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Differential Identification of Hyperacusis and Misophonia: Implications of Discrete Decreased Sound Tolerance (DST) Condition Subtypes

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"Differential Identification of Hyperacusis and Misophonia: Implications of Discrete Decreased Sound Tolerance (DST) Condition Subtypes"

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Abstract

Hyperacusis and misophonia are two conditions of decreased sound tolerance (DST) studied in the psychological literature due to their association with psychological symptoms and mechanisms. DSTs are differentiated from normal sound sensitivity due to the reported impairment and distress individuals experience. Researchers suggest that DSTs are differentiated by types of sounds and emotional reactions elicited, such that hyperacusis is a fear and pain response to ordinary environmental sounds perceived as uncomfortably loud, and misophonia is an anger and disgust response to human-made sounds, but these distinctions, and associated characteristics, have not been empirically demonstrated. Undergraduate students (N = 1572) completed self-report measures assessing DST symptoms, clinical correlates, and psychological symptoms and mechanisms. Latent class analysis revealed six clusters, including no DST symptoms (28.6%), hyperacusis (10.1%), misophonia (13.7%), comorbid hyperacusis/misophonia (23.9%), and two mixed symptom clusters (13.2 and 10.6%). People with DST symptoms exhibited more symptoms on psychopathology measures than the no symptom cluster, and individuals with comorbid hyperacusis and misophonia reported the greatest number of symptoms. Hyperacusis is associated with more severe psychopathology than misophonia. Hyperacusis and misophonia were not easily differentiated by specific emotions or sounds, and total emotions appeared to be a better indicator of impairment and a better method to differentiate DSTs than a single emotion. On average, participants found human-made/mouth sounds more aversive than loud sounds and examining hyperacusis-specific sounds was a better method to differentiate "pure" hyperacusis and misophonia clusters than misophonia-specific sounds. This study empirically characterizes DSTs and offers insight into their distinctions.

Differential Identification of Hyperacusis and Misophonia: Implications of Discrete Decreased Sound Tolerance (DST) Condition Subtypes

Hyperacusis and misophonia, referred to as decreased sound tolerance (DST) conditions, are commonly identified within audiological, otolaryngological, and medical settings (Baguley & McFerran, 2011; Jastreboff & Jastreboff, 2004). Hyperacusis involves a decreased tolerance for ordinary environmental sounds that are moderate volume (Baguley, 2004; Gold, Frederick, & Formby, 1999; Jastreboff & Jastreboff, 2004). Misophonia is characterized by an extreme negative emotional reaction to human-made sounds that occur within a normal functioning auditory system (Jastreboff & Jastreboff, 2004, Møller, 2011). These conditions were first encountered in audiological clinics due to their co-occurrence with tinnitus, a disorder characterized by the perception of ringing in one's ears (Jastreboff & Hazell, 2004). Both hyperacusis and misophonia occur independently of tinnitus and often co-occur with one another (Cash, 2015; Jastreboff & Jastreboff, 2004). DSTs are distinguished from normal sound sensitivity because individuals experience adverse emotions and impairment when exposed to trigger sounds. Hyperacusis and misophonia are believed to be differentiated from one another based on the type of sounds that elicit distress, but both conditions result in emotional reactions and share similar functional impairment and coping strategies (Edelstein et al., 2013; Tyler et al., 2014), which can make it difficult to distinguish between the two.

Tinnitus is better documented within the literature and is highly associated with DST conditions (Goldstein & Shulman, 1996; Jastreboff & Jastreboff, 2004). Prevalence rates of tinnitus and comorbid DST conditions range between 10 – 60% (Hadjipavlou, Baer, Lau, & Howard, 2008; Jastreboff & Jastreboff, 2004, 2006; Sztuka, Pospiech, Gawron & Dudek, 2010). Prevalence of hyperacusis ranges between 8 – 26% (Andersson et al., 2002; Baguley &

McFerran, 2011; Cash, 2015), and rates of clinically significant misophonia range between 6 – 20% (Cash, 2015; Rouw & Erfanian, 2017; Wu, Lewin, Murphy, & Storch, 2014; Zhou, Wu, & Storch, 2017). High levels of tinnitus-related distress affect sleep and concentration and are associated with increased depression, anxiety, and difficulty in social and occupational domains (Budd & Pugh, 1995). DST conditions are associated with a range of functional impairment (Andersson et al., 2002; Cash, 2015), and impairment for hyperacusis and misophonia is similar to tinnitus (Cash, 2015; Cavanna & Seri, 2015; Edelstein et al., 2013; Rouw & Erfanian, 2017; Tyler et al., 2014; Wu et al., 2014).

Individuals with hyperacusis and misophonia describe similar functional impairment, emotional reactions, and coping strategies, and there is significant comorbidity between the two conditions (Jastreboff & Jastreboff, 2004). Further, results show that anxiety, depression, neuroticism (Cash, 2015; Jager, de Koning, Bost, Denys, & Vulink, 2020; Jüris et al., 2013), obsessive-compulsive spectrum disorder symptoms (Cash, 2015; Schröder et al., 2013), emotion regulation difficulties, anger symptoms, and general sensory intolerance (Cash, 2015; Wu et al., 2014) are associated with both DST conditions, though this work has been studied more extensively with misophonia. However, despite the similarities, the literature also suggests that the two conditions are different. For example, hyperacusis and misophonia involve emotional reactions to different categories of acoustic stimuli. Hyperacusis is a response to the loudness of ordinary sounds typically not bothersome to most people, whereas misophonia is a response to specific, usually human-made sounds. Second, there appear to be differences in the emotional responses to sounds. Hyperacusis involves responses commonly characterized by fear and pain (Tyler et al., 2014). On the other hand, while people report a variety of emotional responses to misophonic sounds, the primary emotions are anger and disgust (Edelstein et al., 2013).

Distinguishing between hyperacusis and misophonia is important to assist in conceptualizing and assessing these new disorders. In addition, there are likely different implications for treatment (Bernstein, Angell, & Dehle, 2013; Jüris et al., 2014; McGuire, Wu, & Storch, 2015).

Although the existing literature suggests that hyperacusis and misophonia are associated with similar clinical correlates and psychological mechanisms, there are reasons to be skeptical about this conclusion. First, most of the research on associated psychological factors has been done on misophonia, with very little attention to hyperacusis. Second, it is difficult to empirically distinguish between these two conditions, and in fact many studies do not seem to differentiate between them (Jüris et al., 2014; Wu et al., 2014). Finally, there are comorbidities between these DST conditions (Cash, 2015; Jastreboff & Jastreboff, 2004), which have not been considered when evaluating clinical correlates. Hyperacusis and misophonia have not been studied within the same sample, while also taking their comorbidity into consideration. Thus, relationships found between misophonia and anxiety, for example, may instead be driven by a relationship between hyperacusis and anxiety. In this study we will empirically distinguish between groups of people with normal sound sensitivity, hyperacusis, misophonia, and a combination of hyperacusis and misophonia, and examine similarities and differences in clinical correlates, psychological mechanisms, and functional impairment in people with hyperacusis, misophonia, or a comorbid presentation of the two.

We will first identify groups of participants with hyperacusis, misophonia, a combination of symptoms, and normal sound sensitivity based on participants' self-reported DST symptoms using latent class analysis (LCA). We will then examine how these empirically-defined clusters differ in terms of mental health symptoms, individual differences, and clinical correlates to learn more about the characteristics associated with misophonia, hyperacusis, and their comorbid presentation. If there are differences between hyperacusis, misophonia, and normal sound sensitivity based on these factors, the field will better understand empirically how DST conditions are distinct from one another and from normal sound sensitivity and understand what specific factors maintain these disorders. Increasing understanding of the differences in psychological mechanisms between hyperacusis and misophonia can also aid in making more accurate assessment of these conditions and designing effective treatments for them.

We are also interested in assessing whether hyperacusis and misophonia differ in the types of sounds and associated emotions. Once we define groups of participants, we will examine whether there are differences in the types of sounds and associated emotional reactions. Using a measure that assesses emotional reactions to hyperacusis-specific, misophonia-specific, and other distressing sounds (Cash, 2015), we will examine whether a distinction between hyperacusis and misophonia involves the typical sounds that elicit distress, and whether they differ in the emotional responses that are evoked. DST self-report measures are commonly used in the literature, and available measures assess symptoms and impairment (Blaesing & Kroener-Herwig, 2012; Greenberg & Carlos, 2018; Khalfa, Dubal, Veuillet, Perez-Sdiaz, Jouvent, & Collet 2002; Nelting, Rienhoff, Hesse, & Lamparter, 2002; Schröder et al., 2013; Wu et al., 2014). Because the type of sound that elicits distress is a potential distinction between hyperacusis and misophonia, this work warrants exploration. This distinction can help clinicians better assess DSTs and determine the most appropriate treatment based on factors that characterize groups.

The current study will enhance understanding about the similarities and differences between hyperacusis and misophonia. Research shows that both DST conditions are associated with anxiety, depression, emotion regulation difficulties, neuroticism, and clinical correlates

(Cash, 2015), but most work has examined the association between mechanisms and correlates in misophonia, neglecting to account for the comorbidity with hyperacusis. These results are difficult to interpret because the association between misophonia and psychological mechanisms may be confounded. Specifically, it is unclear if these relationships are driven by misophonia alone, hyperacusis alone, or a combination of both hyperacusis and misophonia. It remains to be seen how associated features of DSTs differ between groups of individuals reporting hyperacusis, misophonia, and a combination of both. Hyperacusis and misophonia are associated with different emotional reactions. We will examine how emotional reactions to hyperacusis- and misophonia-specific sounds differ by groups, which could further help differentiate these disorders. Little is known about how individuals with DST conditions and normal sound sensitivity differ psychologically, whether these differences warrant further exploration, and what treatment implications these differences may have.

There are three primary goals of this study:

1. Use a latent class analysis (LCA) approach to empirically identify groups of individuals with similar symptoms of DST conditions and normal sound sensitivity.
2. Examine how individuals in each group identified by the LCA are similar to one another and distinct from other clusters by analyzing group differences in anxiety, depression, personality factors, anger symptoms, posttraumatic stress symptoms, general sensitivity, and ability to regulate emotions.
3. Examine how our LCA-identified clusters differ on reported aversiveness to different sounds that are either hyperacusis- or misophonia-specific, with the aim of differentiating these conditions. We will also examine the emotions commonly

associated with hyperacusis- and misophonia-specific sounds to further differentiate these conditions.

In order to provide background on this study's goals, this study will review the literature on hyperacusis and misophonia and discuss current findings about the comorbidity between DSTs, the relationship between psychological factors and DST conditions, and existing assessment tools designed to measure these conditions.

Review of the Literature

Definitions and Prevalence of DST Conditions

Decreased sound tolerance (DST) conditions are recognized within the audiological, otolaryngological, and neurological literature (Jastreboff & Jastreboff, 2004) and have more recently been studied within the psychological community (Dozier, 2015; Jüris et al., 2013; Wu et al., 2014;). DST is an umbrella term that includes hyperacusis and misophonia (Baguley & McFerran, 2011; Jastreboff & Jastreboff, 2004). Hyperacusis is characterized by sensitivity to everyday sounds at moderate volume (Aazh et al., 2018; Baguley & McFerran, 2011; Katzenell & Segal, 2001). Misophonia is a condition characterized by extreme negative emotional reactions to specific, usually human-made sounds (Jastreboff & Jastreboff, 2001; Potgieter, MacDonald, Partridge, Cima, Sheldrake, & Hoare, 2019). Researchers have sought to understand DST conditions as unique phenomena and better establish prevalence rates. Epidemiological studies suggest that both hyperacusis and misophonia are prevalent in the population. Rates for clinically significant misophonia range between 15 – 23% of university samples and the general population (Cash, 2015; Wu et al., 2014; Zhou, Wu, & Storch, 2017). Prevalence estimates suggest that hyperacusis occurs in approximately 2 – 15% of the general population (Sheldrake et al., 2015). An online and postal survey in Sweden revealed that 8 – 9% of responders endorsed symptoms of hyperacusis (Andersson et al., 2002), and 3% of responders reported clinically significant symptoms, which was defined as symptoms requiring use of ear protection. Cash (2015) also assessed hyperacusis in university and community samples. Of the 826 participants included in analyses, 26.3% endorsed clinically significant symptoms.

Tinnitus is described as ringing, roaring, or buzzing in the ear(s) or head (Jastreboff & Hazell, 2004) and often occurs comorbidly with DST conditions (Jastreboff & Jastreboff, 2004). Although not considered a DST condition, within clinical settings, 10 – 60% of individuals with tinnitus also have a DST condition (Hadjipavlou, Baer, Lau, & Howard, 2008; Jastreboff & Jastreboff, 2004, 2006; Sztuka, Pospiech, Gawron & Dudek, 2010). Tinnitus and DST conditions are highly comorbid, but research has demonstrated that hyperacusis and misophonia also occur without tinnitus (Andersson et al., 2002).

Tinnitus severity is associated with increased functional impairment (Davis, 1995), such that those reporting increased severity also endorse increased impairment. A similar relationship between severity and impairment has been reported for hyperacusis and misophonia (Aazh et al., 2018; Cash 2015; Greenberg & Carlos, 2018; Wu et al., 2014). Within a sample of participants reporting clinically significant misophonia symptoms, defined as those in which participants are "often or always bothered by a specific sound", Wu and colleagues (2014) found that 52.1% endorsed impairment in work and school domains, 22.9% in social functioning, and 18.8% in the family/home domains. Individuals reporting moderate misophonia symptoms also endorsed impairment: 14.9% reported impairment in work/school domains, 6.4% reported social impairment, and 5.6% reported impairment within in family/home functioning (Zhou et al., 2017). A tool developed to measure symptoms of hyperacusis showed that increased perceived severity was associated with decreased quality of life and increased anxiety and depression

(Greenberg & Carlos, 2018). Individuals with DSTs report a range of impairment, and it will be beneficial to increase understanding about how this impairment affects individuals with different symptoms.

Specific sounds associated with misophonia are often repetitive and socially-based, typically produced by a human (Edelstein et al., 2013). Trigger sounds often include other people chewing, pen clicking, throat clearing, foot tapping, and lip smacking (Cash, 2015; Edelstein et al., 2013; Potgieter et al., 2019; Schröder et al., 2013; Wu et al., 2014). Hyperacusis is characterized by an intolerance of everyday sounds at normally-comfortable loudness levels (Aazh et al., 2018; Baguley & McFerran, 2011; Katzenell & Segal, 2001), and some individuals with hyperacusis describe experiencing discomfort to sounds at 40 – 50 decibels, equivalent to the ambient sound in a quiet library (Anari, Axelsson, Eliasson, & Magnusson, 1999). Baguley and McFerran (2011) reported that audiologists and other specialists differentiate hyperacusis from other DST conditions based on the general intolerance of sounds based on loudness, rather than to specific sounds. Jastreboff and Jastreboff (2004) stated that, while misophonia is characterized by aversion to specific sounds, hyperacusis's defining feature is aversion to all sounds above a specific loudness level. The reported impairment and functional effects are similar for hyperacusis and misophonia, and a potential distinction is the type of sound that elicits a reaction. In order to better understand these conditions, different models have been proposed to enhance understanding of their development and maintenance.

