily sensations intervenes in the relationship between misophonia symptom presence and severity provides the first empirical support for conceptualizing misophonia as a behavioral medicine condition. As has been demonstrated with chronic pain, panic disorder, and other conditions conceptualized from a bio-psychosocial perspective, this model suggests that misophonia develops and is maintained, at least in part, by the misattribution of neutral sensory stimuli as threatening. In the case of misophonia, the stimuli are external sound triggers, whereas, in panic disorder or chronic pain, the stimuli are internal cues, but the common tendency to amplify a sensation, resulting in greater distress and impairment, links these conditions. Because evidence-based treatment approaches for these conditions typically operate by modifying cognitive interpretations, this finding provides a strong theoretical basis for applying CBT to modify cognitions about misophonia triggers to reduce distress and impairment associated with misophonia symptoms. In general, the strong associations found between DST conditions and psychological mechanisms known to operate in other mental health problems calls further into question the prevailing assumption in audiology and ENT— that DST conditions result at least in part from deficits in auditory processing and that successful treatment requires use of noise generators. Rather, it appears that psychological factors are key to conceptualizing and treating these conditions, as demonstrated by recent case reports and an RCT of successful treatment with CBT (Bernstein et al., 2014; Jüris et al., 2014; McGuire et al., 2015) and further justified by the identification of specific psychological mechanisms and individual difference variables in this study.

Development of the DST-10 and its subscales, the LSS and HSS, provides the first instrument specifically designed to assess for the presence of DST symptoms and to identify hyperacusis and misophonia type sound sensitivities in the general population. This study found initial evidence to support the reliability and validity of this tool for use among college students and community adults. In order to assess the clinical utility of this tool, it is recommended that future work should apply this tool within a treatment-seeking clinical sample (e.g., tinnitus specialty clinic, community mental health clinic) in an effort to identify clinical cutoff scores or ranges that aid in identifying and potentially diagnosing individuals with misophonia or hyperacusis.

An emerging area for debate (and future research) is whether misophonia and hyperacusis are best conceptualized and treated as more traditional mental health conditions (e.g., OCD, ASD) or as behavioral medicine conditions (e.g., chronic pain, tinnitus). While a bio-psychosocial perspective calls into question this artificial division of "mental" and "physical" health, the fact remains that such divisions persist and have implications for the manner in which a condition is conceptualized, assessed, and treated. Thus far, it appears that research in audiology and ENT have approached these conditions using theory and methods more closely aligned with a biological basis, while the research published in psychological journals has drawn parallels to traditional psychiatric disorders. This study aimed to incorporate both perspectives in an effort to work towards a truly bio-psychosocial conceptualization of DST conditions. It is our view that future research in this area will be best served by collaborating across disciplines to arrive at an integrative framework for prevention, assessment, and treatment of DST conditions.

Limitations

The primary limitation of this study is the use of a cross-sectional research design, which limits the opportunity to investigate temporal and causal relationships. In the mediation analyses reported within this study, we sought to test theorized causal relationships between proposed mechanisms of action (e.g., anxiety sensitivity) and outcomes (e.g., misophonia symptom severity). However, it is important to note that the presumed direction of the causal relationships proposed in this study cannot be confirmed and may in fact operate in a different temporal sequence, due to the cross-sectional nature of this data. Therefore, it is also plausible, for example, that more severe misophonia symptoms led to heightened anxiety sensitivity, either directly or through some other mechanism that was not evaluated in this study. Relatedly, because none of the variables evaluated in this study were experimentally manipulated, we cannot confirm that the hypothesized causal relationships are legitimate. Longitudinal work as well as experimental studies in which the variables of interest are manipulated will be needed to confirm the direction of the relationships identified in this study.

This study is also limited by its reliance on a quantitative survey format to assess an emerging area. Although the use of multiple types of measures (e.g., screening, standardized, and newly developed) is a strength of this investigation, none of the included measures provided opportunities for feedback or qualitative responses from participants. The inclusion of free-response style items as well as more open-ended, in-person study formats (e.g., focus groups) may be useful in future studies of DST in order to spark new research directions.

A final limitation of this study is the lack of assessment of the social/relational aspects of DST conditions. Some prior studies (e.g., Edelstein et al., 2013) and case reports (e.g., Bernstein et al., 2013) found that misophonics experience their triggers as more aversive when the sounds are made by certain individuals (e.g., family members, a significant other) than by others (e.g., strangers, oneself). As these social elements are likely to be important in conceptualizing treatment of misophonia (and potentially hyperacusis), researchers should focus on these factors in future investigations of DST.

Conclusion

This empirical survey of DST conditions provides the most comprehensive documentation to date of the prevalence and comorbidity rates, clinical correlates, individual differences, and underlying mechanisms of action of misophonia and hyperacusis in representative undergraduate and community samples. Prevalence rates of clinically significant misophonia and hyperacusis symptoms (15-20%) are on par with or higher than rates for other common mental health problems, suggesting that these conditions represent an under-recognized public health concern. Associations between DST symptoms and other mental health symptoms were found, with elevated rates of comorbidity across DST conditions, tinnitus, and between OCD and misophonia. At the same time, mechanisms of action (e.g., somatic amplification, anxiety sensitivity) and individual difference risk factors (e.g., neuroticism) that are common to both DST and other mind-body illnesses (e.g., chronic pain, panic disorder) provide a basis for applying behavioral medicine treatment approaches (e.g., CBT, mindfulness) to address DST symptoms. On the other hand, factors that are unique to misophonia and hyperacusis (e.g., synesthesia, sensory sensitivity) suggest distinct pathways and imply that novel approaches and collaboration with multidisciplinary healthcare providers will be the surest route to understanding and successfully treating these clinical problems. Finally, the DST Scale, which was developed and subjected to psychometric validation in this study, provides a brief assessment tool to quickly screen for the presence of DST symptoms and to differentiate between misophonic- and hyperacusis- type sound sensitivity profiles. In sum, this study represents the most extensive and methodologically-sound classification of misophonia and hyperacusis as novel behavioral medicine conditions documented in the general population and provides a strong empirical basis for launching a research agenda focused on the characterization, prevention, and treatment of DST conditions.

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Appendix A

Measures

DST and related measures

DST and tinnitus screening items

Introductory statement:
Before you answer these questions, please keep in mind that we are evaluating three different things: (1) tinnitus, (2) sound tolerance, (3) hearing. Each question is specific to tinnitus, sound tolerance, or hearing. Tinnitus refers to any kind of sound in your head- ringing, hissing, and so on. Sound tolerance refers to how you react to different sounds in your environment. Hearing refers to your ability to detect sounds in your environment or to your ability to understand the speech of others.

Tinnitus:

1. Do you experience ringing, roaring, or buzzing in your ears or head?
Yes No

2. How long have you experienced this symptom?
Less than 3 months
3-6 months
6 months-1 year
Longer than 1 year

Sound tolerance:

1. Do you have a decreased tolerance to sound? That is, are sounds bothersome or unpleasant to you when they seem normal to other people (family and friends) around you?
Yes No

2. If yes, how old were you when you first noticed that you have a decreased tolerance to sound?
_______years old

3. Do sounds cause you pain or physical discomfort?
Yes No

4. Compared to other people, are you sensitive to certain sounds made by other people. Examples might include the sound of people eating, repetitive tapping, rustling, nasal sounds, throat sounds, consonants and/or vowels, or other environmental sounds.

Yes No Sometimes

5. Please select the specific emotion(s) that you most often experience in response to sounds that bother you:

Anger
Disgust
Fear
Anxiety
Sadness
Guilt
Other (please specify):

Hearing:

1. Do you have difficulty detecting sounds in your environment and/or understanding the speech of others?

2. Have you ever worn hearing aids?

Yes No

3. Have you ever had hearing aids recommended to you?

Yes No

General Sensory Intolerance:

1. Tactile intolerance: "I am very bothered by certain tactile sensations, such as clothing textures or tightness; substances that feel sticky, greasy, or wet, or activities like haircuts or cutting my nails."

Yes No

2. Auditory intolerance: "I am very bothered by certain auditory sensations, such as the sound of alarms sirens, appliances, or background noises like people talking or ticking clocks."

Yes No

(Taylor et al., 2014)

Decreased Sound Tolerance Scale (DST Scale)

Cash, Sheerin, Gulin, & Vrana

Please rate your level of discomfort in response to the following sounds on a 1 (Does not bother me at all/Not at all aversive), 2 (Bothers me a little bit/Slightly aversive), 3(Bothers me a moderate amount/Moderately aversive) to 4 (Bothers me intensely/Extremely aversive) scale. Imagine that you are hearing these sounds while you are not wearing any ear protection.
For those sounds that you indicate give you at least some discomfort, please select and rate the intensity of the emotion(s) you experience.

(For all items endorsed at 2, 3, or 4 above, the following drop-down boxes will be provided)

Most prominent emotion(s):

Anger/rage
Disgust
Guilt
Fear
Anxiety
Sadness
Other: __________ (please specify)

(For all emotions selected above, the following drop-down box will be provided)

Please rate the intensity of the emotion using the following scale (1=low intensity, 10= highest intensity possible).