Conceptualization

Sensitivity to certain sounds and avoidance of said sounds are characteristic of a healthy auditory system, and tinnitus and DST conditions are differentiated from normal sound sensitivity based on the impairment caused by reactions to sounds (Møller, 2011). Due to the high comorbidity between hyperacusis, misophonia, and tinnitus, researchers have aptly used the tinnitus literature to conceptualize DSTs. Hypotheses about the development of tinnitus implicate the central auditory system and suggest that, over time, overstimulation or deprivation of signals to the auditory nervous system cause tinnitus through a homeostatic compensatory procedure via neural plasticity (Møller, 2011). The current data supporting these assumptions are insufficient. There are cases when tinnitus is associated with physical brain damage (Baguley et al., 2013; Henry, Roberts, Caspary, Theodorff, & Salvi, 2014), but the majority of sufferers experience symptoms idiopathically (Baguley et al., 2013). Studies examining neurological activity in tinnitus suggest there is "…abnormal neural activity associated with tinnitus but [studies] do not offer insight into the neural mechanism(s) giving rise to perception" (Henry et al., 2016, p. 5). Researchers assessing hyperacusis and misophonia have begun to examine neurological correlates as well (Kumar et al., 2017). However, data supporting the presence of physical abnormalities associated with DSTs are lacking, and at present, evidence favors behavioral and cognitive mechanisms in the development and maintenance of DST conditions (Hadjipavlou et al., 2008).

A common conceptualization of tinnitus uses the neurophysiological model (Jastreboff & Hazell, 1993). Within this framework, emotional processing is integral to development of symptoms. The auditory and limbic systems are closely related (Mazurek et al., 2010), and this relationship affects perception and interpretation of sounds. The tinnitus signal, which is the conscious perception of auditory stimuli that are not coming from the environment, activates the limbic and sympathetic autonomic nervous systems and triggers a negative emotional response. This emotional response is distressing and sometimes enhances perception of the tinnitus signal and subsequent distress, resulting in tinnitus (Baguley et al., 2013). For individuals who do not develop problematic symptoms, a habituation process occurs, and the signal no longer elicits distress after a period of time. The sound is no longer consciously perceived; thus, it does not cause distress. However, some people continue to perceive the sound negatively. The elicited distress becomes associated with the sound through negative emotional reinforcement (Jastreboff, 1999), causing perception of the tinnitus signal to persist. This distress causes individuals to do things to reduce the distress, such as: taking drugs or alcohol, using avoidant or wishful thinking, and avoidance of social situations (Budd & Pugh, 1996; Hallberg et al., 1992). These behaviors temporarily reduce distress and thus are reinforced.

Theorists have proposed similar models for the development and maintenance of hyperacusis and misophonia. Cash (2015) provides a useful analogy from the panic literature. Panic symptoms are relatively common in the population (Barlow, 2002). Whereas many people perceive panic symptoms benignly, those who develop panic disorder view these symptoms dangerously and subsequently fear and avoid these symptoms (Barlow, 2002), resulting in increased symptom severity and impairment. A similar process is hypothesized to occur with DST conditions. Many people find loud sounds or mouth sounds mildly annoying. Individuals who develop clinically significant hyperacusis and misophonia symptoms interpret sounds as unbearable, eliciting strong negative emotions. Individuals with hyperacusis and misophonia begin to fear the elicited emotions and worry about encountering these sounds. They engage in behaviors that decrease the likelihood of encountering a sound or use coping strategies that decrease the adverse effect of the elicited emotional reaction (e.g., noise cancelling headphones, music, eating dinner alone). These avoidance behaviors temporarily reduce distress but create impairment in the long-term because individuals expect the associated distress is guaranteed to occur and learn that avoidance is the most helpful strategy.

This psychological conceptualization of hyperacusis and misophonia provides context for appropriate assessment and intervention. Despite similarities in the conceptualization, hyperacusis and misophonia are different in the sounds that elicit a response and in the emotional reaction. The overlap between DST conditions warrants further exploration into the clinical correlates and individual differences that may help explain why people are responding to these different stimuli.

DSTs: Overlap and Distinctions

Psychological mechanisms appear to be primary in the development and maintenance of DSTs (Cash, 2015; Wu et al., 2014; Zhou et al., 2017). Due to the relationship between psychological components and the development of DSTs, researchers have examined psychological mechanisms and correlates of hyperacusis and misophonia. It is important to note, however, that substantial work has examined mechanisms and correlates related to misophonia, but there is less research examining these factors in relation to hyperacusis.

Potgieter and colleagues (2019) recently conducted a review of the misophonia literature and catalogued misophonic triggers, reactions, coping strategies, and comorbid conditions identified in studies that are described below. Wu and colleagues (2014) examined the relationship between misophonia symptoms and severity with psychological symptoms and other clinical correlates. Misophonia symptoms were strongly associated with impairment and general sensory sensitivities and moderately associated with obsessive-compulsive, depressive, and anxiety symptoms. Studies examining the comorbidity between DST conditions and psychiatric symptoms show a relationship with obsessive-compulsive personality disorder (OCPD), obsessive-compulsive disorder (OCD), mood disorders, autism spectrum disorder (ASD), anxiety disorders, post-traumatic stress disorder (PTSD), attention deficit hyperactivity disorder

(ADHD), and eating disorders (e.g., Edelstein et al., 2013; Hesser & Andersson, 2009; Kluckow, Telfer, & Abraham, 2014; Jager et al., 2020; Jüris et al., 2013; Potgieter et al., 2019; Rouw & Erfanian, 2018; Schroder et al., 2013; Stiegler & Davis, 2010; Wu et al., 2014). More in-depth analyses reveal a strong association between misophonia and OCSDs, suggesting that the two share common maintaining factors (Cash, 2015; Cusack, Cash, & Vrana, 2018; Jager et al., 2020; Taylor et al., 2014).

Both hyperacusis and misophonia are characterized by an exaggerated emotional response to stimuli. Researchers identified individual differences and personality factors that act as a predisposing condition for development. Cash (2015) conducted one of the first large-scale analyses of individual differences and mechanisms of action theorized to be associated with DST conditions. Results revealed moderate associations between anger, anxiety sensitivity, distress tolerance, emotion regulation difficulty, and sensitivity to bodily sensations. Higher trait neuroticism and sensory defensiveness were associated with both hyperacusis and misophonia (Cash, 2015; Jüris et al., 2013). Jager and colleagues (2020) also found a strong relationship between higher trait neuroticism and perfectionism and misophonia severity. The results described here for misophonia are consistent with similar research (Wu et al., 2014). However, the results for hyperacusis may be due to the high levels of comorbidity with misophonia and vice versa. We do not know whether hyperacusis or misophonia, when examined independently, are associated with this level of psychological impairment. Cash (2015) further showed that the relationship between misophonia symptoms and severity was mediated by amplification of bodily sensations, and the relationship between misophonia symptoms and impairment was mediated by anxiety sensitivity and amplification of bodily sensations. Presence of misophonia symptoms and anger was mediated by anxiety sensitivity as well. Analyses examining variables that make an individual more susceptible to develop misophonia revealed that synesthesia, neuroticism, and sensory sensitivity all moderated the relationship between misophonia symptoms and functional impairment.

Extending on these findings, McKay, Kim, Mancusi, Storch, and Spankovich (2018) examined profiles of mental health symptoms that characterize misophonia. The researchers examined mental health correlates using a profile analysis via a multidimensional scaling technique. Measures assessed misophonia, obsessive-compulsive symptoms, anxiety, and depression symptoms, in addition to clinical correlates such as anger, anxiety sensitivity, behavioral inhibition, distress tolerance, and interoceptive awareness. One extracted profile accounted for 11% of the variance and was associated with increased sensitivity to interoceptive sensations, anxiety, depression, stress, and cognitions related to inflated responsibility, threat estimation, and perfectionism (McKay et al., 2018). If these symptom profiles are replicable, they have important implications for treatment. Both cognitions and bodily awareness are associated with misophonia, suggesting that dysfunctional cognitions and increased interoceptive sensitivity are distinct targets for intervention. Further research will be needed to replicate these findings to determine how these symptom profiles are related to misophonia and to see whether these relationships are relevant for people with hyperacusis.

In addition to potential differences in associated clinical characteristics, hyperacusis and misophonia appear to differ in terms of what sounds are found to be distressing. Whereas people with hyperacusis respond to the perceived loudness of everyday sounds, misophonia is characterized by emotional reactions to human-made sounds (Dozier, 2015; Potgieter et al., 2019). In a study documenting the frequency that participants reported sensitivity to misophonia-specific sounds, Wu and colleagues (2014) found that 22.8% were sensitive to the sound of people eating (e.g., chewing, swallowing, slurping) and repetitive tapping (e.g., pen on table, foot on floor), 16.1% were sensitive to the sound of rustling (e.g., paper, plastic), 21.7% were sensitive to nasal sounds (e.g., sniffing, inhale), 19.5% were bothered by throat sounds (e.g., coughing, throat-clearing), and 4.1% were sensitive to certain consonants and/or vowels (e.g., "k" sounds). Context and perception are also important factors in misophonic reactions. Edelstein and colleagues (2013) conducted semi-structured interviews and found that loud chewing was perceived less aversively if a baby or animal made the sound. Participants stated that babies and animals have less control over their actions and "don't know any better". Accumulating evidence suggests that perception and individual differences clearly underlie responses in misophonia, potentially affecting the severity of reactions and impairment. However, we know much less about the context in which hyperacusis-specific responses are elicited.

Hyperacusis and misophonia are both associated with adverse emotional reactions, however the most typical emotions experienced in the two DSTs are different. Studies examining reactions to misophonic triggers reveal a variety of emotions (Cash, 2015; Potgieter et al., 2019; Schröder et al., 2013). Results show that 59.5% of patients reported irritation to trigger sounds, and 40.5% reported disgust that "immediately became anger" (Schröder et al., 2013). These results mirrored those found in other studies (Edelstein et al., 2013; Wu et al., 2014). On the other hand, the most common reactions for hyperacusis-specific sounds seem to be fear and pain (Tyler et al., 2014). Tyler and colleagues (2014) differentiate between types of hyperacusis based on the emotion experienced. Fear hyperacusis is characterized by an anticipatory response or avoidance behavior when the sound is encountered. Individuals primarily reporting fear hyperacusis avoid going places where they expect to hear the sound they fear. One of the main consequences is avoidance; either by staying away from the sound or by using headphones (Baguley et al., 2014). Tyler and colleagues (2014) also describe pain hyperacusis, which includes a reported stabbing pain in the ear or head for sounds much lower than the typical pain threshold of 120 decibels. Examining the unique emotions experienced by individuals with DSTs can provide information about how hyperacusis and misophonia are distinct.

Assessment of DST Conditions

When an individual experiences tinnitus, they are typically first referred to an otolaryngologist, audiologist, or other hearing professional who will assess and rule out any physical causes. Professionals complete an extensive medical history and conduct an audiological exam that helps to rule out hearing loss and other identifiable causes of tinnitus (Baguley, McFerran, & Hall, 2013). Other tests commonly administered during a comprehensive audiological evaluation include pure tone audiometry, immittance measures (tympanometry and middle ear muscle reflexes), and loudness discomfort levels. These measures rule out any peripheral hearing deficits. Audiologists use similar procedures to diagnose DSTs as they use for other audiological disorders (Spankovich & Hall, 2014), but many patients with tinnitus and DST conditions are found to have normal hearing sensitivity.

Assessment of idiopathic tinnitus is difficult because without physical damage, there is no way to reliably identify a cause (Greimel & Kröner-Herwig, 2011). Audiologists define perceived symptom severity of chronic tinnitus as mild, moderate, and severe (Møller, 2011), based on patient self-report (Reed, 1960). The audiometer, a device that tests the hearing threshold of varying intensities and tones of sounds, is used to mimic sounds like those experienced by individuals with tinnitus (Penner, 1993). Results using this measure reveal no differences in self-reported annoyance to computer-recreated tinnitus sounds between people with and without tinnitus (Penner, 1996). Other studies assessed tinnitus loudness threshold by matching tinnitus sounds against a tone for which a patient has normal hearing (Penner, 1996). Estimates of loudness changed when individuals were retested, suggesting poor test-retest reliability, or alternatively, tinnitus is variable and may change due to different factors.

Tinnitus severity is affected by stress and other psychological mechanisms, and more subjective measures were developed to assess individuals' perceptions. Use of visual analogue scales and ecological momentary assessments have been used in clinical and research settings to capture changes in tinnitus (Henry et al., 2012). Identification of appropriate treatment for tinnitus has prompted an influx of self-report measures created to measure severity and impairment. The Tinnitus Questionnaire (Hallam, 1996; Mini TQ; Hiller & Goebel, 2004) was developed to assess sleep difficulties, emotional disturbances, and audiological/perceptual difficulties associated with tinnitus. Additional measures have been developed to assess distress commonly associated with tinnitus. The Tinnitus Reaction Questionnaire (TRQ; Wilson et al., 1991) measures tension, anger, and depression related to tinnitus. The Tinnitus Handicap Inventory (THI; Newman et al., 1996) is commonly used in clinical settings to assess impairment associated with tinnitus. This measure has shown high convergent validity with measures of tinnitus distress (Baguley et al., 2013). Other targeted measures of tinnitus have been introduced to measure coping strategies (Henry & Wilson, 1995) and cognitions (Wilson & Henry, 1998) common to tinnitus. In summary, audiologists have a comprehensive assessment for tinnitus but report that, "...the measurement of tinnitus is far from satisfactory and, in particular, the psychological aspects of tinnitus…have yet to be explored" (Baguley et al., 2013).

Like the assessment of tinnitus, there are no assessment tools that definitively provide a diagnosis of hyperacusis or misophonia. Accordingly, there is no measure currently available that reliably identifies individuals with hyperacusis and misophonia using a distinction between them, sounds. Different measures have been developed to assess DST conditions, and as interest in DST assessment and conceptualization has grown, more measures have been introduced in the field.