(Sound stimuli items provided in order)

1. Eating sounds (e.g., chewing, lip smacking, crunching, slurping, swallowing, etc.)

2. Breathing/nose sounds

3. Finger/hands sounds (e.g., finger snapping, finger tapping, fingers drumming on table, knuckle cracking)

4. Foot/leg sounds (e.g., foot tapping, ankle cracking, footsteps)

5. Repetitive visual movements (e.g., leg twitching, blinking, etc.)

6. Pen clicking

7. Clock or watch ticking

8. Low frequency bass sounds (e.g., music playing nearby, music leaking through someone's headphones, music playing in a car beside you)

9. Whistling or humming sounds

10. Typing on a computer keyboard (or other repetitive computer sounds)

11. Rustling or crinkling sounds (e.g., opening a plastic bag, moving papers around)

12. Throat and nose sounds (e.g., throat clearing, coughing, sniffling, sneezing)

13. Consonant or vowel sounds (e.g. 'k' sound, 'o' sound, etc.)

14. Baby or animal eating sounds

15. Whispering

16. Talking at low to moderate volume

17. Electronic sounds (e.g., computer booting up, text message alert, phone ringing)

18. TV or radio playing at a moderate volume while you are in the room.

19. TV or radio playing at a moderate volume while you are in the next room.

20. Large truck or bus driving by while you are on the sidewalk

21. Traffic noise you can hear from inside your home or other building

22. Car horn while you are inside of a car or other vehicle

23. Audience applause

24. Loud music at a concert

25. Dog barking nearby

26. Vacuum that you are operating

27. Vacuum running in the next room

28. Children laughing nearby

29. Heavy rainfall

30. Fire/smoke alarm

31. Ambulance sirens

32. Nails on a chalkboard

33. Screeching tires

34. Gunshot

35. Baby crying

36. Man or woman screaming

37. Thunder

38. Construction noises (i.e., beeping when machine backing up, loud thumps, jackhammer)

39. Burping sounds

40. Farting sounds

41. Vomiting sounds

Amsterdam Misophonia Scale (**A-MISO-S**)

Current Severity of Misophonia Symptoms: This rating scale is designed to rate the severity and type of symptoms in individuals with misophonia (emotional distress and/or impairment in daily living caused by sensitivity to specific sounds produced by other humans, such as chewing, lip smacking, talking, leg tapping, etc.). Rate the characteristics of each item during the past week, including today. Your ratings should reflect the average occurrence of each item for the entire week.

List the misophonic sounds that trigger the most irritation, anger or disgust:

____

1. How much of your time is occupied by misophonic sounds? (How frequently do the thoughts about the misophonic sounds occur?)

None

Mild, less than 1hr/day, or occasional (thoughts about) sounds (no more than 5 times a day).

Moderate, 1 to 3 hrs/day, or frequent (thoughts about) sounds (more than 8 times a day, most of the hours are unaffected).

Severe, greater than 3 hrs and up to 8 hrs/day or very frequent (thoughts about) sounds.

Extreme, greater than 8 hrs/day or near constant (thoughts about) sounds.

2. How much do these misophonic sounds interfere with your social functioning? (Is there anything that you don't do because of them? If currently not working estimate how much your performance would be affected if you were employed).

None

Mild, slight interference with social or occupational activities, but overall performance not impaired.

Moderate, definite interference with social or occupational performance, but still manageable.

Severe, causes substantial impairment in social or occupational performance.

Extreme, incapacitating.

3. How much distress do the misophonic sounds cause you? (Distress may include irritation, anger, or disgust. Only rate the emotion that seems triggered by misophonic sounds, not generalized irritation or irritation associated with other conditions).

None

Mild, occasional irritation/distress, not too disturbing.

Moderate, disturbing irritation/anger/disgust, but still manageable.

Severe, very disturbing irritation/anger/disgust.

Extreme, near constant and disabling anger/disgust.

4. How much of an effort do you make to resist (the thoughts about the) misophonic sounds? (How often do you try to disregard or turn your attention away from these sounds? Only rate the effort made to resist, not success or failure in actually controlling the thought or sound).

None

Mild, less than 1hr/day, or occasional (thoughts about) sounds (no more than 5 times a day).

Moderate, 1 to 3 hrs/day, or frequent (thoughts about) sounds (more than 8 times a day, most of the hours are unaffected).

Severe, greater than 3 hrs and up to 8 hrs/day or very frequent (thoughts about) sounds.

Extreme, greater than 8 hrs/day or near constant (thoughts about) sounds.

5. How much control do you have over the misophonic sounds? (How successful are you in stopping or diverting your thinking about the misophonic sounds? Can you dismiss them?)

Complete control.

Much control, usually able to stop or divert thoughts about misophonic sounds with some effort and concentration.

Moderate control, rarely successful in stopping or dismissing thoughts about misophonic sounds, can only divert attention with difficulty.

No control, experienced as completely involuntary, rarely able to even momentarily alter thinking about misophonic sounds.

6. Have you been avoiding doing anything, going any place or being with anyone because of your misophonia? (How much do you avoid, for example, by using other loud sounds, such as music?)

No deliberate avoidance.

Mild, minimal avoidance. Less than 1 hr/day, or occasional avoidance.

Moderate, some avoidance. 1 to 3 hrs/day and frequent avoidance.

Severe, much avoidance. Greater than 3 and up to 8 hrs/day. Very frequent avoidance.

Extreme, very extensive avoidance. Greater than 8 hrs/day. I do almost everything that I can to avoid triggering symptoms.

What would be the worst thing that could happen (to you) if you were not able to avoid the misophonic sounds? Describe.

Misophonia Questionnaire (**MQ**)

Directions: Please rate how much the following statements describe you on a scale from 0 to 4, 0 being "Not at all true" and 4 being "Always true."

0-----------------------1-----------------------2 -----------------------3 ------------------------4
Not at all True   Rarely True   Sometimes True   Often True   Always True

In comparison to other people, I am sensitive to the sound of:
1. People eating (e.g. chewing, swallowing, lips smacking, slurping, etc.).
2. Repetitive tapping (e.g. pen on table, foot on floor, etc.).
3. Rustling (e.g. plastic, paper, etc.).
4. People making nasal sounds (e.g. inhale, exhale, sniffing, etc.).
5. People making throat sounds (e.g. throat-clearing, coughing, etc.).
6. Certain consonants and/or vowels (e.g. "k" sounds, etc.).
7. Environmental sounds (e.g. clock ticking, refrigerator humming, etc.).
8. Other: ______________________________

Directions: If any of the aforementioned statements were given a value of "1 – Rarely True" or higher, please continue onto the following section and rate how often the subsequent statements occur, 0 being "Never" and 4 being "Always."

0-----------------------1-----------------------2 -----------------------3 -----------------------4
Never Rarely Sometimes Often Always

Once you are aware of the sound(s), because of the sound(s), how often do you:

1. Leave the environment to a place where the sound(s) cannot be heard anymore?
2. Actively avoid certain situations, places, things, and/or people in anticipation of the sound(s)?
3. Cover your ears?
4. Become anxious or distressed?
5. Become sad or depressed?
6. Become annoyed?
7. Have violent thoughts?
8. Become angry?
9. Become physically aggressive?
10. Become verbally aggressive?
11. Other: ______________________________

Directions: Please rate the severity of your sound sensitivity on the following scale from 1 (minimal) to 15 (very severe). Please consider the number of sounds that you are sensitive to, the degree of distress, and the impairment in your life due to your sound sensitivities.

If you do not have any sound sensitivities, please check here. ________

Minimal within range of normal or very mild sound sensitivities. I spend little time resisting or being affected by my sound sensitivities. Almost no or no interference in daily activity.
Mild sound sensitivities. Mild sound sensitivities that are noticeable to me and to an observer, cause mild interference in my life and which I may 6 resist or be affected for a minimal period of time. Easily tolerated by others.
Moderate sound sensitivities. Sounds sensitivities that cause significant interference in my life and which I spend a great deal of conscious energy resisting or being affected by. Require some help from others to function in daily activity.
Severe sound sensitivities. Sound sensitivities that are crippling to me, interfering so that daily activity is “an active struggle.” I may spend full time resisting my sound sensitivities or being affected by them. Require much help from others to function.
Very severe sound sensitivities. Sound sensitivities that completely cripple me so that I require close supervision over eating, sleeping, and so forth. It is hard to function on a day-to-day basis because of this.

Hyperacusis Questionnaire (HQ)

In the following questionnaire, put a cross in the box corresponding to the answer which best applies to you:

	No	Yes, a little	Yes, quite a lot	Yes, a lot
1) Do you ever use earplugs or earmuffs to reduce your				

noise perception (Do not consider the use of hearing protection during abnormally high noise exposure situations)?				
2) Do you find it harder to ignore sounds around you in everyday situations?				
3) Do you have trouble reading in a noisy or loud environment?				
4) Do you have trouble concentrating in noisy surroundings?				
5) Do you have difficulty listening to conversations in noisy places?				
6) Has anyone you know ever told you that you tolerate noise or certain kinds of sound badly?				
7) Are you particularly sensitive to or bothered by street noise?				
8) Do you find the noise unpleasant in certain social situations (e.g. night clubs, pubs or bars, concerts, firework displays, cocktail receptions)?				
9) When someone suggests doing something (going out, to the cinema, to a concert, etc.), do you immediately think about the noise you are going to have to put up with?				
10) Do you ever turn down an invitation or not go out because of the noise you would have to face?				
11) Do noises or particular sounds bother you more in a quiet place than in a slightly noisy room?				
12) Do stress and tiredness reduce your ability to concentrate in noise?				
13) Are you less able to concentrate in noise towards the end of the day?				
14) Do noise and certain sounds cause you stress and irritation?				

Mini Tinnitus Questionnaire (Mini TQ)

The purpose of this questionnaire is to find out whether the noises in your ears / head have had any effect on your moods, habits or attitudes. Please mark the answer that applies to you to each statement (only one answer is possible).

Answer choices:
True =2 points; Partly true = 1 point; Not true = 0 points

1	I am aware of the noises from the moment I get up to the moment I sleep.
2	Because of the noises I worry that there is something seriously wrong with my body.
3	If the noises continue my life will not be worth living.
4	I am more irritable with my family and friends because of the noises.
5	I worry that the noises might damage my physical health.
6	I find it harder to relax because of the noises.
7	My noises are often so bad that I cannot ignore them.
8	It takes me longer to get to sleep because of the noises.
9	I am more liable to feel low because of the noises.
10	I often think about whether the noises will ever go away.
11	I am a victim of my noises.
12	The noises have affected my concentration.

Clinical correlate measures

Neurobehavioral Symptom Inventory (NSI)

Please rate the following symptoms with regard to how much they have disturbed you IN PAST THE MONTH:
0 = None- Rarely if ever present; not a problem at all
1 = Mild- Occasionally present, but it does not disrupt activities; I can usually continue what I'm doing; doesn't really concern me.
2 = Moderate- Often present, occasionally disrupts my activities; I can usually continue what I'm doing with some effort; I feel somewhat concerned.
3 = Severe- Frequently present and disrupts activities; I can only do things that are fairly simple or take little effort; I feel like I need help.
4 = Very Severe- Almost always present and I have been unable to perform at work, school or home due to this problem; I probably cannot function without help.

	0 NONE	1 MILD	2 MODERATE	3 SEVERE	4 VERY SEVERE
1. Feeling dizzy:					
2. Loss of balance:					
3. Poor coordination, clumsy:					
4. Headaches:					
5. Nausea:					
6. Vision problems, blurring, trouble seeing:					
7. Sensitivity to light					
8. Hearing difficulty:					
9. Sensitivity to noise:					
10. Numbness or tingling on parts of my body:					
11. Change in taste and/or smell:					
12. Loss of appetite or increase appetite:					

13. Poor concentration can't pay attention, easily distracted:					
14. Forgetfulness, can't remember things:					
15. Difficulty making decisions:					
16. Slowed thinking, difficulty getting organized, can't finish things:					
17. Fatigue, loss of energy, getting tired easily:					
18. Difficulty falling or staying asleep:					
19. Feeling anxious or tense:					
20. Feeling depressed or sad:					
21. Irritability, easily annoyed:					
22. Poor frustration tolerance, feeling easily overwhelmed by things:					

Obsessive Compulsive Inventory-Revised (**OCI-R**)

The following statements refer to experiences that many people have in their everyday lives. Circlethe number that best describes **HOW MUCH** that experience has **DISTRESSED or BOTHERED you during the PAST MONTH.** The numbers refer to the following verbal labels:

0	1	2	3	4
Not at all	A little	Moderately	A lot	Extremely

1. I have saved up so many things that they get in the way.
2. I check things more often than necessary.
3. I get upset if objects are not arranged properly.
4. I feel compelled to count while I am doing things.

5. I find it difficult to touch an object when I know it has been touched by strangers or certain people.
6. I find it difficult to control my own thoughts.
7. I collect things I don't need.
8. I repeatedly check doors, windows, drawers, etc.
9. I get upset if others change the way I have arranged things.
10. I feel I have to repeat certain numbers.
11. I sometimes have to wash or clean myself simply because I feel contaminated.
12. I am upset by unpleasant thoughts that come into my mind against my will.
13. I avoid throwing things away because I am afraid I might need them later.
14. I repeatedly check gas and water taps and light switches after turning them off.
15. I need things to be arranged in a particular way.
16. I feel that there are good and bad numbers.
17. I wash my hands more often and longer than necessary.
18. I frequently get nasty thoughts and have difficulty in getting rid of them.

Fear Survey Schedule (FSS-III)

INSTRUCTIONS: The items in this questionnaire refer to things and experiences that may cause fear or other similar, unpleasant feelings. Read each item and decide how much you are disturbed by it nowadays. Then, circle the number that most closely describes how disturbed you feel, using the scale shown below:

Remember: Circle only one number per item. Answer all of the items.
Please work rapidly and do not spend too much time on any one statement.

	I fear…	Not at all	A little	A fair amount	Much	Very Much
1.	Open wounds	1	2	3	4	5
2.	Being alone	1	2	3	4	5
3.	Being in a strange place	1	2	3	4	5
4.	Dead people	1	2	3	4	5
5.	Speaking in public	1	2	3	4	5
6.	Crossing streets	1	2	3	4	5
7.	Falling	1	2	3	4	5
8.	Being teased	1	2	3	4	5
9.	Failure	1	2	3	4	5

10.	Entering a room where other people are already seated	1	2	3	4	5
11.	High places on land	1	2	3	4	5
12.	People with deformities	1	2	3	4	5
13.	Worms	1	2	3	4	5
14.	Receiving injections	1	2	3	4	5
15.	Strangers	1	2	3	4	5
16.	Bats	1	2	3	4	5
17.	Journeys by train	1	2	3	4	5
18.	Journeys by bus	1	2	3	4	5
19.	Journeys by car	1	2	3	4	5
20.	People in authority	1	2	3	4	5
21.	Flying insects	1	2	3	4	5
22.	Seeing other people injected	1	2	3	4	5
23.	Crowds	1	2	3	4	5
24.	Large open spaces	1	2	3	4	5
25.	One person bullying another	1	2	3	4	5
26.	Tough-looking people	1	2	3	4	5
27.	Being watched working	1	2	3	4	5
28.	Dirt	1	2	3	4	5
29.	Crawling insects	1	2	3	4	5
30.	Sight of fighting	1	2	3	4	5
31.	Ugly people	1	2	3	4	5
32.	Sick people	1	2	3	4	5
33.	Being criticized	1	2	3	4	5

34.	Strange shapes	1	2	3	4	5
35.	Being in an elevator	1	2	3	4	5
36.	Witnessing surgical operations	1	2	3	4	5
37.	Mice	1	2	3	4	5
38.	Human blood	1	2	3	4	5
39.	Animal blood	1	2	3	4	5
40.	Enclosed places	1	2	3	4	5
41.	Being rejected by others	1	2	3	4	5
42.	Airplanes	1	2	3	4	5
43.	Medical odors	1	2	3	4	5
44.	Feeling disapproved of	1	2	3	4	5
45.	Harmless snakes	1	2	3	4	5
46.	Cemeteries	1	2	3	4	5
47.	Being ignored	1	2	3	4	5
48.	Nude men	1	2	3	4	5
49.	Nude women	1	2	3	4	5
50.	Doctors	1	2	3	4	5
51.	Making mistakes	1	2	3	4	5
52.	Looking foolish	1	2	3	4	5

Hospital Anxiety and Depression Scale (HADS)

Choose one response from the four given for each question. Do not think too much about your answers. Answer based on how it currently describes your feelings.

I feel tense or 'wound up'.

Most of the time

A lot of the time

From time to time, occasionally

Not at all

I still enjoy the things I used to enjoy.

Definitely as much

Not quite so much

Only a little

Hardly at all

I get a sort of frightened feeling as if something awful is about to happen.

Very definitely and quite badly

Yes, but not too badly

A little, but it doesn't worry me

Not at all

I can laugh and see the funny side of things.

As much as I always could

Not quite so much now

Definitely not so much now

Not at all

Worrying thoughts go through my mind.

A great deal of the time

A lot of the time

From time to time, but not too often

Only occasionally

I feel cheerful.

Not at all

Not often

Sometimes

Most of the time

I can sit at ease and feel relaxed.

Definitely

Usually

Not often

Not at all

I feel as if I am slowed down.

Nearly all the time

Very often

Sometimes

Not at all

I get a sort of frightened feeling like 'butterflies' in the stomach.

Not at all

Occasionally

Quite often

Very often

I have lost interest in my appearance.

Definitely

I don't take as much care as I should

I may not take quite as much care

I take just as much care as ever

I feel restless as if I have to be on the move.

Very much indeed

Quite a lot

Not very much

Not at all

I look forward with enjoyment to things.

As much as I ever did

Rather less than I used to

Definitely less than I used to

Hardly at all

I get sudden feelings of panic

Very often indeed

Quite often

Not very often

Not at all

I can enjoy a good book or radio or TV program.

Often

Sometimes

Not often

Very seldom

Autism Quotient (AQ)

Please answer the following questions based on what is generally true for you. There are no right or wrong answers.

Definitely agree Slightly agree Slightly disagree Definitely disagree

1 I prefer to do things with others rather than on my own.
2 I prefer to do things the same way over and over again.
3 If I try to imagine something, I find it very easy to create a picture in my mind.
4 I frequently get so strongly absorbed in one thing that I lose sight of other things.
5 I often notice small sounds when others do not.
6 I usually notice car number plates or similar strings of information.
7 Other people frequently tell me that what I've said is impolite, even though I think it is polite.
8 When I'm reading a story, I can easily imagine what the characters might look like.
9 I am fascinated by dates.
10 In a social group, I can easily keep track of several different people's conversations.
11 I find social situations easy.
12 I tend to notice details that others do not.
13 I would rather go to a library than to a party.
14 I find making up stories easy.
15 I find myself drawn more strongly to people than to things.
16 I tend to have very strong interests, which I get upset about if I can't pursue.
17 I enjoy social chitchat.
18 When I talk, it isn't always easy for others to get a word in edgewise.
19 I am fascinated by numbers.
20 When I'm reading a story, I find it difficult to work out the characters' intentions.
21 I don't particularly enjoy reading fiction.
22 I find it hard to make new friends.
23 I notice patterns in things all the time.
24 I would rather go to the theater than to a museum.
25 It does not upset me if my daily routine is disturbed.
26 I frequently find that I don't know how to keep a conversation going.
27 I find it easy to 'read between the lines' when someone is talking to me.
28 I usually concentrate more on the whole picture, rather than on the small details.
29 I am not very good at remembering phone numbers.
30 I don't usually notice small changes in a situation or a person's appearance.
31 I know how to tell if someone listening to me is getting bored.
32 I find it easy to do more than one thing at once.
33 When I talk on the phone, I'm not sure when it's my turn to speak.
34 I enjoy doing things spontaneously.
35 I enjoy doing things alone.
36 I find it easy to work out what someone is thinking or feeling just by looking at their face.
37 If there is an interruption, I can switch back to what I was doing very quickly.
38 I am good at social chitchat.