Audiologists use uncomfortable loudness levels (ULL), or the point at which presented sounds tested at different frequency levels become uncomfortable, to evaluate hyperacusis (Baguley et al., 2013). Patients are presented with auditory stimuli that vary in decibel levels, and patients are required to alert the provider when the stimulus becomes uncomfortable. Lower ULLs are associated with greater hyperacusis severity (Jüris et al., 2013). This measure requires the patient to self-report the discomfort of sounds, and so, lacks objectivity. It has high within-subject variability (Valente, Potts, & Valente, 1997), and research has shown that reported discomfort levels can be influenced by how the instructions are administered (Bornstein & Musiek, 1993). In addition, there are also five self-report measures used to assess symptoms of hyperacusis. These include the Inventory of Hyperacusis Symptoms (IHS; Greenberg & Carlos, 2018), the Hyperacusis Questionnaire (HQ; Khalfa, Dubal, Veuillet, Perez-Sdiaz, Jouvent, & Collet 2002), the Questionnaire on Hypersensitivity to Sound (Nelting, Rienhoff, Hesse, & Lamparter, 2002), the Noise Avoidance Questionnaire (NAQ; Blaesing & Kroener-Herwig, 2012), and the Multiple Activity Scale for Hyperacusis (MASH; Dauman & Bouscau-Faure, 2005). Available measures are used to characterize severity and distress (Baguley et al., 2013), but a diagnosis of hyperacusis is difficult to make due to the subjectivity of symptom reports and lack of consistent definitions across fields (Goldstein & Shulman, 1996).

The Inventory of Hyperacusis Symptoms (IHS) is a 25-item self-report questionnaire (Greenberg & Carlos, 2018) and the most recently developed measure of hyperacusis. It was developed using a sample of 469 individuals identified using online support forums for hyperacusis and tinnitus. Results yielded a five-factor solution that accounted for 66.5% of the total variance and included psychosocial impact, emotional arousal, functional impact, general loudness, and communication. The mean overall score for the HIS was 75 (SD = 15), which was used as a cutoff for the clinical presence of hyperacusis.

The Hyperacusis Questionnaire (HQ) is 14-item self-report questionnaire (Khalfa, et al., 2002) developed using a sample of 201 community members that assesses sound stimuli, responses, and behaviors. A three-factor solution that accounted for 48.4% of variance was found, and factors included attentional, social, and emotional domains. Jüris and colleagues (2013) examined the relationship between HQ scores, Hospital Anxiety and Depression Scale (HADS), and loudness discomfort levels (LDLs) in 62 individuals with hyperacusis. Higher scores on the HQ were associated with higher anxiety on the HADS and lower LDLs, suggesting that participants endorsed increased hyperacusis and discomfort to sounds that were not loud. More recently, Yilmaz1, Taş, Bulut, and Nurçin (2017) assessed hyperacusis in university students and found that 52.1% of participants had scores that were ≤ 16 with only 6% scoring higher than the proposed cutoff of 28.

The Questionnaire on Hypersensitivity to Sound (GUF, based on the initials of the questionnaire name in German) was developed to assess negative emotional responses to loud sounds (Nelting, et al., 2002). The validation study was conducted in a German sample, and the 15-item measure was normed in a clinical sample of individuals with chronic tinnitus and hypersensitivity to sound. Similar to the HQ, analyses revealed that three factors, cognitive reactions, behavioral responses, and emotional reactions to external noises, explained a majority of the variance in scores (Nelting et al., 2002). The GUF demonstrated good convergent validity based on correlation with other self-report and audiometric measures of hyperacusis (Blaesing et al., 2010).

The final two measures of hyperacusis, the NAQ and the MASH, are less commonly used. The NAQ was developed based on the notion that avoiding sounds maintains hyperacusis (Blaesing & Kroener-Herwig, 2012). The NAQ discriminated between participants with hyperacusis and tinnitus, tinnitus alone, and controls by showing that individuals with hyperacusis and tinnitus endorsed more noise-related avoidance than the control and tinnitus only groups. The NAQ was also associated with higher levels of hyperacusis-specific distress, as measured by the GUF (Blaesing & Kroener-Herwig, 2012). The MASH is an interview-based tool that measures the impact of hyperacusis on everyday activities (Dauman & Bouscau-Faure, 2005). The MASH was initially validated in a French sample of individuals with chronic tinnitus. There was a high correlation (r = .89) between MASH score and self-reported hyperacusis annoyance.

Several self-report surveys for misophonia have been developed. Schröder and colleagues (2013) proposed diagnostic criteria based on misophonia's association with symptoms of obsessive-compulsive disorder (OCD), though these criteria are not yet widely accepted. They developed the Amsterdam Misophonia Scale (A-MISO-S) using the proposed diagnostic criteria. The A-MISO-S is a six-item clinician-administered scale that assesses daily preoccupation with misophonic stimuli, social impairment, intensity of anger, effort required to cognitively resist or avoid the sounds, control over thoughts about stimuli, and the amount of time individuals avoid stimuli (Schröder et al., 2013). The psychometric properties of the A-MISO-S have not sufficiently been assessed. Schröder and colleagues (2013) concluded that misophonia should be characterized as a distinct psychiatric disorder, and the A-MISO-S could improve recognition of misophonia (Schröder et al., 2013). There is an English version available, but continued work needs to be conducted to validate the tool.

Wu and colleagues (2014) developed the Misophonia Questionnaire (MQ) to measure the presence and severity of symptoms. The measure is comprised of three sections: the Misophonia Symptom Scale, which examines presence of sensitivities to specific sounds, the Misophonia Emotions and Behaviors Scale, which assesses emotional and behavioral reactions to misophonic sounds, and the Misophonia Severity Scale. The Misophonia Severity Scale is rated on a scale of 1 – 15 and allows the respondent to rate the severity of their sound sensitivity. They sampled 483 American undergraduate students to assess misophonia symptoms, associated correlates, and impairment, and found that the MQ demonstrated good convergent validity and adequate discriminant validity with measures of other sensory sensitivities.

Dozier (2015) describes three additional misophonia measures. The Misophonia Assessment Questionnaire (MAQ; Johnson, 2014) was developed by an audiologist who treats misophonia and assesses the impact of misophonia on activities, thoughts, and feelings. The Misophonia Coping Resources (MCR) survey documents specific coping strategies. The Misophonia Trigger Severity Scale is used to rate the severity of physical/emotional responses to sounds. These instruments have not been validated, are published in a single case study, and because the scales focus on “sound issues” broadly without identifying specific sounds, the scale is unable to differentiate between hyperacusis and misophonia (Dozier, 2015).

The tools commonly used to assess DST conditions examine hyperacusis and misophonia in isolation. Cash (2015) sought to develop a scale that assesses discomfort to specific sounds in order to differentiate between individuals with hyperacusis, misophonia, and normal sound sensitivity. It was hypothesized that DST conditions could best be differentiated based on the sounds that elicit an emotional reaction. Cash (2015) hypothesized that a three-factor solution would emerge, differentiated by misophonia sounds (e.g., eating sounds, foot tapping), hyperacusis sounds (e.g., traffic noise, radio playing at moderate volume), and normal sound sensitivity (e.g., nails on a chalkboard, gunshot). Using participants from university and community samples, scale development occurred in four steps: (1) exploratory factor analysis (EFA) using the 41 original items in the full student sample, (2) a second EFA using a randomly selected portion of the community sample, (3) confirmatory factor analysis (CFA) on another randomly selected portion of the community sample, and (4) evaluation of estimated internal reliability and construct validity of scores on final items and scale with both samples. Results revealed a two-factor, ten-item solution. Although a three-factor solution was not supported (Cash, 2015), the two-factor solution showed that hyperacusis- and misophonia-specific sounds loaded onto distinct factors, loudness- and human-specific sounds. Internal reliability was supported for both subscales and the total scale, but construct validity was mixed. Results suggest that the subscales of the 10-item scale are appropriate for ruling out misophonia and hyperacusis, but the measure is not suitable in identifying the presence of these disorders (Cash, 2015).

Empirical evidence supporting the use of these measures is incomplete. Despite increased interest in measure development that assess for symptoms associated with DST conditions, it is still unclear whether hyperacusis and misophonia can be validly differentiated from each other (Cash, 2015). In this study, we will examine the responses to the most commonly used misophonia- and hyperacusis-specific sounds in groups identified by the LCA. An additional goal of this study is to examine the different emotions associated with hyperacusis and misophonia. This work will contribute to our understanding of the distinction between hyperacusis and misophonia based on distressing sounds and associated emotions.

Emotions

There is overlap in functional impairment and coping strategies between hyperacusis and misophonia, and they are currently differentiated primarily based on the sounds that elicit an emotional reaction. Hyperacusis involves an emotional response to everyday sounds, whereas misophonia involves distress caused by specific human-made sounds. It is also hypothesized that hyperacusis and misophonia elicit different emotional reactions. Hyperacusis is more closely associated with fear and pain, and misophonia is more closely related to anger and disgust, suggesting that the type of emotional reaction could potentially be used to differentiate these disorders.

Emotions serve distinct purposes. Anger and disgust manage social rule violations, and the expression of anger helps communicate that behaviors violate a social or moral norm (Haidt, 2003). Expression of anger and disgust can affect other individuals (Miller & Leary, 1992) and help guide others' behaviors. Misophonia is characterized by emotional reactions to human-made sounds, and anger and disgust may be expressed more often because the emotion is typically directed towards the individual making the sound as a tool to manage perceived social norms (Edelstein et al., 2013). Fear and pain are related to the activation of behaviors to avoid threat and increase safety, and individuals with hyperacusis may be more acutely aware of sounds in their environment to aid in avoidance of danger (Tyler et al., 2014). Whereas anxiety and fear operate to increase safety and often serve an intrapersonal purpose, anger and disgust often function interpersonally to communicate with others. The DST literature demonstrates that individuals with hyperacusis and misophonia experience different emotions to trigger sounds

(Cash, 2015; Edelstein et al., 2013). In this study we will examine the types of emotions associated with the groups identified and assess whether these emotions differentiate the hyperacusis- and misophonia-specific groups.

Discriminating between the types of emotional responses in hyperacusis and misophonia is particularly important because individuals who react more frequently with fear and pain as opposed to anger and disgust will require different treatment. Individuals who react frequently with pathological anxiety or fear may be better suited to exposure-based interventions because these emotions are successfully treated using exposure. Frequent anger often suggests difficulty regulating emotions (Mauss, Cook, Cheng, & Gross, 2007), and skills-based interventions prove most beneficial. Anger is an emotion that is often interpreted negatively, prompting suppression of that emotion. Emotion regulation strategies, such as reappraisal, acceptance-based interventions or distress tolerance and cognitive interventions are appropriate forms of treatment to target emotions such as anger and disgust (Potter-Efron, 2015).

Rationale for LCA

Although a great deal of work has been devoted to developing assessment instruments for misophonia and hyperacusis, the field has not yet come up with a good way to empirically identify individuals with DSTs, and to differentiate between them. In this study we will use Latent Class Analysis (LCA) to identify groups of people reporting symptoms of hyperacusis, misophonia, and a combination of both. DST conditions are proposed to occur comorbidly with one another (Jastreboff & Jastreboff, 2004), and LCA can identify distinctions between participants with one DST condition versus a combination of both.

LCA is a flexible, person-centered statistical approach that groups individuals into “latent” (i.e., unobserved) classes based on patterns of responding on indicator variables (i.e., selected variables relevant to the research question; McCutcheon, 1987). Researchers examining the nosology and comorbidity of psychiatric disorders often use LCA to identify groups of individuals with shared symptom patterns (El-Gabalawy et al., 2013; Welch et al., 2011). This analysis is appropriate for disorders with high comorbidities and shared etiologies because LCA can characterize the unique typologies that identify differences between groups. Using a latent class analysis can highlight differences between hyperacusis, misophonia, and normal sound sensitivity and show how participants within the same group are similar. Accordingly, because most research does not account for the comorbidity of hyperacusis and misophonia, results have been confounded. It is currently unclear whether results identifying relationships between DST conditions and psychological mechanisms are due to either hyperacusis or misophonia alone or the combination. It will be important to account for both conditions when examining their associations with other correlates to determine the nature of these relationships.

Aims and Hypotheses

1. Hyperacusis and misophonia are conceptualized differently but share similarities. DST conditions are difficult to distinguish between and are primarily differentiated by the types of sounds that elicit an emotional reaction. Prevalence studies assessing DSTs suggest that hyperacusis and misophonia occur frequently in the population and often occur comorbidly with one another. This study will empirically identify groups of individuals reporting different symptoms and impairment related to normal sound sensitivity, hyperacusis, and misophonia, which will allow further analyses to examine differences between these groups. Based on estimates in non-clinical student samples, we hypothesize that at least four groups will be identified by the LCA. The largest group will be comprised of individuals with minimal to no DST symptoms or

impairment. The second largest group will be characterized by hyperacusis-only symptoms, followed by the misophonia-only group. Based on the compounding effects of comorbidities of symptoms, we hypothesize that a hyperacusis and misophonia combination group will be associated with greater functional impairment than the groups comprised of hyperacusis or misophonia only.

2. Studies examining hyperacusis and misophonia show that both conditions are associated with mental health symptoms, clinical correlates, and psychological mechanisms, though the misophonia literature is more extensively examined than hyperacusis. Because most of the literature examines misophonia, and misophonia is confounded with hyperacusis, this study will be the first to look at associated features of DSTs separately. We hypothesize that both the hyperacusis and misophonia groups will be associated with increased anxiety, depression, neuroticism, anger symptoms, posttraumatic symptoms, and general sensitivity, and a decreased ability to regulate emotions compared to the normal sensitivity group, and the combined hyperacusis and misophonia group will be associated with the greatest psychological impairment.
3. Hyperacusis and misophonia are differentiated based on the type of sounds found distressing in each condition, and previous work suggests that different emotions are associated with hyperacusis and misophonia. This study examines whether hyperacusis and misophonia are differentiated based on the sounds they respond to and on the typical emotional reactions engendered. This study will identify the primary sounds and typical emotions associated with clusters, with the aim of further differentiating DSTs. We hypothesized that the emotions of fear and pain would be more frequently reported in individuals with hyperacusis, and anger and disgust

would be more frequently reported in individuals with misophonia. We further hypothesized that the DST combination cluster would report a greater number of emotions than the other clusters. Another method to differentiate hyperacusis and misophonia is the type of sound that elicits a reaction. We hypothesized that hyperacusis-specific sounds would be closely associated with the hyperacusis cluster, and the misophonia-specific sounds would be more closely related to the misophonia cluster. A repeated measures ANOVA was conducted to examine whether clusters differ by specific emotional reactions and sound groups that are rated more aversively.

Method

Participants

Participants were drawn from the Virginia Commonwealth University undergraduate participant pool using an online system that allows students to participate in research for extra credit in psychology courses. A sample comprising of 1572 university students (1154 females, 412 males, and 6 identifying as other) aged between 18 and 66 years, with a mean age of 19.49 ± 3.50 years.

Design

This is 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 SONA with a link to take the survey at an external, secure electronic data storage system, RedCAP. The survey was made available until approximately 1000 students completed it. Data collection occurred between January 2018 and

December 2019. The survey required approximately 45 minutes to complete. Most participants answered questionnaires in the same order, beginning with demographic and screening items and continuing 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 keep related constructs together to allow for ease of comprehension by participants.

Measures

Participants completed several 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, 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. Other measures were collected that are not relevant to the current study and will not be described here. A complete set of assessment tools is included in the Appendix, and all measures included in analyses are described briefly below.

The MQ Total Scale, MQ Severity Scale, HQ Loudness scale, and the HQ Attentional, Emotional, and Social subscales were used as indicator variables in the LCA to create clusters. The second hypothesis examined differences in clinical correlates, psychological mechanisms, and individual differences between clusters. Each of these measures served as a dependent variable to assess how clusters differed psychologically. The goal of the third hypothesis was to assess whether clusters differed on specific sounds and emotions. Specific sounds and emotions from the DST Scale were used to conduct these analyses. The specific cluster x specific sound types and cluster x emotion types served as the within-subjects variables to analyze differences between clusters. This will be elaborated on further below.

LCA Indicator Variables. 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). The MQ Total Scale (comprising the Symptom Scale and the Emotions and Behaviors Scale) and Severity Scale were used as LCA indicator variables.

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). It has good psychometric properties and provides information about hyperacusis symptoms within attentional, social, and emotional domains (Khalfa et al., 2002). Within their initial validation study, the authors reported that a cutoff score of 28 or higher was indicative of clinically significant symptoms. However, many studies show varied prevalence rates for hyperacusis based on the measure used to assess it (Tortorella et al., 2017) and suggest that a lower cutoff is indicative of hyperacusis (Aazh & Moore, 2017).

Critics of the HQ found that ten items (Fackrell, Fearnley, Hoare, & Sereda, 2015) and even six items might be appropriate for measuring hyperacusis (Fioretti et al., 2015; Tortorella et al., 2017). Hyperacusis is differentiated from misophonia based on the loudness of sounds. The HQ includes questions that are specific to the loudness of sounds and questions that assess the emotional and behavioral effects of general sounds. Based on the premise that hyperacusis can be assessed using fewer items, this study identified the six questions on the HQ that were specific to loudness and created the Loudness Scale (items 3, 4, 5, 7, 8, 12). This scale will be used as a LCA indicator variable to assess symptoms of hyperacusis. The HQ is comprised of three subscales that measure the attentional (items 1 to 4), social (items 5 to 10) and emotional (items 11 to 14) effects of sounds (see Appendix for HQ Loudness Scale questions and HQ subscales). The Attentional, Emotional, and Social subscales of the HQ were also used as indicator variables for the LCA.

Other 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 (Möller et al., 2011). These screening items were presented first. Only participants who respond affirmatively to questions about tinnitus, DST in general, or misophonia specifically were asked to complete the Mini Tinnitus Questionnaire. These questionnaires presuppose some level of tinnitus symptoms; therefore, only participants endorsing these symptoms were asked to complete these measures.

The Decreased Sound Tolerance Differential Diagnostic Scale (DST Scale; Cash, 2015) asked individuals to rate their level of discomfort (1=*no discomfort*, 4=*extreme discomfort*) in response to 40 environmental and human-produced sounds. 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 the DST Scale, a drop-down menu appeared asking participants to select the most prominent emotion(s) experienced in response to the sound. Emotion response options are anger/rage, annoyance/irritation, fear, anxiety, sadness, disgust, guilt, pain, and other (*please specify*), and participants could select more than one emotion for each sound.

Several variables were created from participant responses on the DST Scale to be used in this study. Cash (2015) identified a two-factor solution based on aversiveness ratings to the sounds, a **loudness-specific sounds (LSS) factor** and a **human-specific sounds (HSS) factor**. The HSS and LSS are each comprised of five sounds (discussed below), and each participant received a score for each scale (5 – 20) based on the summed aversiveness rating for the sounds on each scale. In addition, because hyperacusis and misophonia are closely associated with loud sounds and mouth/eating sounds, respectively, two *a priori* categories labelled **Loud Sounds** and **Mouth Sounds** were also created. Each of these categories included six sounds (discussed below), and participants received a score for each scale (6 – 24) based on the summed aversiveness rating for the sounds on each scale.

The **Total Emotions** variable was calculated by summing all the emotions that participants reported for sounds they found aversive. Because there are 40 sounds included in the DST Scale and eight possible emotions for each sound, the possible range for Total Emotions was 0 – 320. We also calculated frequency counts for the eight emotions (not including "other") to assess our third hypothesis. This variable was the sum of times each specific emotion was endorsed for a sound they found aversive. Totals for each of the eight emotions ranged between 0 and 40.

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 **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. The HHIA Total and HHIA-Social and HHIA-Emotional scales were used to assess differences between clusters.

Clinical Correlate Measures. The **Fear Survey Schedule** (**FSS-III - Social Phobia subscale**; Arrindell, Emmelkamp, & Van der Ende, 1984; Wolpe & Lang, 1964) 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) was used in this sample. Cronbach’s alpha calculated for this sample was 0.923, suggesting excellent internal consistency.

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 and depression levels. The total HADS score and anxiety (HADS- Anxiety) and depression total scores (HADS- Depression) were used as variables in this study. Cronbach's alpha calculated for HADS-Total in this sample was 0.816, suggesting good internal consistency.

The **Primary Care PTSD Screen for DSM-5** (**PC-PTSD-5**; Prins, et al., 2015) is a brief screener designed to assess PTSD symptoms. The first question asks individuals whether they have experienced or witnessed a traumatic event (e.g., serious accident, physical/sexual assault). The participant can respond either 'yes' or 'no'. If the participant positively endorses experiencing a traumatic event, they may report 'yes' or 'no' whether they experienced any of the five symptoms of PTSD over the last month (e.g., nightmares, avoidance, reexperiencing, hyperarousal, emotional numbing). Traumatic Experience was coded as either '0' or '1', and a total score (0-5) for the number of posttraumatic stress symptoms (PTSS) was calculated for use in analyses. The sample size is smaller (N = 1292) for this measure because it was introduced after the study began.

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 total score (MAI Total) was used for analyses. Cronbach's alpha calculated for this sample was 0.902, suggesting excellent internal consistency.

The **Ten Item Personality Inventory** (**TIPI**; Gosling, Rentfrow, & Swann 2003) is a brief, face valid, self-report questionnaire that assesses personality traits from the Five Factor model. 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 TIPI includes five subscales that provide a score for the “Big Five” personality factors: extraversion, agreeableness, conscientiousness, openness, and emotional stability. Higher scores on each of these scales reflects “better” personality functioning. This study examines each of these five personality traits to examine differences across clusters.

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 ASI Total score was used in analyses. Cronbach’s alpha calculated for the ASI Total in this sample was 0.915, suggesting excellent internal consistency.

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, difficulties engaging in goal directed behavior, impulse control difficulties, lack of emotional awareness, limited access to emotion regulation strategies, and lack of emotional 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 DERS Total score was used in analyses, and Cronbach's alpha calculated for this sample was 0.940, suggesting excellent internal consistency.

The **Somatosensory Amplification Scale** (**SSAS**; Barsky, Wyshak, & Klerman, 1990) is a ten-item self-report scale designed to assess sensitivity to mild bodily experiences that 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. Cronbach's alpha calculated for this sample was 0.733, suggesting acceptable internal consistency.

Analytic Strategy

Hypothesis 1. A latent class analysis was performed using Latent Gold 5.1. We collected data from 1572 participants, which meets the recommended minimum sample size for LCA (100 – 500) (Collins & Wugalter, 1992; Finch & Bronk, 2011; Wurpts & Geiser, 2014). Latent class indicator variables assessed hyperacusis and misophonia symptoms using the two measures in the DST literature most commonly used to assess these conditions. The indicator variables used in the LCA were the Total MQ, MQ Sound Severity, HQ Loudness Scale, and the HQ Attentional, Emotional, and Social subscales. Total sample means were calculated for each of the indicator variables, and cutoffs were created using the standard deviations of a normal distribution. Based on patterns of responding on the MQ Total and HQ Loudness Scale, scores were grouped by standard deviations (SDs): -3 - -0.5 SDs, -0.49 – 0 SDs, 0.01 – 0.5 SDs, and 0.51 – 3 SDs. Scores on the HQ Attentional, Social, and Emotional subscales were grouped by scores falling below the mean and those that were higher than the mean. These cutoffs were chosen because when the four cutoffs were entered into the LCA model, the 10-class exploratory model was exceeded and showed poor model fit. Based on previous data (Wu et al., 2014), the Misophonia Sound Severity scores were combined so that individuals who scored a 0 or 1 were "No/Low Severity", those who scored a 4 or 7 "Mild/Moderate Severity", and participants who scored an 11 or 15 were "Severe/Very Severe".

An exploratory strategy was used to build the model, and number of classes was increased until there was a class solution identified that appropriately fit the data using the following procedures. A maximum of ten latent class models was estimated to identify underlying clusters of DST symptoms. LCA involves different indices of fit that allow the researcher to examine models that fit the data best. Each of these indices were examined to assess appropriate number of classes. The model fit likelihood ratio chi-squared statistic (L^2) provides an indication of how similar model-based estimated frequencies are to observed frequencies (Vermunt & Magidson, 2005; 2016). This statistic shows the amount of the observed relationship between the variables that is unexplained, so, the larger the value, the poorer the model fit. The L^2 statistic can also be compared with degrees of freedom to assess model fit. A good model fit is one in which the L^2 is not substantially larger than the degrees of freedom. Number of parameters (NPar) is the distinct parameters estimated by the model and provides a metric of parsimony to examine conditional independence of groups. The AIC and BIC are estimations of fit based on L^2. These indices take the parsimony of the model into account (degrees of freedom; NPar), and the lower the BIC and AIC, the better the model fit (Vermunt & Magidson, 2005; 2016). The classification error is the proportion of cases that are estimated to be misclassified. The closer this statistic is to zero, the better the fit of the model.

Hypothesis 2. Psychological differences between identified LCA clusters were examined using multiple analyses of variance (ANOVA) tests to determine whether there are statistically significant differences between the LCA clusters. We hypothesized that the hyperacusis and misophonia groups would both be associated with increased functional impairment, and the hyperacusis and misophonia combination group would be associated with the most significant impairment and decreased psychological functioning. The independent variables used in analyses are correlates and mechanisms associated with DST symptoms such as tinnitus (Mini TQ; Hiller & Goebel, 2004), social phobia (FSS-III Social Phobia subscale; Wolpe & Lang, 1964), anxiety and depression subscales and total scale (Hospital Anxiety and Depression Scale; HADS; Zigmond & Snaith, 1983), trait-level anger (Multidimensional Anger Inventory; MAI; Siegel, 1986), personality factors (Ten Item Personality Inventory; TIPI; Gosling, Rentfrow, & Swann, 2003), difficulties in emotion regulation (Difficulties in Emotion Regulation Scale; DERS; Gratz & Roemer, 2004), hearing-related functional impairment (Hearing Handicap Inventory-Adult Version; HHIA; Newman, Weinstein, Jacobson, & Hug, 1991)**,** emotional reactivity to aversive sounds (Total Emotions), and somatosensory amplification (Somatosensory Amplification Scale; SSAS; Barsky, Wyshak, & Klerman, 1990). Descriptive statistics for all variables are presented, and we tested the assumptions for ANOVA to ensure all assumptions are met. Assumptions of normality were assessed by evaluating skewness and kurtosis. Non-parametric tests were used if these assumptions were violated. To address Type I error due to multiple comparisons, the Bonferroni correction was applied (Hochberg, 1988). When any assumptions were violated for any of the analyses, the appropriate post-hoc tests were performed to meet the assumptions of normality and homogeneity of variance.

Hypothesis 3. We were interested in whether there was a difference in specific emotions reported in response to sounds by cluster membership. We hypothesized that the emotions of fear and pain would be more closely associated with the hyperacusis cluster, and anger and disgust would be more closely associated with the misophonia cluster. We further hypothesized that the DST combination cluster would report a greater number of emotions than the other clusters. We first assessed the typical emotions associated with each cluster by conducting a chi-square analysis to examine whether there is a difference in the frequency counts of each emotion endorsed. We then conducted repeated measures ANOVAs, with LCA cluster membership as the within-subjects variable, to examine whether there was an effect of emotions on cluster membership.

We were also interested in how different sound types (hyperacusis-specific, misophonia-specific) distinguish between clusters. The DST Scale identifies specific sounds related to hyperacusis, misophonia, and those that are generally distressing (Cash, 2015). We created a score for each participant based on their endorsement of the hyperacusis- and misophonia-sounds included in this scale and created a frequency count of each sound endorsed as distressing in each a priori category. Repeated measures ANOVAs, with LCA cluster as the between-subjects variable, were conducted to examine whether there was an effect of sounds on cluster membership. We hypothesized that hyperacusis-specific sounds would be more frequently reported as aversive by individuals in the hyperacusis cluster and that misophonia-specific sounds would be more frequently reported as aversive by those in the misophonia cluster.

Strong order effects related to questionnaire presentation are a potential limitation in this study. To examine whether questionnaire order affected participant responding, we changed the order of questionnaires so that DST- and sound-related questions were presented in a randomized manner. Questionnaire order was randomized on October 6th, 2019. Latin square analyses were conducted to examine order effects.

Results

Data collection occurred between January 2018 and December 2019. To account for order effects, the order that the grouping of questionnaires was presented was changed in October 2019. Prior to October 4, 2019, the DST questionnaires were presented first (N = 1160) and beginning October 4, 2019, this group of questionnaires were presented after the clinical correlates and psychological mechanisms measures (N = 412). T-tests were conducted, and there were no significant differences between participants' responses when the order of questionnaires was changed.

Total Sample Descriptives

Table 1 shows demographics, misophonia symptoms and severity, and hyperacusis symptoms for the total sample (N = 1572). Approximately three-quarters of the sample was female, and the average age was 19 years old. The sample was ethnically diverse with 38.7% identifying as "non-Hispanic White", 21.6% identifying as "African American or Black", 18% identifying as "Asian American", 10.8% identifying as "Hispanic/Latino", 3.4% identifying as "Middle Eastern", and 7.6% identifying as multiracial or "Other". A large portion of the sample reported their highest level of education completed as "High School/GED" (37.5%) and "Some college" (50.3%), 8.5% reported having an "Associates degree", 2.9% reported earning a "Four-year college degree", and 0.8% reported a "Masters" or "Professional degree".

A range of DST symptoms and severity were also reported. The MQ Severity Scale revealed that 12.7% of participants reported "No sound sensitivity", 37.7% described "Minimal sensitivity", 36.5% endorsed "Mild sensitivity", 11.3% reported "Moderate sensitivity", 1.7% reported "Severe sensitivity", and 0.1% described "Very severe sensitivity". According to the criteria proposed by authors who developed the MQ (Wu et al., 2014), 13.1% of our sample endorsed clinically significant misophonia symptoms a score of 7 or higher. Means were calculated for the MQ total, HQ total, HQ Loudness Scale, and the HQ Attentional, Emotional, and Social subscales. Means and SDs for these scales are in Table 1.