39 People often tell me that I keep going on and on about the same thing.
40 When I was young, I used to enjoy playing games involving pretending with other children.
41 I like to collect information about categories of things (e.g., types of cars, birds, trains, plants).
42 I find it difficult to imagine what it would be like to be someone else.
43 I like to carefully plan any activities I participate in.
44 I enjoy social occasions.
45 I find it difficult to work out people's intentions.
46 New situations make me anxious.
47 I enjoy meeting new people.
48 I am a good diplomat.
49 I am not very good at remembering people's date of birth.
50 I find it very easy to play games with children that involve pretending.

Medical Questionnaire

Please indicate if you have been diagnosed with any of the following problems by checking “yes” or “no”:

1. Diabetes	yes _______	no ________
2. Epilepsy	yes _______	no ________
3. Head Injury	yes _______	no ________
4. Ulcer	yes _______	no ________
5. Heart Problems	yes _______	no ________
6. Kidney Disorder	yes _______	no ________
7. Liver Problems	yes _______	no ________
8. Hypertension	yes _______	no ________
9. Hearing Loss	yes _______	no ________
10. Cancer	yes _______	no ________
11. Allergies	yes _______	no ________
12. Respiratory Disease	yes _______	no ________

Please indicate if you have any of the following health problems by checking “yes” or “no”:

1. Headaches	yes _______	no ________
2. Dizziness	yes _______	no ________
3. Black-out spells	yes _______	no ________
4. Ringing in ears	yes _______	no ________
5. Blurred Vision	yes _______	no ________
6. Shortness of breath	yes _______	no ________
7. Rapid breathing	yes _______	no ________
8. Racing heart	yes _______	no ________
9. Irregular heartbeat	yes _______	no ________
10. Heart flutters	yes _______	no ________
11. Sexual disinterest	yes _______	no ________
12. Impotence	yes _______	no ________
13. Inability to achieve orgasm	yes _______	no ________

14. Constipation	yes ______	no _______
15. Diarrhea	yes ______	no _______
16. Nausea	yes ______	no _______
17. Butterflies	yes ______	no _______
18. Gas	yes ______	no _______
19. Stomach cramps	yes ______	no _______
20. Muscle aches	yes ______	no _______
21. Nail Biting	yes ______	no _______
22. Backache	yes ______	no _______

Mechanisms and individual difference measures

Multidimensional Anger Inventory (MAI)

Instructions: Everybody gets angry from time to time. A number of statements that people have used to describe the times that they get angry are included below. Read each statement and select the number to the left of the statement that best describes you. There are no right or wrong answers.

1, The statement is completely undescriptive of you.
2, The statement is mostly undescriptive of you.
3, The statement is partly undescriptive and partly descriptive of you.
4, The statement is mostly descriptive of you.
5, The statement is completely descriptive of you.

1. I tend to get angry more frequently than most people.
2. Other people seem to get angrier than I do in similar circumstances.
3. I harbor grudges that I don't tell anyone about.
4. I try to get even when I'm angry with someone.
5. I am secretly quite critical of others.
6. It is easy to make me angry.
7. When I am angry with someone, I let that person know.
8. I have met many people who are supposed to be experts who are no better than I am.
9. Something makes me angry almost every day.
10. I often feel angrier than I think I should.
11. I feel guilty about expressing my anger.
12. When I am angry with someone, I take it out on whoever is around.
13. Some of my friends have habits that annoy and bother me very much.
14. I am surprised at how often I feel angry.
15. Once I let people know I'm angry, I can put it out of my mind.
16. People talk about me behind my back.
17. At times, I feel angry for no specific reason.
18. I can make myself angry about something in the past just by thinking about it.
19. Even after I have expressed my anger, I have trouble forgetting about it.
20. When I hide my anger from others, I think about it for a long time.
21. People can bother me just by being around.

22. When I get angry, I stay angry for hours.
23. When I hide my anger from others, I forget about it pretty quickly.
24. I try to talk over problems with people without letting them know I'm angry.
25. When I get angry, I calm down faster than most people.
26. I get so angry. I feel like I might lose control.
27. If I let people see the way I feel, I'd be considered a hard person to get along with.
28. I am on my guard with people who are friendlier than I expected.
29. It's difficult for me to let people know I'm angry.
30a. I get angry when someone lets me down.
30b. I get angry when people are unfair.
30c. I get angry when something blocks my plans.
30d. I get angry when I am delayed.
30e. I get angry when someone embarrasses me.
30f. I get angry when I have to take orders from someone less capable than I.
30g. I get angry when I have to work with incompetent people.
30h. I get angry when I do something stupid..
30i. I get angry when I am not given credit for something I have done.

Anxiety Sensitivity Inventory-3 (ASI-3)

Enter the number from the scale below that best describes how typical or characteristic each of the 16 items is of you, putting the number next to the item. You should make your ratings in terms of how much you agree or disagree with the statement as a general description of yourself.

0	1	2	3	4
very little	a little	some	much	very much

1. It is important for me not to appear nervous.
2. When I cannot keep my mind on a task, I worry that I might be going crazy.
3. It scares me when my heart beats rapidly.
4. When my stomach is upset, I worry that I might be seriously ill.
5. It scares me when I am unable to keep my mind on a task.
6. When I tremble in the presence of others, I fear what people might think of me.
7. When my chest feels tight, I get scared that I won't be able to breathe properly.
8. When I feel pain in my chest, I worry that I'm going to have a heart attack.
9. I worry that other people will notice my anxiety.

10. When I feel "spacey" or spaced out I worry that I may be mentally ill.

11. It scares me when I blush in front of people.

12. When I notice my heart skipping a beat, I worry that there is something seriously wrong with me.

13. When I begin to sweat in a social situation, I fear people will think negatively of me.

14. When my thoughts seem to speed up, I worry that I might be going crazy.

15. When my throat feels tight, I worry that I could choke to death.

16. When I have trouble thinking clearly, I worry that there is something wrong with me.

17. I think it would be horrible for me to faint in public.

18. When my mind goes blank, I worry there is something terribly wrong with me.

Distress Tolerance Scale (DTS)

Directions: Think of times that you feel distressed or upset. Circle the number that best describes your beliefs about feeling distressed or upset.

1= Strongly agree

2= Mildly agree

3= Agree and disagree equally

4= Mildly disagree

5= Strongly disagree

1. Feeling distressed or upset is unbearable to me.	1	2	3	4	5
2. When I feel distressed or upset, all I can think about is how bad I feel.	1	2	3	4	5
3. I can't handle feeling distressed or upset.	1	2	3	4	5
4. My feelings of distress are so intense that they completely take over.	1	2	3	4	5
5. There's nothing worse than feeling distressed or upset.	1	2	3	4	5
6. I can tolerate being distressed or upset as well as most people.	1	2	3	4	5

7. My feelings of distress or being upset are not acceptable.	1	2	3	4	5
8. I'll do anything to avoid feeling distressed or upset.	1	2	3	4	5
9. Other people seem to be able to tolerate feeling distressed or upset better than I can.	1	2	3	4	5
10. Being distressed or upset is always a major ordeal for me.	1	2	3	4	5
11. I am ashamed of myself when I feel distressed or upset.	1	2	3	4	5
12. My feelings of distress or being upset scare me.	1	2	3	4	5
13. I'll do anything to stop feeling distressed or upset.	1	2	3	4	5
14. When I feel distressed or upset, I must do something about it immediately	1	2	3	4	5
15. When I feel distressed or upset, I cannot help but concentrate on how bad the distress actually feels.	1	2	3	4	5

Discomfort Intolerance Scale (DIS)

Directions: Circle the number that best describes your beliefs about pain and discomfort.

0= Not at all like me
1= Mostly not like me
2= Somewhat not like me
3= Neither like me nor not like me
4= Somewhat like me
5= Mostly like me
6= Extremely like me

1. I can tolerate a great deal of physical discomfort.
2. I have a high pain threshold.
3. I take extreme measures to avoid feeling physically uncomfortable.
4. I'm the kind of person who never takes medication, like aspirin, when I have aches and pains.
5. I push my physical limits when I exercise.
6. When I begin to feel physically uncomfortable, I quickly take steps to relieve the discomfort.
7. I am more sensitive to feeling discomfort compared to most persons.

Ten Item Personality Inventory (TIPI)

Here are a number of personality traits that may or may not apply to you. Please write a number next to each statement to indicate the extent to which you agree or disagree with that statement. You should rate the extent to which the pair of traits applies to you, even if one characteristic applies more strongly than the other.

Disagree Strongly	Disagree Moderately	Disagree a Little	Neither Agree nor Disagree	Agree a Little	Agree Moderately	Agree Strongly
1	2	3	4	5	6	7

I see myself as:
1. _____ Extraverted, enthusiastic.
2. _____ Critical, quarrelsome.
3. _____ Dependable, self-disciplined.
4. _____ Anxious, easily upset.
5. _____ Open to new experiences, complex.
6. _____ Reserved, quiet.
7. _____ Sympathetic, warm.
8. _____ Disorganized, careless.
9. _____ Calm, emotionally stable.
10. _____ Conventional, uncreative.

Absorption Scale (AS)* (Synesthesia subscale items are in bold)

Here you will find a series of statements a person might use to describe his or her attitudes, opinions, interests, and other characteristics. Read each statement, and decide which choice, True or False, best describes you. Read each statement carefully, but don't spend too much time deciding on an answer.