Table 1

Total Sample Descriptives

Characteristic	Total N = 1572 N (%) or M (SD)
Gender	
Male	412 (26.2%)
Female	1154 (73.4%)
Other	6 (0.4%)
Age in years*	19.49 (3.5)
Ethnic Identity	
African American or Black	339 (21.6%)
Asian American	283 (18%)
White (non-Hispanic)	608 (38.7%)
White (Hispanic)	169 (10.8%)
Middle Eastern	54 (3.4%)
Other	119 (7.6%)
Level of Education*	
High School/GED	589 (37.5%)
Some College	790 (50.3%)
Two-Year College (Associates)	134 (8.5%)
Four-Year College	45 (2.9%)
Master's Degree	9 (0.6%)
Professional Degree	3 (0.2%)
Misophonia Sound Severity	
0, No sound sensitivity	199 (12.7%)
1, Minimal sound sensitivity	592 (37.7%)
4, Mild sound sensitivity	574 (36.5%)
7, Moderate sound sensitivity	178 (11.3%)
11, Severe sound sensitivity	27 (1.7%)
15, Very severe sound sensitivity	2 (0.1%)
Misophonia Questionnaire Total (MQ)	17.76 (11.92)
Hyperacusis Questionnaire Total (HQ)	10.66 (7.01)
HQ Loudness Scale	5.97 (3.70)
HQ Attentional subscale	4.21 (2.73)
HQ Social subscale	2.60 (2.76)
HQ Emotional subscale	3.85 (2.95)

* Indicates responses missing
Age in years: N = 32 missing; Level of education: N = 2 missing

Hypothesis 1: Latent Class Analysis

A latent class analysis was run using the following indicator variables: the MQ Total, MQ Sound Severity, HQ Loudness Scale, and the HQ Attentional, Social, and Emotional subscales to identify clusters of participants with DST symptoms. The indices of fit outlined in the Analytic Strategy section were assessed to determine the appropriate number of classes for this model.

The model was first run and revealed significant associations between the HQ Emotional, Social, and Attentional subscales, and a significant relationship between the HQ Emotional subscale and MQ Sound Severity. These results suggest that the local independence assumption was violated. The local independence assumption of latent class analysis presumes that the indicator variables are conditionally independent of each other given a score on each of the indicator variables (Vermunt & Magidson, 2005; 2016). Because we were using subscales from a total scale to predict class membership within our analyses, we expected that this assumption may be violated. Vermunt and Magidson (2016) recommend a "relaxing" of the local independence assumption by allowing for associations between indicator variables (Hagenaars & McCutcheon, 2002; McCutcheon, 2011). Within LatentGold, the user can easily account for these associations.

Based on the findings of the first model, the model was run again using the same indicator variables but accounting for the relationships between the indicators that violated the local independence assumption (statistics for this model are presented in Table 2). Based on the BIC, the fit of the model improved from a 1-class model (16459.40) to the 6-class model (14129.78) but weakened following the 6-class model to the 10-class model (14142.23 – 14318.14). Based on the AIC, the fit of the model improved from the 1-class model (16379.00) to the 8-class model (13663.22) but weakened following the 8-class model to the 10-class model (13665.94 – 13658. 85) The 1-class model had the lowest number of parameters (15), and number of parameters increased with each model (27 – 123). Classification errors remained below 15% for all models. The 1-class model had the highest L^2 statistic (3097.90) with subsequent models gradually decreasing (1251.83 – 161.75). Based on the BIC, AIC, classification error, L^2 statistic, and the *p*-value, the 6-class model was chosen as the best fit. The 6-class model had an AIC of 13727.77, a classification error of 13%, an L^2 statistic of 326.66, and 75 parameters.

Table 2

Latent Class Model Comparisons

Number of classes	AIC	BIC	Class Err.	L^2	Npar	*p*
1	16379.00	16459.40	0	3097.90	15	1.1e-425
2	14556.93	14701.66	0.04	1251.83	27	5.6e-100
3	14046.19	14255.23	0.07	717.10	39	2.0e-28
4	13897.26	14170.62	0.12	544.16	51	1.7e-12
5	13795.26	14132.77	0.11	417.98	63	0.00018
6	**13727.77**	**14129.78**	**0.13**	**326.66**	**75**	**0.22**
7	13675.90	14142.23	0.14	250.80	87	0.97
8	13665.76	14193.87	0.14	214.12	99	1.00
9	13661.62	14260.92	0.13	192.84	111	1.00
10	13655.98	14318.14	0.13	161.75	123	1.00

Note: Bolded text indicates final model selected. Class. Err indicates classification error. Npar indicates number of parameters.

Table 3 shows the conditional probabilities for the 6-class model. Conditional probabilities show the probability that a person assigned to a cluster is likely to have scored at each particular level of an indicator variables. For each indicator variable, conditional probabilities sum to one within each cluster (Vermunt & Magidson, 2005). Conditional probabilities ranging from 0-0.30 are considered low, 0.31-0.60 are considered moderate, and 0.61-0.90 are considered high (Nasim, Blank, Cobb, & Eissenberg, 2012; Nasim, Guy, Soule, Cobb, Blank, & Eissenberg, 2016). Each cluster was assigned a label (see top row of Table 3) based on the conditional probability patterns found for the indicator variables, the "Low DST" cluster was the largest, representing 28.6% (N = 449) of participants. This group was characterized by a high probability of experiencing no severity of sound sensitivity, endorsing no or minimal symptoms of both misophonia and hyperacusis, and reporting limited impairment due to sounds. The "High DST" cluster included 23.9% (N = 376) of participants and was characterized by a high probability of experiencing mild to moderate sound sensitivities, high misophonia and hyperacusis symptoms, and endorsing high attentional, emotional, and social impairment due to sounds. The "Misophonia" cluster included 13.7% of (N = 215) had a high probability of experiencing mild to moderate sound sensitivities, a high probability of experiencing misophonia symptoms, and a high probability of experiencing no hyperacusis symptoms and no associated impairment. The "DST; Attentional Difficulties" cluster (N = 207) had a high probability of experiencing mild to moderate sound sensitivities, a high probability of experiencing moderate to high misophonia and hyperacusis symptoms, and a high probability of having attentional difficulties due to sounds. The "DST; Social Difficulties" cluster (N = 166) had a high probability of experiencing mild to moderate sound sensitivities, a moderate probability of experiencing both misophonia and hyperacusis symptoms, and a high probability of experiencing social difficulties due to sound. The "Hyperacusis" cluster (N = 159) had moderate to high probability of experiencing hyperacusis symptoms, a high probability of reporting no to minimal misophonia sound severity a high probability of experiencing minimal misophonia symptoms, and a high probability of endorsing minimal to moderate impairment due to sounds.

Table 3

Latent Class Conditional Probabilities

	Low DST	High DST	Misophonia	DST; Attentional Difficulties	DST; Social Difficulties	Hyperacusis
Cluster size	28.6%	23.9%	13.7%	13.2%	10.6%	10.1%
N = 1572	449	376	215	207	166	159
MQ Sound Severity						
None – Minimal (0-1)	0.93	0.14	0.31	0.28	0.29	0.95
Mild – Moderate (4-7)	0.07	0.80	0.69	0.72	0.68	0.05
Severe – Very severe (11-15)	0.00	0.06	0.00	0.00	0.03	0.00
Total MQ						
-3 – -0.5 SDs	0.77	0.05	0.12	0.10	0.11	0.63
-0.49 – 0 SDs	0.14	0.07	0.28	0.21	0.16	0.22
0.01 – 0.5 SDs	0.07	0.16	0.32	0.33	0.31	0.14
0.51 – 3 SDs	0.02	0.72	0.28	0.36	0.42	0.01
HQ Loudness						
-3 – -0 .5 SDs	0.93	0.01	0.66	0.00	0.21	0.00
-0.49 – 0 SDs	0.07	0.02	0.29	0.27	0.42	0.38
0.01 – 0.5 SDs	0.00	0.12	0.05	0.53	0.34	0.43
0.51 – 3 SDs	0.00	0.85	0.00	0.20	0.03	0.19
Attentional subscale						
-3 – 0 SDs	0.99	0.04	0.88	0.03	0.99	0.43
0.01 – 3 SDs	0.01	0.96	0.12	0.97	0.01	0.57
Social subscale						
-3 – 0 SDs	0.97	0.02	0.99	0.87	0.04	0.60
0.01 – 3 SDs	0.03	0.98	0.01	0.13	0.96	0.40
Emotional subscale						
-3 – 0 SDs	0.98	0.16	0.77	0.44	0.71	0.68
0.01 – 3 SDs	0.02	0.84	0.23	0.56	0.29	0.32

Descriptive Results

Table 4 displays demographics for each of the six clusters. Chi square analyses were calculated to identify any significant differences between the groups. There were significant differences between the six LCA classes and the distribution of gender ($p < 0.001$). Overall, 61.6% of the sample is female, and the “Low DST” and “DST; Social Difficulties” clusters consisted of 61 – 64% females. However, females appeared to be overrepresented in the “High DST”, “Misophonia”, “DST; Attentional Difficulties”, and the “Hyperacusis” clusters, which were comprised of 79 – 81% females. There were also significant differences in ethnic identity between the six clusters. Descriptively, the “DST; Attentional Difficulties” and “Hyperacusis” clusters had a lower proportion of individuals identifying as African American or Black than the other four groups, and there were higher proportions of individuals identifying as Asian American in the “Misophonia” and “DST; Social Difficulties” clusters. In individuals who identified as White (non-Hispanic), there was a larger proportion of individuals in the “High DST” and “DST; Attentional Difficulties” clusters, and a smaller proportion of individuals in the “Misophonia” cluster. There were not enough participants in the other ethnic groups to make meaningful comparisons, even at the descriptive level. There were no significant differences in education level or age between the six clusters.

Table 4

Cluster Sample Characteristics

Characteristics	Low DST	High DST	Misophonia	DST; Attentional Difficulties	DST; Social Difficulties	Hyperacusis	*p*
Gender							**<0.001**
Male	172 (38.4%)	70 (18.9%)	40 (18.6%)	38 (18.4%)	59 (35.5%)	33 (20.8%)	
Female	276 (61.6%)	301 (81.1%)	175 (81.1%)	169 (81.6%)	107 (64.5%)	126 (79.2%)	
Ethnic Identity							**0.014**
African American/Black	101 (22.5%)	85 (22.6%)	53 (24.7%)	38 (18.4%)	36 (21.7%)	26 (16.4%)	
Asian American	76 (16.9%)	58 (15.4%)	50 (23.3%)	37 (17.9%)	38 (22.9%)	24 (15.1%)	
White (non-Hispanic)	163 (36.3%)	165 (43.9%)	64 (29.8%)	93 (44.9%)	58 (34.9%)	65 (40.9%)	
White (Hispanic)	61 (13.6%)	31 (8.2%)	22 (10.2%)	18 (8.7%)	17 (10.2%)	20 (12.6%)	
Middle Eastern	14 (3.1%)	12 (3.2%)	6 (2.8%)	3 (1.4%)	10 (6.0%)	9 (5.7%)	
Other	34 (7.6%)	25 (6.6%)	20 (9.3%)	18 (8.7%)	7 (4.2%)	15 (9.4%)	
Level of Education							0.107
High School/GED	176 (39.3%)	120 (32.0%)	79 (36.7%)	82 (39.6%)	70 (42.2%)	62 (39.0%)	

Some College	224 (50.0%)	204 (54.4%)	100 (46.5%)	109 (52.7%)	77 (46.4%)	76 (47.8%)	
Two-Year College (Associates)	35 (7.8%)	33 (8.8%)	27 (12.6%)	13 (6.3%)	15 (9.0%)	11 (6.9%)	
Four-Year College	8 (1.8%)	13 (3.5%)	8 (3.7%)	3 (1.4%)	4 (2.4%)	9 (5.7%)	
Masters Degree	5 (1.1%)	3 (0.8%)	1 (0.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Professional Degree	0 (0.0%)	2 (0.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.6%)	
Mean Age Mean (SD)	19.38 (3.43)	19.70 (3.32)	19.53 (3.09)	19.12 (2.21)	19.83 (5.13)	19.44 (3.91)	0.345

Hypothesis 2 Results

Table 5 includes the overall sample means for the independent variables that were used in analyses to examine differences between clusters.

Table 5

Overall Sample Means (and SDs) for DST Measures, Clinical Characteristics, and Psychological Mechanisms

Measure	Mean (SD)	Range	N
MQ Total	17.76 (11.92)	0 - 68	1572
MQ - Sounds	5.48 (4.66)	0 - 24	1572
MQ - Emotions & Behaviors	12.44 (6.52)	0 - 40	1350
MQ Sound Severity	2.84 (2.47)	0 - 15	1572
HQ Total	10.66 (7.01)	0 - 37	1572
HQ Loudness	5.97 (3.70)	0 - 18	1572
HQ Attentional	4.21 (2.73)	0 - 12	1572
HQ Social	2.60 (2.76)	0 - 16	1572
HQ Emotional	3.86 (2.95)	0 - 12	1572
Mini TQ Total	5.08 (4.74)	0 - 24	466
HHIA Total	9.11 (15.96)	0 - 98	1566
HHIA – Emotional	5.18 (8.99)	0 - 52	1566
HHIA – Social	3.93 (7.38)	0 - 46	1566
Traumatic Experiences	0.39 (0.49)	0 - 1	1299
PTSS Total	1.68 (1.80)	0 - 5	1292

HADS Total	13.16 (6.38)	0 - 35	1570
HADS – Anxiety	8.47 (4.07)	0 - 21	1570
HADS – Depression	4.69 (3.39)	0 - 21	1570
MAI total	71.53 (18.23)	15 - 131	1570
SSAS Total	28.88 (6.49)	10 - 48	1571
DERS Total	87.69 (23.99)	36 - 163	1571
Extraversion	6.75 (4.01)	1 - 14	1567
Agreeableness	8.90 (3.23)	1 - 14	1569
Conscientiousness	10.16 (3.39)	1 - 14	1570
Emotional Stability	7.36 (3.81)	1 - 14	1570
Openness	10.08 (3.02)	1 - 14	1569
ASI Total	18.78 (13.60)	0 - 71	754
FSS – Social Phobia	37.38 (12.07)	13 - 65	1559
Total Emotions	16.50 (13.52)	0 - 122	1572

Note: N is lower for Mini TQ because only individuals who reported experiencing a ringing in the ears completed this measure. N is also lower for Traumatic Experiences, PTSS, and ASI because these measures were added after the other measures were made available to participants.

Cluster Differences in DST Measures

One-way ANOVAs were conducted examining the differences between clusters in the DST measures. Analysis of skewness and kurtosis revealed that three of the variables (HHIA Total, HHIA Emotional subscale, HHIA Social subscale) were moderately to highly skewed. Because this assumption was violated, the Kruskal-Wallis test was run for each of these variables. All variables violated the assumption of homogeneity of variance, so the Welch statistic was used for interpretation. There was a significant effect of cluster membership (all $p < .001$) on all DST variables.