1. Sometimes I feel and experience things as I did when I was a child.
2. I can be greatly moved by eloquent or poetic language.
3. While watching a movie, a TV show, or a play, I may become so involved that I forget about myself and my surroundings and experience the story as if it were real and as if I were taking part in it.
4. If I stare at a picture and then look away from it, I can sometimes "see" an image of the picture, almost as if I were still looking at it.
5. Sometimes I feel as if my mind could envelop the whole world.
6. I like to watch cloud shapes change in the sky.
7. If I wish, I can imagine (or daydream) some things so vividly that they hold my attention as a good movie or story does.
8. I think I really know what some people mean when they talk about mystical experiences.
9. I sometimes "step outside" my usual self and experience an entirely different state of being.
10. Textures--such as wool, sand, wood--sometimes remind me of colors or music.
11. Sometimes I experience things as if they were doubly real.
12. When I listen to music I can get so caught up in it that I don't notice anything else.
13. If I wish, I can imagine that my body is so heavy that I could not move it if I wanted to.
14. I can often somehow sense the presence of another person before I actually see or hear her/him.
15. The crackle and flames of a wood fire stimulate my imagination.

16. It is sometimes possible for me to be completely immersed in nature or in art and to feel as if my whole state of consciousness has somehow been temporarily altered.
17. Different colors have distinctive and special meanings for me.
18. I am able to wander off into my own thoughts while doing a routine task and actually forget that I am doing the task, and then find a few minutes later that I have completed it.
19. I can sometimes recollect certain past experiences in my life with such clarity and vividness that it is like living them again or almost so.
20. Things that might seem meaningless to others often make sense to me.
21. While acting in a play, I think I could really feel the emotions of the character and "become" her/him for the time being, forgetting about myself and the audience.
22. My thoughts often don't occur as words, but as visual images
23. I often take delight in small things (like the five-pointed star shape that appears when you cut an apple across the core or the colors in soap bubbles).
24. When listening to organ music or other powerful music, I sometimes feel as if I am being lifted into the air.
25. Sometimes I can change noise into music by the way I listen to it.
26. Some of my most vivid memories are called up by scents and smells.
27. Some music reminds me of pictures or changing color patterns.
28. I often know what someone is going to say before he/she says it.
29. I often have "physical memories"; for example, after I've been swimming, I may still feel as if I'm in the water.

Difficulties in Emotion Regulation Scale (DERS)

1	2	3	4	5
Almost never	Sometimes	About half the time	Most of the time	Almost always
(0-10%)	(11-35%)	(36-65%)	(66-90%)	(91-100%)

Please indicate how often the following 36 statements apply to you by writing the appropriate number from the scale above (1 – 5) in the box alongside each item.

1 I am clear about my feelings.

2. I pay attention to how I feel.

3. I experience my emotions as overwhelming and out of control.

4. I have no idea how I am feeling.

5. I have difficulty making sense out of my feelings.

6. I am attentive to my feelings.

7. I know exactly how I am feeling.

8. I care about what I am feeling.

9 I am confused about how I feel.

10. When I’m upset, I acknowledge my emotions.

11. When I’m upset, I become angry with myself for feeling that way.

12. When I’m upset, I become embarrassed for feeling that way.

13. When I’m upset, I have difficulty getting work done.

14. When I’m upset, I become out of control.

15. When I’m upset, I believe that I will remain that way for a long time.

16. When I’m upset, I believe that I’ll end up feeling very depressed.

17. When I’m upset, I believe that my feelings are valid and important.

18. When I’m upset, I have difficulty focusing on other things.

19. When I’m upset, I feel out of control.

20. When I’m upset, I can still get things done.

21. When I’m upset, I feel ashamed with myself for feeling that way.

22. When I’m upset, I know that I can find a way to eventually feel better.

23. When I’m upset, I feel like I am weak.

24. When I’m upset, I feel like I can remain in control of my behaviours.

25. When I’m upset, I feel guilty for feeling that way.

26. When I’m upset, I have difficulty concentrating.

27. When I’m upset, I have difficulty controlling my behaviours.

28. When I’m upset, I believe that there is nothing I can do to make myself feel better

29. When I’m upset, I become irritated with myself for feeling that way.

30. When I'm upset, I start to feel very bad about myself.

31. When I'm upset, I believe that wallowing in it is all I can do.

32. When I'm upset, I lose control over my behaviours.

33. When I'm upset, I have difficulty thinking about anything else.

34. When I'm upset, I take time to figure out what I'm really feeling.

35. When I'm upset, it takes me a long time to feel better.

36. When I'm upset, my emotions feel overwhelming

Adult Sensory Questionnaire (**ASQ**)

Circle the item as T – true or F – False as it applies to you.

1. T F I am sensitive and get bothered by smells that don't seem to bother other people.

2. T F I am sensitive or bothered by sounds that don't seem to bother other people.

3. T F I am bothered by looking down a long flight of stairs or going down an escalator.

4. T F I get car sick.

5. T F I am sensitive to movement. I get dizzy very easily.

6. T F I am sensitive to and bothered by lights/contrasts/reflections or objects close to my face (that don't seem to bother others).

7. T F I am bothered by some food textures in my mouth (or I avoid them).

8. T F It bothers me to be barefoot on grass or sand.

9. T F I am bothered by tags and labels in my clothes (or I remove them).

10. T F I am bothered by turtleneck shirts, tight fitting clothes, elastic, nylons, or synthetic material in clothes (any of the above).

11. T F I am bothered by the feeling of jewelry (or I never wear it because of this).

12. T F I am very aware that certain parts of my body are very sensitive.

13. T F I avoid putting creams and lotions on my skin because of how it feels.

14. T F I have a sensitive scalp.

15. T F I do not like being in crowded areas such as elevators, malls, subways, crowded shops or bars (or I never put myself in these situations).

16. T F Growing up, I did not like to be hugged (except by my mother).

17. T F I am often uncomfortable with physical intimacy because touching bothers me.

18. T F I feel bothered when someone touches me from behind or unexpectedly, or stands too close.

19. T F I was very active as a child (or I am now).

20. T F I have mood swings more than other people.

21. T F I do not go to sleep easily and wake up easily and/or I don't sleep between 6 and 8 hours each night.

22. T F I consider myself to be anxious.

23. T F I feel I must mentally prepare myself for situations in which people are apt to touch me.

24. T F It is important for me to be in control and know what to expect.

25. T F I am perfectionistic, or compulsive.

26. T F I avoid if at all possible, situations in which my senses will be stressed.

____________ Total Score (count up the number of "Trues")

Scoring:

> 10 = definite sensory defensiveness

6 – 10 = moderate sensory defensiveness

< 6 = not sensory defensive

Barcelona Music Reward Questionnaire (BMRQ- English version)

Each item of this questionnaire is a statement that a person may either agree with or disagree with. For each item, indicate how much you agree or disagree with what the item says. Please respond to all the items; do not leave any blank. Choose only one response to each statement. Please be as accurate and honest as you can be. Respond to each item as if it were the only item. That is, don't

worry about being consistent in your responses. Choose from completely disagree (left) to completely agree (right) one of the five options.
Answer with a number from 1 to 5 where

1 -> Completely disagree
2 -> Disagree
3 -> either agree nor disagree
4 -> Agree
5 -> Completely agree

1. When I share music with someone I feel a special connection with that person.

2. In my free time I hardly listen to music.

3. I like listen to music that contains emotion.

4. Music keeps me company when I'm alone.

5. I don't like to dance, not even with music I like.

6. Music makes me bond with other people.

7. I inform myself about music I like.

8. I get emotional listening to certain pieces of music.

9. Music calms and relaxes me.

10. Music often makes me dance.

11. I'm always looking for new music.

12. I can become tearful or cry when I listen to a melody that I like very much.

13. I like to sing or play an instrument with other people.

14. Music helps me chill out.

15. I can't help humming or singing along to music that I like.

16. At a concert I feel connected to the performers and the audience.

17. I spend quite a bit of money on music and related items.

18. I sometimes feel chills when I hear a melody that I like.

19. Music comforts me.

20. When I hear a tune I like a lot I can't help tapping or moving to its beat.

Somatosensory Amplification Scale (SSAS)

1. I can’t stand smoke, smog or pollutants in the air.

2. I am often aware of various things happening within my body

3. When I bruise myself, it stays noticeable for a long time.

4. I sometimes can feel the blood flowing in my body.

5. Sudden loud noises really bother me.

6. I can sometimes hear my pulse or my heartbeat throbbing in my ear.

7. I hate to be too hot or too cold.

8. I am quick to sense the hunger contractions in my stomach.

9. Even something minor, like an insect bite or a splinter, really bothers me.

10. I can’t stand pain.

Functional impact measures

SF-12 Short Form Health Survey (SF-12)

Instructions: This survey asks for your views about your health. This information will help keep track of how you feel and how well you are able to complete your usual activities. If you are unsure about how to answer a question, please give the best answer you can.

1. In general, would you say your health is:
Excellent
Very Good
Good
Fair
Poor

2. The following questions are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?

a. Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf.

Yes, limited a lot

Yes, limited a little
No, not limited at all

b. Climbing several flights of stairs.
Yes, limited a lot
Yes, limited a little
No, not limited at all

3. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of your physical health?
a. Accomplished less than you would have liked?
Yes
No
b. Were limited in the kind of work or other activities?
Yes
No

4. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?
a. Accomplished less than you would have liked?
Yes
No
b. Didn't do work or other activities as carefully as usual?
Yes
No

5. During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?
Not at all
A little bit
Moderately
Quite a bit
Extremely

6. These questions are about how you feel and how things have been with you during the past 4 weeks. For each question, please give the one answer that comes closest to the way you have been feeling.