Table 6 displays means, SDs, and significant differences by cluster for the DST measures. Means by cluster for each variable are graphically depicted in Figure 1. For ease of comparison, each variable was standardized in Figure 1, with a mean of 50 and SD of 10. As can be seen in the table and the figure, the "High DST" cluster was significantly higher than all other clusters on all DST measures. The "Low DST" cluster had the lowest mean of all other clusters on all but one of the DST measures, and was *significantly* lower than all five other clusters on the MQ Total, HQ Total, HQ Loudness Scale, HQ Attentional subscale, and HQ Emotional subscale.

The best way to understand the results for the other clusters is to organize them by the different types of DST measures. For the four subscales of the Misophonia Questionnaire (MQ, the four left-most measures in Figure 1), the "DST; Social Difficulties" cluster is low and not significantly different from the "Low DST" cluster. In contrast, the other clusters ("Misophonia", "DST; Attentional Difficulties", "Hyperacusis") exhibit scores on the misophonia scales that are midway between these low clusters and the "High DST" cluster.

The results are consistent for all three measures of hearing-related functional impairment (HHIA; the three right-most measures in Figure 1). There are four clusters with low scores: the "Low DST", "DST; Social Difficulties", "Misophonia", and "DST; Attentional Difficulties" clusters are not significantly different from each other, and all are significantly lower than the "Hyperacusis" and "High DST" clusters. The "Hyperacusis" cluster occupies a middle position, significantly lower than the "High DST" cluster. Tinnitus results (Mini TQ) are similar to hearing-related functional impairment, in that "High DST" is significantly greater than "Hyperacusis", which is in turn significantly greater than all other clusters. The "Misophonia" and "DST; Attentional Difficulties" clusters both report significantly greater tinnitus than the "Low DST" and "DST; Social Difficulties" clusters.

Results on the Hyperacusis Questionnaire (HQ) scales are more complicated. As can be seen in Figure 1, for all HQ subscales, "Low DST" and "High DST" have the lowest and highest scores, respectively. The “Misophonia” cluster has the second-lowest scores on all HQ subscales, though as can be seen in Table 6 means for this cluster are in general significantly higher than those of the “Low DST” cluster. The HQ scores for the other three clusters fall in between, with different cluster patters for each HQ scale. For the HQ Total score, the “DST; Attentional Difficulties” cluster is significantly greater than the “DST; Social Difficulties” and the “Hyperacusis” scores; for the HQ Loudness Scale, the “DST; Attentional Difficulties” and “DST; Social Difficulties” clusters are significantly greater than the “Hyperacusis” cluster, and for the HQ-Emotional scale, scores for the “DST; Attentional Difficulties” and “Hyperacusis” clusters are significantly greater than the “DST; Social Difficulties” cluster. For the HQ Attentional scale, the “DST; Attentional Difficulties” cluster is significantly higher than the “DST; Social Difficulties” cluster, which is in turn significantly higher than the “Hyperacusis” cluster. The pattern for the HQ Social scale is just the opposite: the “DST; Attentional Difficulties” cluster is significantly lower than the “DST; Social Difficulties” cluster, which is in turn significantly lower than the “Hyperacusis” cluster.

Figure 1

DST Measures

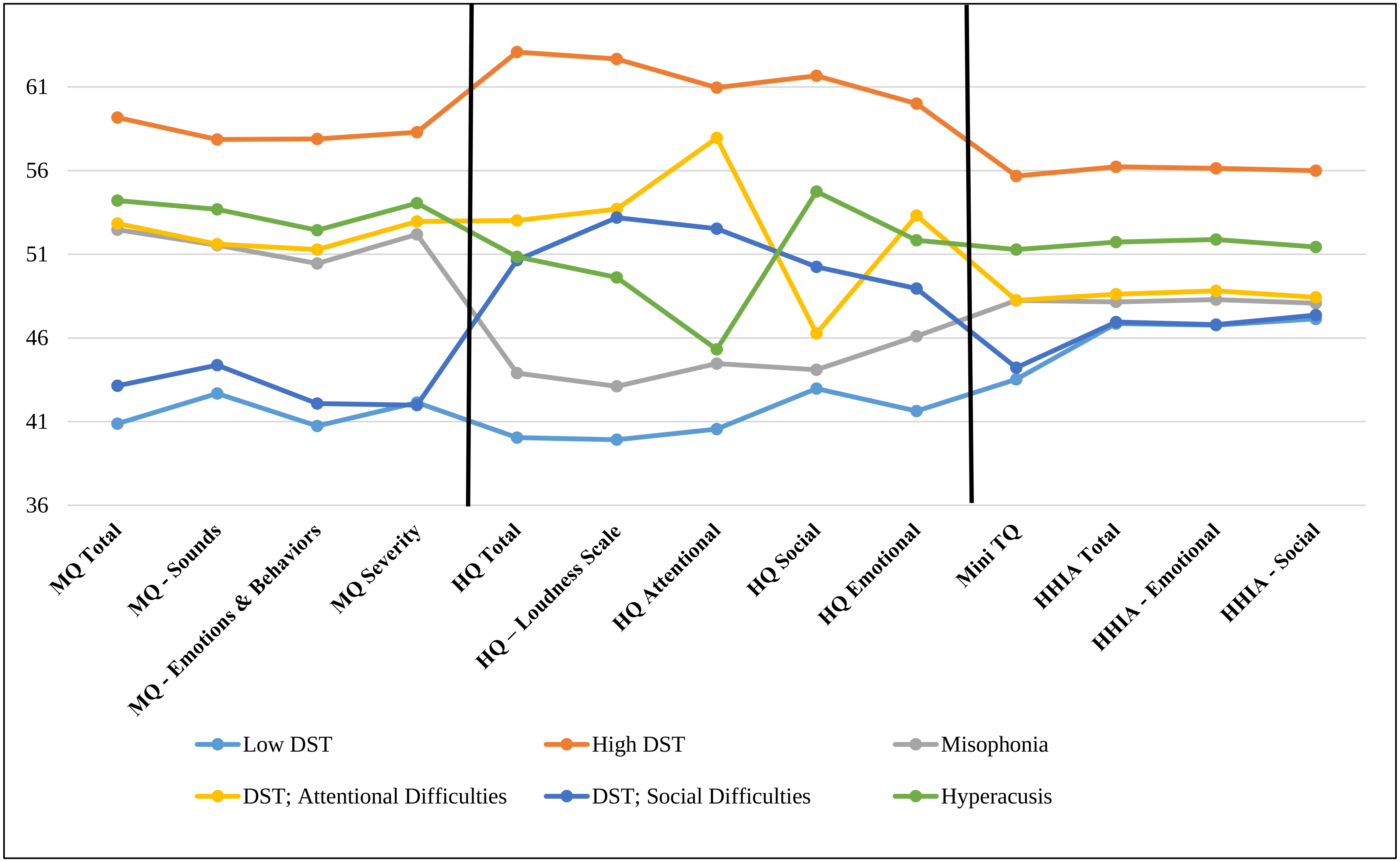


Table 6

Group Mean Differences (and SDs) for DST Measures

Measure M (SD) or N (%)	Low DST	High DST	Misophonia	DST; Attentional Difficulties	DST; Social Difficulties	Hyperacusis	Test Statistic
MQ Total	6.88 (6.77) [a]	28.70 (10.33) [d]	20.70 (8.15) [c]	21.14 (7.77) [c]	9.59 (6.51) [b]	22.78 (8.55) [c]	355.76 *
MQ - Emotions & Behaviors	6.40 (3.92) [a]	17.59 (6.17) [c]	12.73 (5.17) [b]	13.27 (4.64) [b]	7.28 (3.50) [a]	14.03 (4.66) [b]	182.10 *
MQ - Sounds	2.07 (2.66) [a]	9.14 (4.88) [c]	6.20 (3.77) [b]	6.23 (3.74) [b]	2.86 (2.75) [a]	7.20 (4.22) [b]	218.07 *
MQ Severity	0.90 (1.18) [a]	4.89 (2.55) [c]	3.38 (1.74) [b]	3.57 (1.90) [b]	0.86 (0.35) [a]	3.84 (2.31) [b]	366.41 *
HQ Total	3.68 (2.54) [a]	19.83 (4.85) [e]	6.38 (2.84) [b]	12.78 (3.04) [d]	11.12 (3.38) [c]	11.25 (3.02) [c]	880.20 *
HQ Loudness Scale	2.24 (1.64) [a]	10.66 (2.24) [e]	3.42 (1.75) [b]	7.34 (1.49) [d]	7.15 (1.66) [d]	5.83 (1.52) [c]	909.09 *
HQ Attentional	1.63 (1.32) [a]	7.20 (1.80) [e]	2.70 (1.49) [b]	6.38 (1.33) [d]	4.90 (1.87) [c]	2.93 (1.07) [b]	721.53 *
HQ Social	0.66 (0.90) [a]	5.82 (2.78) [e]	0.97 (0.77) [a]	1.57 (1.20) [b]	2.67 (2.30) [c]	3.91 (2.14) [d]	310.55 *
HQ Emotional	1.39 (1.41) [a]	6.81 (2.56) [e]	2.71 (2.04) [b]	4.84 (2.46) [d]	3.55 (2.39) [c]	4.40 (2.08) [d]	321.10 *
Mini TQ	2.01 (2.97) [a]	7.77 (5.23) [d]	4.25 (4.70) [b]	4.25 (3.03) [b]	2.34 (2.04) [a]	5.69 (3.84) [c]	132.87 *
HHIA Total	4.09 (10.66) [a]	19.04 (21.87) [c]	6.17 (12.18) [a]	6.89 (11.83) [a]	4.23 (9.38) [a]	11.86 (15.65) [b]	238.68 *
HHIA - Emotional	2.27 (5.84) [a]	10.69 (12.34) [c]	3.65 (6.97) [a]	4.12 (6.81) [a]	2.30 (5.25) [a]	6.87 (8.89) [b]	239.66 *
HHIA - Social	1.82 (5.09) [a]	8.35 (10.16) [c]	2.51 (5.59) [a]	2.77 (5.55) [a]	1.99 (4.46) [a]	4.99 (7.11) [b]	229.62 *

Note: * *F* is significant at $p < .001$. Within each row, means with different superscripts are significantly different at the 0.05 level after a Bonferroni correction for multiple comparisons. MQ Total = Misophonia Questionnaire; MQ – Emotions & Behaviors = Misophonia Questionnaire – Emotions & Behaviors Scale; MQ – Sounds = Misophonia Questionnaire Sounds Scale; MQ Severity = Misophonia Questionnaire Severity Scale; HQ Total = Hyperacusis Questionnaire; HQ – Loudness Scale = Hyperacusis Questionnaire Loudness Scale; HQ Attentional = Hyperacusis Questionnaire Attentional subscale; HQ Social = Hyperacusis Questionnaire Social subscale; HQ Emotional = Hyperacusis Questionnaire Emotional subscale; Mini TQ = Mini Tinnitus Questionnaire; HHIA Total = Hearing Handicap Inventory – Adult version; HHIA – Emotional = Hearing Handicap Inventory – Adult version Emotional subscale; HHIA – Social = Hearing Handicap Inventory – Adult version Social subscale

Cluster Differences in Clinical Correlates

One-way ANOVAs were conducted examining the differences in the clinical correlates, with cluster membership serving as the independent variable. Analysis of skewness and kurtosis revealed that one variable (Posttraumatic Stress Symptoms) was moderately to highly skewed, and so the Kruskal-Wallis test was run for this variable. The Traumatic Experiences variable, HADS Total, HADS – Depression subscale, HADS – Anxiety subscale, and SSAS Total, were all normally distributed. All variables violated homogeneity of variance so the adjusted *F* statistic (i.e., Welch statistic) was used to examine differences between clusters. There was a significant effect of cluster membership on all clinical correlate variables, and all were significant at the $p < .001$ level.

Table 7 displays means, SDs, and significant differences by cluster for the clinical correlate measures. Means by cluster for each variable are graphically depicted in Figure 2. As in Figure 1, each variable was standardized, with a mean of 50 and SD of 10. The “Low DST” cluster had the lowest mean of all clusters on all measures. It was significantly lower than all five other clusters on the HADS Total, HADS – Anxiety, and SSAS Total. The “High DST” cluster had the highest mean for all the measures and was significantly higher than all five clusters on HADS Total, HADS – Anxiety, SSAS Total, and FSS – Social Phobia. For HADS-Depression and PTSS, “High DST” was significantly higher than all clusters except the “Hyperacusis” cluster.

The other four clusters had means that fell in between the “Low DST” and “High DST” clusters, and with only a few exceptions were not significantly different from each other. The “Misophonia”, “DST; Social Difficulties”, and “DST; Attentional Difficulties” clusters were not significantly different on any clinical variable, with one exception: Participants in the “DST;

Social Difficulties" cluster reported significantly less posttraumatic stress symptoms than these other two groups. The "Hyperacusis" cluster generally had higher means on clinical scales than all clusters except for the "High DST" cluster. The "Hyperacusis" cluster was not significantly different from these three other clusters on the SSAS Total score or FSS – Social Phobia. This cluster was significantly higher than all these clusters on the PTSS, and significantly higher than "Misophonia" and "DST: Social Difficulties" on HADS-Total and HADS-Anxiety.

Figure 2

Clinical Correlates

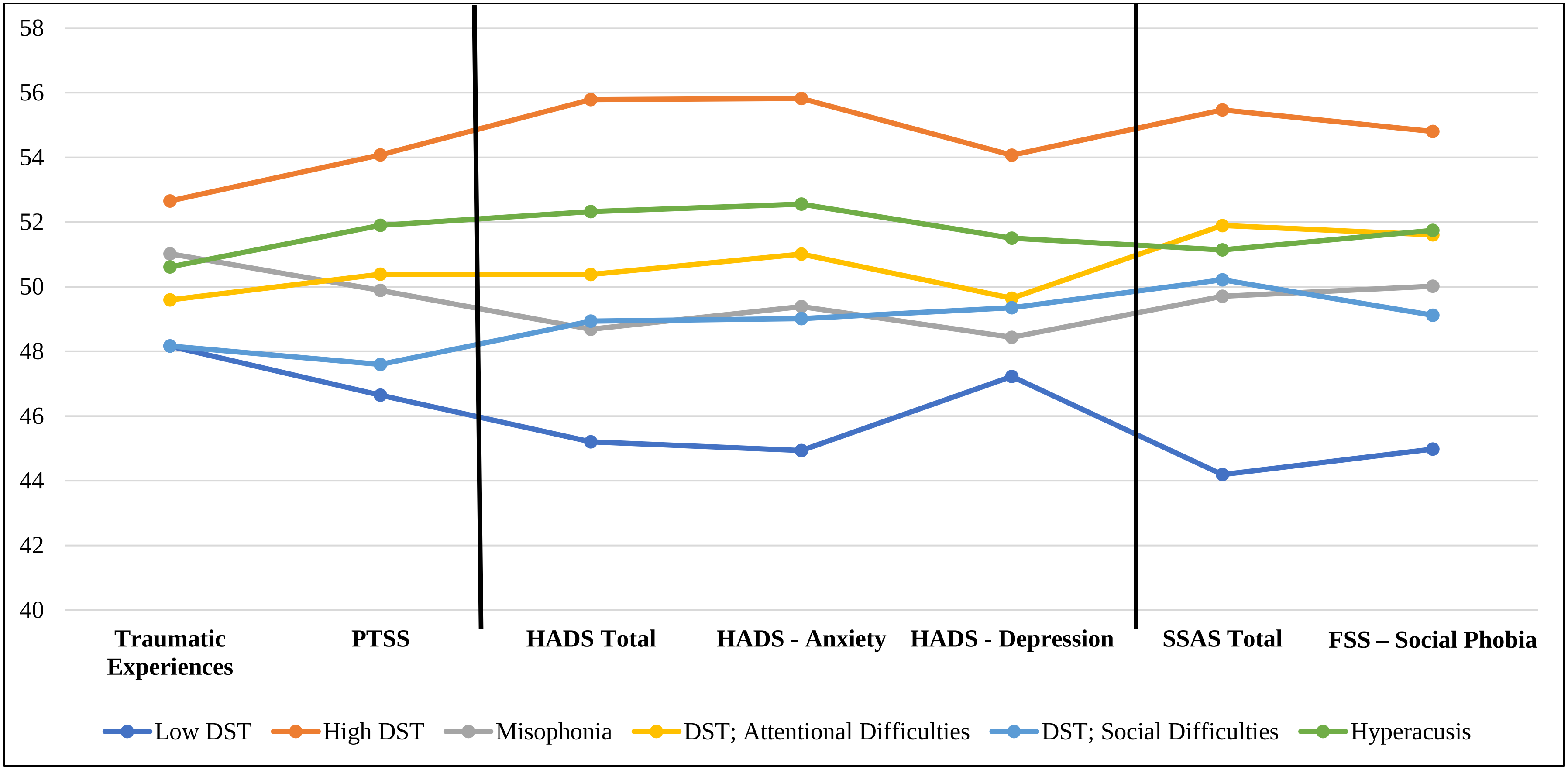


Table 7

Group Mean Differences (and SDs) for Clinical Correlates

Measure M (SD) or N (%)	Low DST	High DST	Misophonia	DST; Attentional Difficulties	DST; Social Difficulties	Hyperacusis	Test Statistic
Traumatic Experiences	0.30 (0.46) [a]	0.52 (0.50) [b]	0.44 (0.50) [a,b]	0.37 (0.49) [a]	0.30 (0.46) [a]	0.42 (0.50) [a,b]	8.18*
PTSS	1.08 (1.55) [a]	2.41 (1.90) [c]	1.66 (1.79) [b]	1.75 (1.66) [b]	1.25 (1.63) [a]	2.02 (1.84) [c]	106.64*
HADS Total	10.10 (5.81) [a]	16.85 (6.20) [d]	12.32 (5.39) [b]	13.40 (5.70) [b,c]	12.48 (5.39) [b]	14.64 (6.53) [c]	54.31*
HADS - Anxiety	6.35 (3.75) [a]	10.78 (3.88) [d]	8.16 (3.52) [b]	8.82 (3.49) [b,c]	8.01 (3.49) [b]	9.45 (4.07) [c]	58.21*
HADS - Depression	3.75 (3.32) [a]	6.07 (3.50) [d]	4.16 (2.97) [a,b]	4.57 (3.11) [b,c]	4.47 (2.99) [a,b,c]	5.20 (3.44) [c,d]	20.89*
SSAS Total	25.11 (6.18) [a]	32.43 (5.96) [c]	28.69 (6.01) [b]	30.11 (4.87) [b]	29.02 (5.93) [b]	29.62 (5.59) [b]	68.89*
FSS – Social Phobia	31.32 (11.36) [a]	43.18 (11.96) [c]	37.40 (10.65) [b]	39.32 (10.91) [b]	36.32 (10.53) [b]	39.49 (11.16) [b]	48.31*

Note: * F is significant at $p < .001$. Within each row, means with different superscripts are significantly different at the 0.05 level after a Bonferroni correction for multiple comparisons. PTSS = Posttraumatic Symptoms; HADS Total = Hamilton Anxiety and Depression Scale; HADS – Anxiety = Anxiety subscale of Hamilton Anxiety and Depression Scale; HADS – Depression = Depression subscale of Hamilton Anxiety and Depression Scale; SSAS Total = Somatosensory Amplification Scale; FSS – Social Phobia = Fear Survey Schedule – Social Phobia subscale

Cluster Differences in Psychological Mechanisms and Individual Differences

One-way ANOVAs were conducted examining the differences in psychological mechanisms and individual differences, with cluster membership serving as the independent variable. Analysis of skewness and kurtosis revealed that five of the variables were moderately to highly skewed (Total Emotions, ASI Total, TIPI – Agreeableness, TIPI – Conscientiousness, and TIPI – Emotional Stability). Because this assumption was violated, the Kruskal-Wallis test was run. The remaining four variables were normally distributed. There was a significant effect of cluster membership on all clinical correlate variables except for Openness. The measures that were significant all were significant at the $p < .001$ level. Table 8 displays means, SDs, and significant differences by cluster for the psychological mechanisms and individual difference measures. Means by cluster for each variable are graphically depicted in Figure 3. As in Figures 1 and 2, each variable was standardized, with a mean of 50 and SD of 10.

We will first describe the results for trait anger (MAI Total), difficulty with emotion regulation (DERS Total), anxiety sensitivity (ASI Total), and total emotional responding (Total Emotions). The "High DST" cluster had the highest means on these four variables and was statistically higher than all clusters on the DERS Total and ASI Total. The "Low DST" cluster had the lowest mean for these four variables and was significantly lower than the five clusters on all measures except Total Emotions. Like the clinical correlate results, the remaining four clusters had means that fell between the "Low DST" and "High DST" clusters for these variables. These four clusters were not statistically significant from each other on three of the four measures (MAI Total, DERS Total, and ASI Total). The Total Emotions score on the "DST; Social Difficulties" cluster was significantly lower than the "Misophonia" cluster, which was in turn statistically lower than Total Emotions for “DST; Attentional Difficulties” and “Hyperacusis” clusters.

The five right-most scales of Figure 3 are from the Ten Item Personality Inventory (TIPI), which measure the Big Five personality traits. Higher scores on the subscales of the TIPI indicate “better” personality functioning. The one-way ANOVA for each of the personality measures except Openness resulted in a significant effect for cluster (all $p < .001$), and thus the results for Openness will not be described further. As can be seen in Figure 3, there is less discrimination between clusters on personality traits, and less of a clear pattern between clusters. with relatively few instances when clusters were significantly different from one another. The “High DST” cluster had the lowest mean on all measures of personality functioning and was significantly lower than the “Low DST” cluster on all measures except Openness. The “High DST” cluster was significantly lower than all clusters on Emotional Stability. The “Low DST” cluster had the second highest mean for Extraversion, Agreeableness, and Conscientiousness and the highest mean for Emotional Stability, though in no case was it significantly different from the mean of the next closest cluster. The other clusters were generally intermediate to the “Low DST” and “High DST” clusters on the personality traits, with relatively few and difficult-to-interpret significant differences between clusters (see Table 8).

The “High DST” cluster had the lowest mean on Extraversion and was significantly lower than the “Low DST”, “Misophonia”, and “DST’ Social Difficulties” clusters. The “Hyperacusis” cluster had the lowest mean on Agreeableness and was significantly lower than the “Low DST” and “DST; Social Difficulties” clusters. The “High DST” cluster had the lowest mean on Conscientiousness and was significantly lower than the “Low DST” and “DST; Attentional Difficulties” clusters. The “High DST” also had the lowest mean for Emotional

Stability and was significantly lower than all clusters. The “Low DST” cluster was significantly higher than all clusters except “DST; Social Difficulties” for Emotional Stability, and this cluster was not statistically different from the “Misophonia” cluster. The two remaining clusters (“DST; Attentional Difficulties” and “Hyperacusis”) were not statistically different from one another.

Figure 3

Individual Differences and Psychological Mechanisms

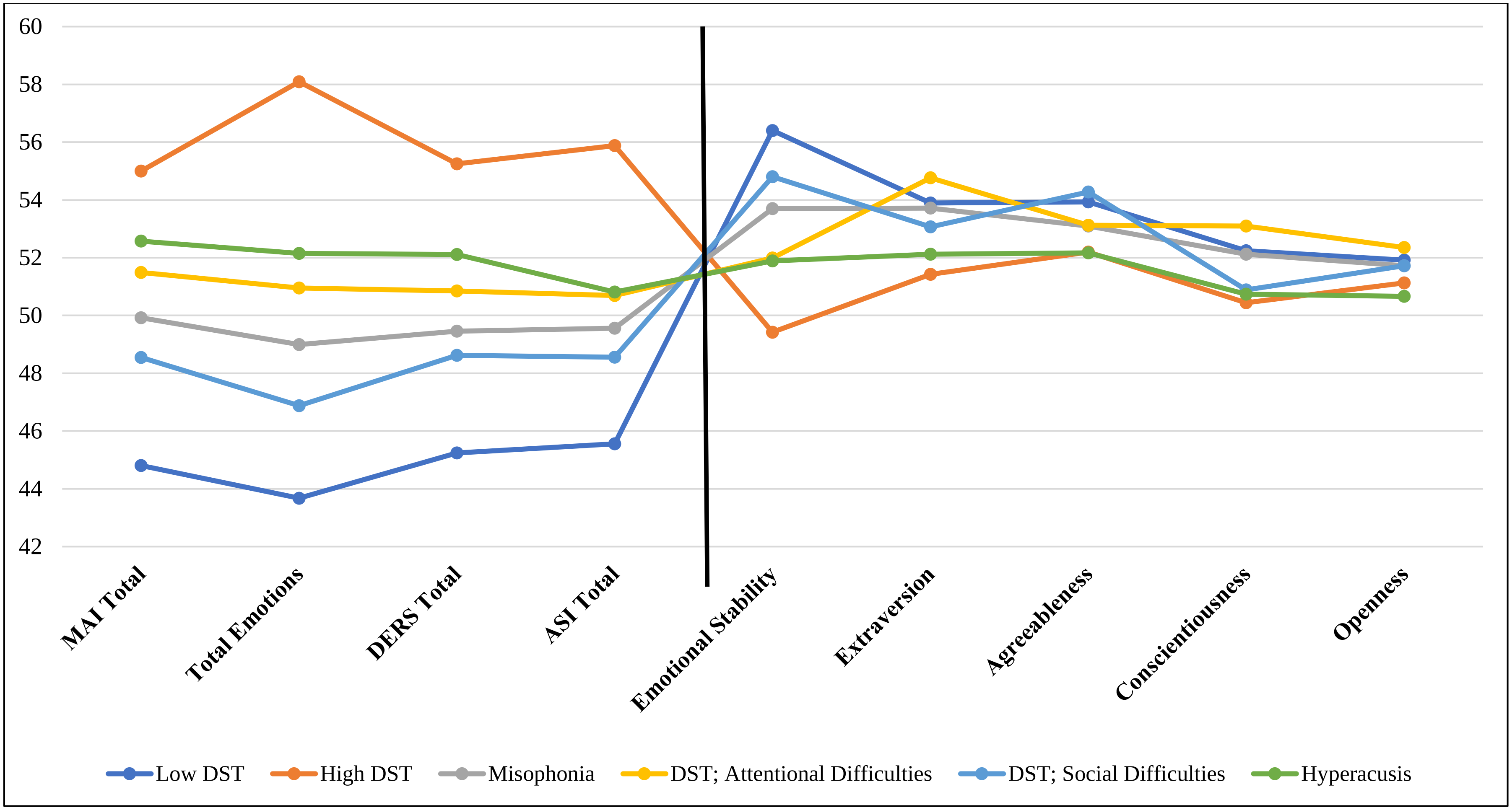


Table 8

Group Mean Differences (and SDs) for Psychological Mechanisms and Individual Differences

Measure M (SD) or N (%)	Low DST	High DST	Misophonia	DST; Attentional Difficulties	DST; Social Difficulties	Hyperacusis	Test Statistic
MAI Total	62.06 (16.18) [a]	80.65 (17.76) [d]	71.38 (18.07) [b,c]	74.24 (16.10) [b,c]	68.88 (16.09) [b]	76.22 (16.46) [b,c,d]	54.70*
DERS Total	76.28 (21.51) [a]	100.29 (23.39) [d]	86.39 (22.60) [b]	89.72 (22.44) [b]	84.38 (21.64) [b]	92.75 (21.91) [b,c]	50.33*
ASI Total	12.74 (11.39) [a]	26.78 (14.54) [c]	18.18 (12.88) [b]	19.72 (12.66) [b]	16.81(10.90) [b]	19.89 (12.65) [b]	111.49*
Total Emotions	7.95 (6.89) [a]	27.44 (17.18) [d]	15.14 (10.01) [b]	17.78 (9.11) [b,c]	12.28 (9.32) [a]	19.40 (11.16) [c,d]	929.60*
Extraversion	8.31 (3.21) [b]	7.32 (3.40) [a]	8.24 (3.30) [b]	8.66 (3.17) [b]	7.98 (3.33) [a, b]	7.60 (3.17) [a]	6.45*
Agreeableness	10.17 (2.35) [b]	9.61 (2.46) [a]	9.90 (2.15) [a]	9.91 (2.21) [a]	10.28 (2.30) [b]	9.60 (2.21) [a]	17.28*
Conscientiousness	10.92 (2.60) [b]	10.31 (2.77) [a]	10.88 (2.43) [a]	11.21 (2.54) [b]	10.46 (2.75) [a]	10.41 (2.51) [a]	24.35*
Emotional Stability	9.80 (2.80) [d]	7.14 (2.92) [a]	8.77 (2.81) [b,c]	8.12 (2.87) [b]	9.19 (2.69) [c,d]	8.08 (2.71) [b]	177.29*
Openness	10.66 (2.26)	10.42 (2.45)	10.60 (2.45)	10.79 (2.25)	10.60 (2.22)	10.28 (2.36)	1.28

Note: * *F* is significant at $p < .001$. Within each row, means with different superscripts are significantly different at the 0.05 level after a Bonferroni correction for multiple comparisons. MAI Total = Multidimensional Anger Inventory; DERS Total = Difficulties in Emotion Regulation Scale; ASI Total = Anxiety Sensitivity Index; Total Emotions = Total Summed Emotions; Extraversion = TIPI – Extraversion subscale; Agreeableness = TIPI – Agreeableness subscale; Conscientiousness = TIPI – Conscientiousness subscale; Emotional Stability = TIPI – Emotional Stability subscale; Openness = TIPI – Openness subscale

Results: Hypothesis 3

A chi-square analysis was conducted to examine what percentage of participants in each cluster endorsed experiencing each of the eight types of emotions (Table 9). These totals were calculated by recoding the variables on the Decreased Sound Tolerance Differential Diagnostic Scale so that if a participant reported a specific emotion to any of the 40 sounds, they were coded as '1' for experiencing that emotion. If a participant never reported experiencing an emotion, they were coded '0' for that emotion. The table below displays what percentage of participants in each cluster reported experiencing each of the emotions at least once. There were significant differences in the number and types of emotions reported between clusters and all were significant (*p*s < .001) except for pain. Results from the chi square analysis show that the hypothesized combination cluster, "High DST", reported the greatest number of emotional reactions.