How much of the time during the past 4 weeks...

a. Have you felt calm and peaceful?
All of the time
Most of the time
A good bit of the time
Some of the time
A little of the time
None of the time

How much of the time during the past 4 weeks...

b. Did you have a lot of energy?

All of the time
Most of the time
A good bit of the time
Some of the time
A little of the time
None of the time

How much of the time during the past 4 weeks...

c. Have you felt downhearted and blue?

All of the time
Most of the time
A good bit of the time
Some of the time
A little of the time
None of the time

7. During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives, etc)?

All of the time
Most of the time
A good bit of the time
Some of the time
A little of the time
None of the time

Linear Analogue Self Assessment (LASA)

Directions: Please circle the number (0-10) best reflecting your response to the following that describes your feelings during the past week, including today.

1. How would you rate your physical well being over the past week?
This question refers to such things as fatigue, activity, etc.

0	1	2	3	4	5	6	7	8	9	10
As bad as it can be										As good as it can be

2. How would you rate your emotional well being over the past week?
This question refers to such things as depression, anxiety, stress, etc.

0	1	2	3	4	5	6	7	8	9	10
As bad as it can be										As good as it can be

3. How would you rate your spiritual well being over the past week?
This question refers to such things as a sense of meaning and purpose, relationship with God, etc.

0	1	2	3	4	5	6	7	8	9	10
As bad as it can be										As good as it can be

4. How would you rate your intellectual well being over the past week?
This question refers to such things as the ability to think clearly, to concentrate, to remember, etc.

0	1	2	3	4	5	6	7	8	9	10
As bad as it can be										As good as it can be

5. How would you rate your overall well being over the past week?

0	1	2	3	4	5	6	7	8	9	10
As bad as it can be										As good as it can be

Effort measures

Directed Questions Scale

To assess how carefully subjects were reading items, we will embed 7 questions directing subjects to give specific answers within substantive scales in the survey
“Please skip this question” [presented twice]
“This is a control question. Leave this question blank”
“I read instructions carefully. To show that you are reading these instructions, please leave this question blank”
“This is an extra line. Leave this question blank,”
"This is a control question. Mark 'Mostly True' and move on."
"This is a control question. Mark 'Rarely' and move on".
This scale is scored by summing the number of mistakes each subject made on these items to create scores ranging from 0 to 7.

Appendix B

Phonophobia

Within the audiology and otolaryngology literatures, phonophobia is defined by fear or anxiety in response to one or more specific sounds that have gained a particularly negative association for an individual (Baguley & McFerran, 2011). It has been suggested that the sound avoidance characteristic of phonophobia is an extreme behavioral manifestation of misophonia (Jastreboff & Jastreboff, 2004; 2006), and that the two constructs can be distinguished primarily based on differences in the reaction observed to sounds in misophonia (irritation/anger) and phonophobia (fear/anxiety) (Jastreboff & Jastreboff, 2004). In this respect, phonophobia can be described as a type of specific phobia involving fear and avoidance of specific sound stimuli (Anari, Axelsson, Eliasson, & Magnusson, 1999). No empirical literature—not even a case study—could be found on this use of the phonophobia construct, however.

In neurology, phonophobia is used to describe a completely different phenomenon: the generalized increase in sound sensitivity that migraine sufferers show during and between migraine attacks (Ashkenazi, Yang, Mushtaq, & Oshinsky, 2010; Main, Dowson, & Gross, 1997). However, the methods used to assess migraine patients—which include obtaining ratings of discomfort in response to gradually louder tones—appear to be capturing hyperacusis rather than a fear of sound (Baguley & McFerran, 2011). An additional issue is that other forms of sensory sensitivity, including hypersensitivity to light and touch, are also common symptoms among migraine patients.

Therefore, some researchers have suggested that phonophobia or hyperacusis in migraine is part of a generalized hyper-excitability of the sensory pathways (Ashkenazi et al., 2010; Main et al., 1997).

In summary, in the audiology and otolaryngology literatures phonophobia appears to overlap with either misophonia or specific phobia, depending on the context, without adding any conceptual understanding to either construct. Within neurology, phonophobia describes the auditory component of a generalized sensory hypersensitivity found in migraine patients. There does not appear to be any literature on phonophobia independent of these meanings of the term. Thus, in our opinion, there does not appear to be any theoretical or empirical rationale for continued use of "phonophobia" other than to describe sound sensitivity in migraine patients, and a fear of a specific sound (thunder, for example) should be considered a specific phobia.

Appendix C

Table 4b.

Decreased sound tolerance screening in student (N=451), community (N=375), and combined samples (N=826)

	Student sample	Community sample	Combined sample
Tinnitus screening: *Do you experience ringing, roaring, or buzzing in your ears or head?*	24.2%	26.8%	25.5%
^If yes, How long have you experienced this symptom?			
Less than 3 months	6.0%	4.5%	5.3%
3-6 months	2.0%	4.5%	3.1%
6 months-1 year	3.1%	1.1%	2.2%
Longer than 1 year	12.9%	16.4%	14.5%
Hyperacusis screening: *Do sounds cause you pain or physical discomfort?*	16.9%	17.0%	16.9%
Misophonia screening: *Compared to other people, are you sensitive to certain sounds made by other people?*			
Sometimes	44.8%	44.6%	44.7%
Yes	18.4%	13.5%	16.2%
^Please select the specific emotion(s) that you most often experience in response to sounds that bother you:			
Anger	33.9%	23.9%	29.3%

Disgust	31.7%	27.1%	29.6%
Fear	3.8%	5.3%	4.5%
Anxiety	23.5%	22.0%	22.8%
Sadness	1.3%	3.2%	2.2%
Guilt	.7%	1.9%	1.2%
Other (“annoyance”, “irritability”, “nausea”, “pain” “surprise”, “alertness”, “apathy”)	10.2%	9.8%	10.0%
Hearing difficulty screening: *Do you have difficulty detecting sounds in your environment and/or understanding the speech of others?*	19.3%	14.3%	17.0%
Have you ever worn hearing aids or have ever had hearing aids recommended to you?	2.7%	8.5%	5.3%
Screening for sound-related diagnoses			
Misophonia	Not administered	.7%	N/A
Hyperacusis		.8%	
Phonophobia		.5%	
Tinnitus		4.2%	
Selective sound intolerance		1.6%	
Decreased sound tolerance		1.8%	
Recruitment		1.0%	
Other sound-related diagnosis		1.9%	
Treatment screening: *Have you ever sought or received treatment for a hearing or sound sensitivity problem (including hyperacusis, misophonia, or any other issue related to decreased sound tolerance or selective sound intolerance)?*	Not administered	2.5%	N/A
General sensory intolerance screening: *Are you very bothered by certain tactile sensations, such as clothing textures or tightness; substances that feel sticky, greasy, or wet, or activities like haircuts or cutting your nails?**	33.5%	26.5%	30.3%

General auditory intolerance screening: *Are you very bothered by certain auditory sensations, such as the sounds of alarms sirens, appliances, or background noises like people talking or ticking clocks?*	37.9%	31.3%	34.9%
Clinically significant decreased sound tolerance symptoms			
Misophonia Questionnaire Severity Score= 7 or higher	16.2%	14.9%	15.6%
#Amsterdam Misophonia Scale Total Score			
Mild (5 to 9)	42.4%	43.9%	43.0%
Moderate (10 to 14)	19.7%	18.9%	19.4%
Severe (15 to 19)	2.2%	4.8%	3.3%
Extreme (20 to 24)	0.0%	0.0%	0.0%
Hyperacusis Questionnaire Total Score=28 or higher	24.2%	28.9%	26.3%
#Mini Tinnitus Questionnaire Total Score			
Moderately distressed (8 to 12)	13.2%	22.8%*	18.0%
Severely distressed (13 to 18)	6.6%	18.5%*	12.6%
Most severely distressed (19 to 24)	0.0%	5.4%*	2.7%

Note: *Designates a statistically significant difference between the student and community samples with an alpha level of $p<.001$, two-tailed, independent samples t-test; ^Denotes that percentage is taken from those responding positively to the item above, #Denotes that percentage is taken from the subset of participants responding to these items

Table 5b.

Comorbidity rates of tinnitus, hyperacusis, and misophonia in student, community, and combined samples

	Student sample		Total	Community sample		Total	Combined sample		Total
	Positive hyperacusis screen	Negative hyperacusis screen		Positive hyperacusis screen	Negative hyperacusis screen		Positive hyperacusis screen	Negative hyperacusis screen	
Positive misophonia screen									
Positive tinnitus screen	4 (.89%)	18 (4.02%)	22 (4.91%)	12 (3.26%)	16 (4.35%)	28 (7.61%)	10 (1.23%)	33 (4.04%)	43 (5.27%)
Negative tinnitus screen	24 (5.36%)	37 (8.26%)	61 (13.62%)	6 (1.63%)	15 (4.08%)	21 (5.71%)	36 (4.41%)	53 (6.50%)	89 (10.91%)
Total	28 (6.25%)	55 (12.28%)	83 (18.53%)	18 (4.89%)	31 (8.42%)	49 (13.32%)	46 (5.64%)	86 (10.54%)	132 (16.17%)
"Sometimes" misophonia screen									
Positive tinnitus screen	11 (2.46%)	41 (9.15%)	52 (11.61%)	19 (5.16%)	36 (9.78%)	55 (14.95%)	30 (3.68%)	77 (9.44%)	107 (13.11%)
Negative tinnitus screen	24 (5.36%)	124 (27.68%)	148 (33.04%)	16 (4.35%)	93 (25.27%)	109 (29.62%)	40 (4.90%)	217 (26.59%)	257 (31.50%)
Total	35 (7.81%)	165 (36.83%)	200 (44.64%)	35 (9.51%)	129 (35.05%)	164 (44.57%)	70 (8.58%)	294 (36.03%)	364 (44.61%)
Negative misophonia screen									
Positive tinnitus screen	6 (1.34%)	29 (6.47%)	35 (7.81%)	4 (1.09%)	19 (5.16%)	23 (6.25%)	10 (1.23%)	48 (5.88%)	58 (7.11%)

Negative tinnitus screen	7 (1.56%)	123 (27.46%)	130 (29.02%)	5 (1.36%)	127 (34.51%)	132 (35.87%)	12 (1.47%)	250 (30.64%)	262 (32.11%)
Total	13 (2.90%)	152 (33.93%)	165 (36.83%)	9 (2.45%)	146 (39.67%)	155 (42.12%)	22 (2.70%)	298 (36.52%)	320 (39.22%)
Total	372 (83.04%)	76 (16.96%)	**448**	62 (16.85%)	306 (83.15%)	**368**	138 (16.91%)	678 (83.09%)	**816**

Table 6b.

Means and Standard Deviations of Survey Measures within Student, Community, and Combined Samples

	N	Student sample	*N*	Community sample	*N*	Combined sample
Decreased sound tolerance and related measures						
Amsterdam Misophonia Scale	314	6.17 (3.92)	228	6.47 (4.39)	542	6.30 (4.12)
Misophonia Questionnaire Total	451	17.26 (10.95)	375	15.95 (12.06)	826	16.66 (11.48)
Symptom scale	451	6.98 (5.02)	375	6.44 (5.53)	826	6.73 (5.26)
Emotions and behaviors scale	394	11.77 (6.36)	305	11.70 (6.40)	699	11.74 (6.37)
Severity scale	444	2.99 (2.45)	373	2.89 (2.81)	817	2.94 (2.62)
Hyperacusis Questionnaire	451	23.50 (6.08)	375	24.23 (7.74)	826	23.83 (6.89)
Mini Tinnitus Questionnaire	109	4.12 (3.84)	105	7.19 (5.78)*	214	5.63 (5.11)
Hearing Handicap Inventory-Adult	357	5.62 (11.78)	375	11.32 (19.96)*	732	8.54 (16.72)
Social subscale		2.28 (5.28)		5.19 (9.56)*		3.77 (7.90)
Emotional subscale		3.34 (6.83)		6.13 (10.69)*		4.77 (9.12)
Clinical correlate measures						
Neurobehavioral Symptom Inventory	94	17.61 (13.20)	--	Not administered	--	--
Obsessive Compulsive Inventory-Revised	451	13.04 (10.36)	375	11.92 (11.96)	826	12.53 (11.13)
Fear Survey Schedule-III total score	94	99.11 (27.09)				
Social subscale		33.33 (10.39)	373	31.92 (12.69)	467	32.21 (12.26)
Hospital Anxiety and Depression scale total	451	11.06 (5.81)	375	10.89 (7.80)	826	10.98 (6.78)
Anxiety subscale		7.20 (3.91)*		6.19 (4.51)		6.74 (4.22)
Depression subscale		3.86 (2.98)		4.70 (4.06)*		4.24 (3.53)
Autism Quotient	94	18.62 (5.27)	--	Not administered	--	--
Medical Questionnaire	451		377		828	
# Diagnoses endorsed		.41 (.65)		.80 (1.09)*		.59 (.90)
# Somatic symptoms endorsed		2.13 (2.47)		2.28 (2.86)		2.20 (2.65)
Mechanisms and individual difference measures						
Multidimensional Anger Inventory	451	74.24 (18.02)*	375	68.95 (20.27)	826	71.84 (19.24)
Anxiety Sensitivity Index-3	451	18.25 (12.86)	375	18.49 (14.30)	826	18.36 (13.53)
Distress Tolerance Scale	451	48.72 (11.67)	375	51.40 (13.87)	826	49.94 (12.78)
Discomfort Tolerance	451	21.63 (5.33)	375	20.58 (5.77)	826	21.15 (5.55)
Ten Item Personality Inventory	451		375		826	
Extraversion		8.40 (3.02)*		7.40 (3.39)		7.95 (3.23)

Agreeableness		10.05 (2.20)		10.68 (2.72)*		10.34 (2.47)
Conscientiousness		10.88 (2.39)		11.21 (2.56)		11.03 (2.47)
Emotional stability		9.29 (2.85)		9.72 (3.25)		9.48 (3.04)
Openness to experience		10.63 (2.13)*		10.24 (2.72)		10.45 (2.42)
Absorption Scale total	451	18.25 (12.86)	375	18.49 (14.30)*	826	18.36 (13.53)
Synesthesia subscale		4.46 (2.41)		4.06 (2.54)		4.28 (2.47)
Difficulties with Emotion Regulation Scale	451	82.71 (22.85)*	375	76.45 (25.44)	826	79.87 (24.25)
Non-acceptance of emotional responses		13.09 (5.91)		12.47 (5.71)		12.81 (5.83)
Difficulties engaging in goal-directed*		14.19 (4.73)*		12.74 (5.23)		13.53 (5.02)
Impulse control difficulties		11.48 (4.52)		10.88 (4.89)		11.21 (4.70)
Lack of emotional awareness		15.59 (5.00)		14.51 (5.30)		15.10 (5.17)
Limited access to emotion regulation strategies		16.88 (6.82)		16.37 (7.37)		16.65 (7.07)
Lack of emotional clarity		11.48 (4.26)*		9.47 (4.05)		10.57 (4.28)
Adult Sensory Questionnaire	451	7.90 (4.27)	375	8.52 (5.39)	826	8.18 (4.82)
Barcelona Music Reward Questionnaire	94	71.29 (9.78)	--	Not administered	--	--
Sensory Amplification Scale	357	26.40 (5.57)	375	25.49 (6.62)	732	25.94 (6.14)

Note: *Designates a statistically significant difference between the student and community samples with an alpha level of $p<.001$.

Table 7b.

Decreased Sound Tolerance Measures Correlation Matrix within Student/Community Samples

	MQ Total	MQ SS	MQ EBS	MQ Severity	HQ	Mini TQ	HHI-A	HHI-A SS	HHI-A ES
A-MISOS	.56/.69	**.37/.56**	.56/.65	.58/.62	**.47/.63**	.63/.70	**.13*/.48**	**.13*/.45**	**.13*/.49**
MQ Total		.86/.91	.90/.92	.62/.63	**.58/.74**	.45/.66	**.22/.48**	**.19/.45**	**.23/.50**
MQ SS			**.47/.61**	.47/.54	**.44/.63**	.26/.54	**.13*/.40**	**.11*/.38**	**.15/.41**
MQ EBS				.56/.54	**.54/.73**	**.45/.75**	**.21/.47**	**.19/.44**	**.22/.48**
MQ Severe					.53/.63	.44/.55	**.20/.45**	**.20/.44**	**.19/.45**
HQ						.49/.65	.35/.53	.33/.51	**.35/.54**
Mini TQ							**.39/.68**	**.34/.62**	**.39/.71**
HHI-A								.97/.98	.98/.99
HHI-A SS									.89/.94

Notes: Correlation coefficients are presented as student sample *r* value/community sample *r* value, all correlations were significant at p<.01, except where indicated: *p<.05.

The Fisher r to z transformation was used to assess significant differences between correlation coefficients from the two independent samples, two tailed test, p<.001. Significant correlation coefficient differences are highlighted in **bold**.

Measure abbreviations:

A-MISO-S= Amsterdam Misophonia Scale total score

MQ Total= Misophonia Questionnaire total score

MQ SS= Misophonia Questionnaire Symptom Scale

MQ EBS= Misophonia Questionnaire Emotions and Behaviors Scale

MQ Severe= Misophonia Questionnaire Severity item

HQ= Hyperacusis Questionnaire

Mini TQ= Mini Tinnitus Questionnaire

HHI-A= Hearing Handicap Inventory-Adult Version

HHI-A SS= Hearing Handicap Inventory-Adult Version Social Subscale

HHI-A ES= Hearing Handicap Inventory-Adult Version Emotional Subscale

~N=451 within the student sample, except for the following: A-MISO-S (n=314), MQ EBS (n=394), MQ Severe (n=444), Mini TQ (n=109), HHI-A and HHI-A SS and ES (n=357)

~N=375 within the community sample, except for the following: A-MISO-S (n=228), MQ EBS (n=305), Mini TQ (n=105)

Table 8b.
Decreased Sound Tolerance and Clinical Correlate Measures Correlation Matrix within Student/Community Samples

	Clinical correlate measures									
	NSI	OCI-R	FSS-III	FSS-III SS	HADS	HADS-A	HADS-D	AQ	#Med DX	# SS
Decreased sound tolerance measures										
A-MISO-S	.39/--	.30/.49	.32/--	.37/.32	.35/.43	.34/.43	.24/.35	.42/--	^.04/.30	^.05/.32
MQ Total	.47/--	.37/.49	.39/--	.50/.45	.33/.44	.40/.48	.13/.31	.25/--	**^.09/.36**	**.12/.44**
MQ SS	.37/--	.22/.42	.30/--	.37/.38	.20/.36	.27/.38	**^.03/.28**	^.10/--	**^.02/.35**	**^.08/.40**
MQ EBS	.48/--	.46/.49	.47/--	.52/.43	.46/.46	.45/.51	.33/.32	.34/--	.13*/.28	**.11*/.40**
MQ Severity	.40/--	**.29/.50**	.35/--	.35/.37	.28/.39	.28/.44	.18/.26	^.19/--	.10*/.31	**.15*/.38**
HQ	.51/--	.40/.49	.29/--	.33/.46	.37/.47	.39/.49	.21/.37	.40/--	**^.07/.35**	**.21/.42**
Mini TQ	.37/--	.38/.64	.25/--	.32/.36	.36/.56	.29/.53	.30/.49	.71/--	.20/.38	^.08/.28
HHI-A	--/--	**.22/.55**	--/--	--/.26	.25/.46	**.20/.46**	.23/.37	--/--	**^-.01/.35**	**^.02/.29**
HHI-A SS	--/--	**.20/.53**	--/--	--/.23	**.21/.44**	**.15/.44**	.21/.36	--/--	**^-.02/.35**	**^-.00/.27**
HHI-A ES	--/--	**.23/.55**	--/--	--/.28	.27/.46	**.22/.46**	.23/.37	--/--	**^.01/.33**	**^.03/.30**

Notes: Correlation coefficients are presented as student sample *r* value/community sample *r* value, two tailed test, all correlations are significant at p<.01, except where indicated: ^p>.05, *p<.05.
The Fisher r to z transformation was used to assess significant differences between correlation coefficients from the two independent samples, two tailed test, p<.001. Significant correlation coefficient differences are highlighted in **bold**.
~*N*=451 within the student sample, except for the following: A-MISO-S (*n*=314), MQ EBS (*n*=394), MQ Severe (*n*=444), Mini TQ (*n*=109), HHI-A and HHI-A SS and ES (*n*=357), NSI (*n*=94), FSS-III and FSS-III SS (*n*=94), and AQ (*n*=84)
~*N*=375 within the community sample, except for the following: A-MISO-S (*n*=228), MQ EBS (*n*=305), Mini TQ (*n*=105)
The NSI, FSS-III, and AQ were not administered within the community sample.
Measure abbreviations:
A-MISO-S= Amsterdam Misophonia Scale total score
MQ Total= Misophonia Questionnaire total score
MQ SS= Misophonia Questionnaire Symptom Scale
MQ EBS= Misophonia Questionnaire Emotions and Behaviors Scale
MQ Severe= Misophonia Questionnaire Severity item
HQ= Hyperacusis Questionnaire total score
Mini TQ= Mini Tinnitus Questionnaire total score
HHI-A= Hearing Handicap Inventory-Adult Version total score

HHI-A SS= Hearing Handicap Inventory-Adult Version Social Subscale
HHI-A ES= Hearing Handicap Inventory-Adult Version Emotional Subscale
NSI=Neurobehavioral Symptom Inventory total score
OCI-R=Obsessive Compulsive Inventory-Revised total score
FSS-III=Fear Survey Schedule-III total score
FSS-III SS= Fear Survey Schedule-III Social Phobias Subscale
HADS= Hospital Anxiety and Depression Scale
HADS-A= Hospital Anxiety and Depression Scale Anxiety Subscale
HADS-D= Hospital Anxiety and Depression Scale Depression Subscale
AQ=Autism Quotient
#Med DX= The total number of medical diagnoses endorsed on the Medical Questionnaire
SS= The total number of physical symptoms endorsed on the Medical Questionnaire

Table 10b.

Decreased sound tolerance and mechanisms/individual difference measures correlations matrix within student (N=451~) / community (N=375~) samples

	Decreased sound tolerance measures							
Mechanisms and individual difference measures	A-MISO-S	MQ Total	MQ SS	MQ EBS	MQ Severity	HQ	Mini TQ	HHIA
MAI	.30/.47	.46/.49	.30/.39	.49/.48	.31/.36	.36/.44	.40/.50	**.14/.38**
ASI-3	.24/.48	.30/.49	**.17/.43**	.47/.47	.20/.41	**.24/.48**	.41/.61	**.24/.47**
DTS	-.24/-.29	-.30/-.32	-.20/-.25	-.37/-.38	-.21 /-.30	-.28/-.36	-.19*/-.42	-.22/-.27
DS	-.03^/.10	-.01^/.05^	-.06^/.06^	-.00^/.00^	.06^/.08^	.01^/.01^	-.14/.07^	-.05^/.01^
TIPI-O	-.02^/.00^	-.11*/-.02^	-.10*/-.04	-.12*/-.02^	-.11*/.00^	-.10*/-.00^	-.09^/-.17	-.12*/-.13*
TIPI-C	.02^/-.15*	-.03^/-.14	-.00^/-.11*	-.12*/-.19	-.05^/-.17	-.07^/-.19	-.08^/-.33	-.07^/-.28
TIPI-E	-.16/-.04^	-.14/-.01^	-.08^/-.03^	-.16/-.03^	-.11*/.02^	-.24/-.14	-.32/-.03^	-.09^/.00^
TIPI-A	-.15/-.24	-.17/-.24	-.12*/-.19	-.21/-.30	-.20/-.19	-.13/-.26	-.16/-.46	**-.05^/-.31**
TIPI-N	-.33/-.37	-.35/-.35	-.19*/-.29	-.45/-.37	-.26/-.36	-.33/-.36	-.40/-.48	-.10^/-.29
AS	.01^/--	.06^/--	.06^/--	.02^/--	-.01^/--	.11*/--	.09^/--	.10^/--
AS-S	.11/.25	**.08^/.32**	**.02^/.25**	.13/.34	**.07^/.32**	.16/.29	.11/.37	.10^/.30
DERS	.23/.40	.31/.38	.18/.30	.39/.43	.20/.33	.29/.42	.40/.47	.21/.39
DERS-NA	.15/.37	.26/.35	.17/.27	.26/.42	.13/.27	.26/.35	.26/.41	.20/.29
DERS-G	.22/.33	.31/.36	.24/.31	.31/.36	.20/.33	.36/.48	.30/.30	.17/.29
DERS- I	.19/.31	.23/.30	.09^/.23	.37/.37	.14/.29	.19/.34	.41/.44	**.14/.39**
DERS-A	.01^/.14*	.06^/.08^	.00^/.07^	.10*/.08^	.07^/.11*	.03^/.06^	.14/.16	.15/.13*
DERS-S	.24/.41	.30/.36	.19/.29	.37/.42	.17/.29	.28/.42	.38/.48	.15/.36
DERS-C	.15/.27	.16/.28	.07^/.22	.26/.31	.09^/.26	.12/.30	.29/.35	.12*/.33
ASQ	.34/.52	.49/.61	**.34/.55**	.46/.54	.44/.55	.53/.60	.32/.58	.28/.46
BMRQ	-.04^/--	.00^/--	.02^/--	.00^/--	-.14^/--	-.15^/--	-.05^/--	--/--
SSAS	.15/.37	.37/.41	.29/.36	.31/.38	.28/.41	.32/.41	.09^/.35	.09^/.19

Notes: Correlation coefficients are presented as student sample *r* value/community sample *r* value, two tailed test, all correlations are significant at $p<.01$, except where indicated: ^$p>.05$, *$p<.05$.
The Fisher r to z transformation was used to assess significant differences between correlation coefficients from the two independent samples, two tailed test, $p<.001$. Significant correlation coefficient differences are highlighted in **bold**.
~*N*=451 within the student sample, except for the following: A-MISO-S (*n*=314), MQ EBS (*n*=394), MQ Severe (*n*=444), Mini TQ (*n*=109), HHI-A (*n*=357)
~*N*=375 within the community sample, except for the following: A-MISO-S (*n*=228), MQ EBS (*n*=305), Mini TQ (*n*=105)
The AS full scale and the BMRQ were not administered within the community sample.
Measure abbreviations:
DST Scale = Decreased sound tolerance differential diagnosis scale total score
A-MISO-S= Amsterdam Misophonia Scale total score
MQ Total= Misophonia Questionnaire total score
MQ SS= Misophonia Questionnaire Symptom Scale
MQ EBS= Misophonia Questionnaire Emotions and Behaviors Scale
MQ Severe= Misophonia Questionnaire Severity item
HQ= Hyperacusis Questionnaire total score
Mini TQ= Mini Tinnitus Questionnaire total score
HHI-A= Hearing Handicap Inventory-Adult Version total score
MAI= Multidimensional Anger Inventory total score
ASI-3= Anxiety Sensitivity Index-3 total score
DTS=Distress Tolerance scale total score
DS=Discomfort Tolerance scale total score
TIPI-O=Ten Item Personality Inventory-Openness to Experience scale
TIPI-C= Ten Item Personality Inventory-Conscientiousness scale
TIPI-E= Ten Item Personality Inventory-Extraversion scale
TIPI-A= Ten Item Personality Inventory-Agreeableness scale
TIPI-N= Ten Item Personality Inventory-Emotional Stability/Neuroticism scale
AS=Absorption Scale
AS-S= Absorption Scale-Synesthesia subscale
DERS=Difficulties with Emotion Regulation Scale total score
DERS-NA=DERS Nonacceptance of emotional responses subscale
DERS-G= DERS Difficulties engaging in goal-directed behavior subscale
DERS-I=DERS Impulse control difficulties subscale
DERS-A= DERS Lack of emotional awareness subscale
DERS-S=DERS Limited access to emotion regulation strategies subscale

DERS-C= DERS Lack of emotional clarity subscale
ASQ= Adult Sensory Questionnaire total score
BMRQ=Barcelona Music Reward Questionnaire total score
SAS=Sensory Amplification Scale total score

Vita

Thérèse Verkerke Cash was born on July 7, 1987 in New Haven, Connecticut and is an American citizen. She grew up in Charlottesville, Virginia. Thérèse received her Bachelor of Arts, with Highest Distinction in Psychology from University of Virginia, in Charlottesville, Virginia in 2010. She received a Master of Science in Psychology from Virginia Commonwealth University in 2012.