Table 9

Emotions by Cluster

Emotion N (%) of group N = 1572	Low DST	High DST	Misophonia	DST; Attentional Difficulties	DST; Social Difficulties	Hyperacusis	*p*
Anger	116 (25.8%)	277 (73.7%)	122 (56.7%)	130 (62.8%)	64 (38.6%)	101 (63.5%)	**< .01**
Disgust	385 (85.7%)	369 (98.1%)	206 (95.8%)	204 (98.6%)	154 (92.8%)	147 (92.5%)	**< .01**
Fear	263 (58.6%)	338 (89.9%)	168 (78.1%)	172 (83.1%)	113 (68.1%)	128 (80.5%)	**< .01**
Anxiety	25 (5.1%)	69 (18.4%)	15 (7.0%)	20 (9.7%)	6 (3.6%)	18 (11.3%)	**< .01**
Annoyance	72 (16.0%)	178 (47.3%)	60 (27.9%)	78 (37.7%)	41 (24.7%)	53 (33.3%)	**< .01**
Sadness	189 (42.1%)	289 (76.9%)	130 (60.4%)	129 (62.3%)	97 (58.4%)	106 (66.7%)	**< .01**
Guilt	183 (40.8%)	316 (84.0%)	147 (68.4%)	149 (72.0%)	95 (57.2%)	119 (74.8%)	**< .01**
Physical pain	28 (6.2%)	47 (12.5%)	20 (9.3%)	15 (7.2%)	11 (6.6%)	16 (10.0%)	**.037**

We hypothesized that there would be significant cluster differences in emotions reported and in sounds reported as distressing. For emotions, we specifically hypothesized that the emotions of fear and pain would be more frequently reported in people with hyperacusis, and anger and disgust would be more often reported in individuals with misophonia. In order to calculate emotions reported, the number of times that an emotion was reported to a sound was summed across the 40 sounds presented, such that the range for each of the emotions is 0 – 40.

For sounds, we specifically hypothesized that hyperacusis-specific sounds would be more frequently reported as aversive by individuals in the hyperacusis cluster, and misophonia-specific sounds would be more frequently reported as aversive by individuals in the misophonia cluster. To complete this analysis, total number of sounds endorsed was calculated for specific sound groups created using the 40 sounds included in the Decreased Sound Tolerance Differential Diagnostic Scale (DST Scale). Two sound groups were a human sounds scale (HSS) and a loudness sounds scale (LSS), which were developed based on a factor analysis of the sounds on the DST Scale (Cash, 2015). In addition, two sound groups were created from a priori labelled loud sounds and mouth sounds. Repeated measures ANOVAs were conducted to examine differences in emotions and sounds by cluster.

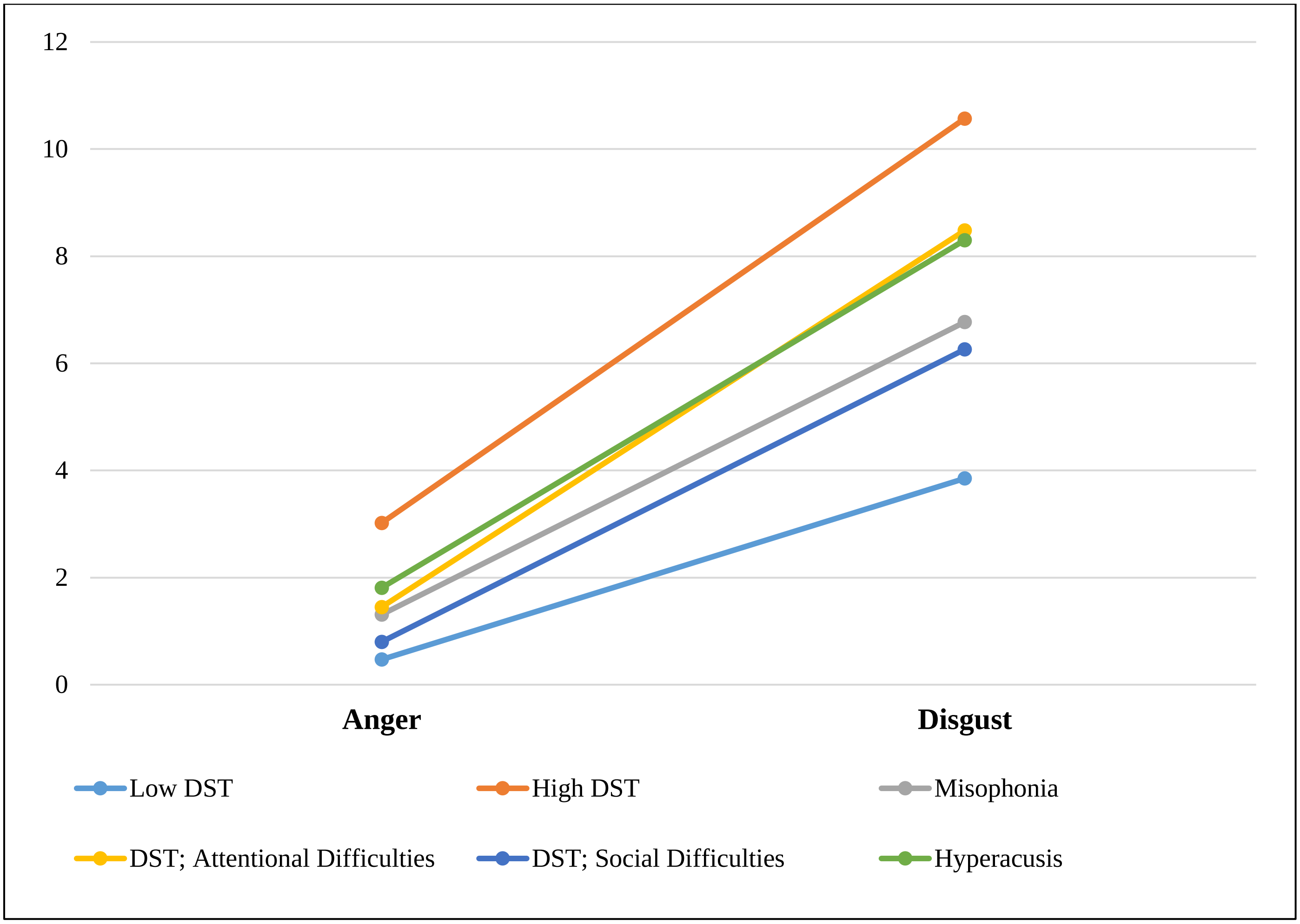
Emotion Differences

In order to examine whether different emotions were reported by different clusters of people, we employed a repeated measures ANOVA with the six clusters as a between-subjects variable and all eight emotions as a within-subjects variable. Mauchly's Test of Sphericity indicated that the assumption of sphericity was violated, $\chi^2(27) = 6863.50$, $p < .001$, so a Greenhouse-Geisser correction for degrees of freedom was used. There was a significant main effect of emotion, $F(2.95,4626.2) = 1548.11$, $p < .001$, $\varepsilon^2 = 0.422$. Clusters also differed significantly, $F(5,1566) = 128.99$, $p < .001$, indicating that clusters differed in their reported emotional reactions to aversive sounds. However, this was modified by a Cluster x Emotion interaction, $F(14.8,4626.2) = 44.64$, $p < .001$, such that clusters differed in their pattern of emotional reactions to aversive sounds. Overall means can be found in Table 10.

Based on our hypothesis that anger and disgust would be more closely associated with the "Misophonia" cluster, we followed up the significant cluster x emotion interaction with a repeated measures ANOVA with the variables cluster and emotion (anger, disgust). There was a significant main effect of cluster, $F(5, 1566) = 102.87$, $p < .001$, showing that clusters differed in their report of the emotions (see Figure 4). Bonferroni-corrected comparisons were used to decompose this main effect of Cluster. The hypothesis received mixed support. The "High DST" cluster, which has high levels of misophonia symptoms, reported significantly greater anger and disgust compared to all other clusters. There were not significant differences between "DST; Attentional Difficulties" and "Hyperacusis" clusters in their frequency of anger and disgust, and these two clusters reported greater anger and disgust than the "Misophonia" and "DST; Social Difficulties" clusters. Finally, the "Low DST" was significantly lower in anger and disgust than all other clusters.

Figure 4

Anger and Disgust by Cluster



Another repeated measures ANOVA was conducted to follow up on the significant Cluster x Emotion interaction and examine our hypothesis that fear and pain would be reported more in the "Hyperacusis" cluster than the remaining clusters. There was a significant main effect of Cluster, $F(5, 1566) = 55.56$, $p < .001$ (see Figure 5). Bonferroni-corrected comparisons were conducted to break down the effect of cluster (Table 10). This hypothesis also received mixed support. The "High DST" cluster, which has high levels of hyperacusis symptoms, reported significantly greater fear and pain compared to all other clusters. There were not significant differences between "Misophonia", "DST; Attentional Difficulties", and

"Hyperacusis" clusters in their frequency of fear and pain, and these three clusters reported significantly greater fear and pain than the "DST; Social Difficulties" and "Low DST" clusters, which were not statistically different from each other.

Figure 5

Fear and Pain by Cluster

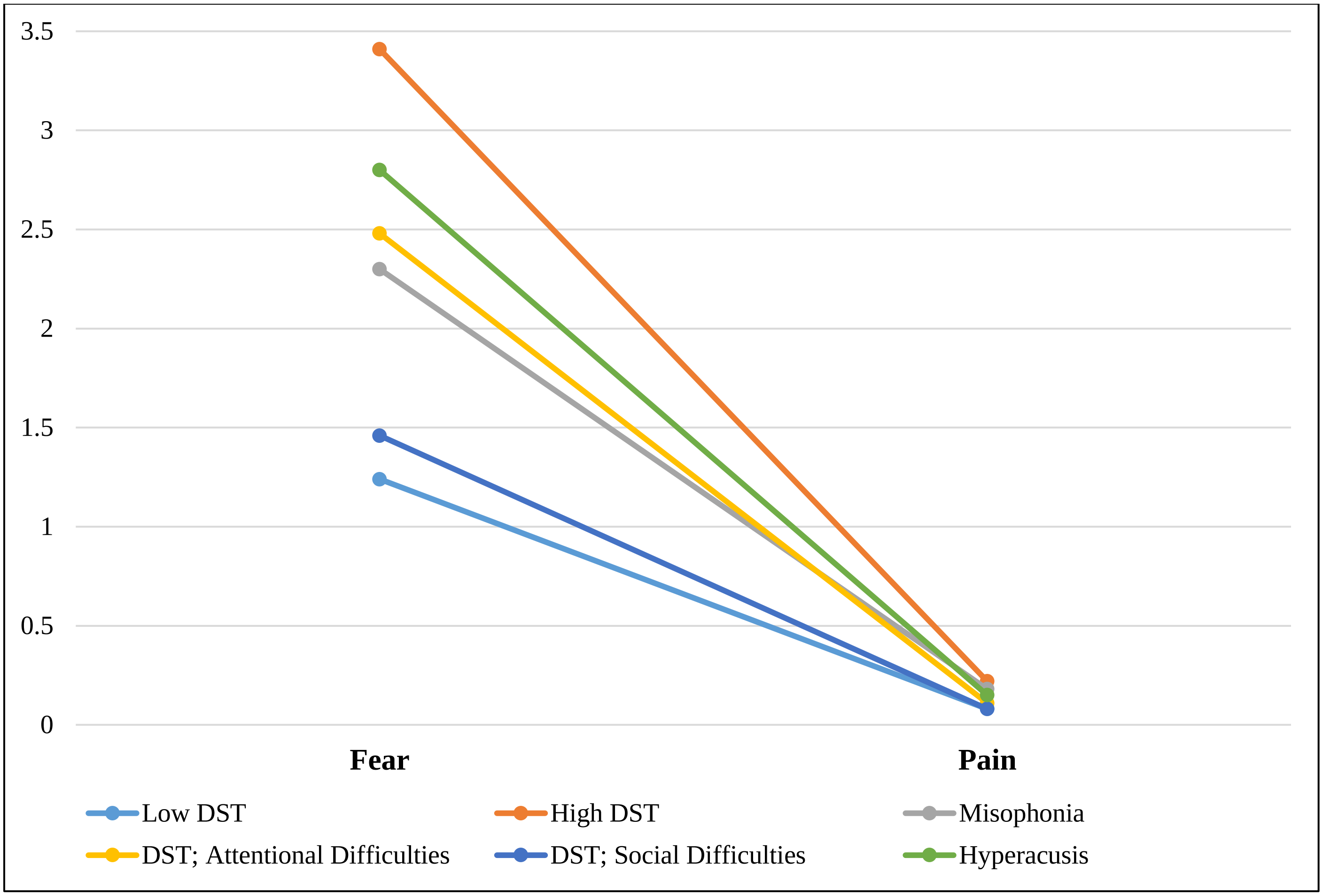


Table 10

Group Differences by Emotion

Emotion Group M (SD)	Low DST	High DST	Misophonia	DST; Attentional Difficulties	DST; Social Difficulties	Hyperacusis	Test Statistic
Anger	0.47 (0.98) [a]	3.02 (3.50) [c]	1.31 (1.72) [b]	1.45 (1.65) [b]	0.80 (1.48) [a]	1.81 (2.34) [b]	56.17*
Disgust	3.85 (3.27) [a]	10.57 (6.50) [d]	6.77 (4.19) [b]	8.48 (4.30) [c]	6.26 (4.36) [b]	8.30 (5.52) [c]	96.62*
Fear	1.24 (1.45) [a]	3.41 (2.77) [c]	2.30 (1.92) [b]	2.48 (1.91) [b]	1.46 (1.47) [a]	2.80 (2.12) [b]	55.05*
Anxiety	0.10 (0.31) [a]	0.39 (1.23) [b]	0.13 (0.65) [a]	0.14 (0.56) [a]	0.10 (0.46) [a]	0.21 (0.79) [a,b]	6.16*
Annoyance	0.23 (0.66) [a]	1.26 (2.10) [c]	0.50 (1.08) [a,b]	0.54 (0.85) [a,b]	0.36 (0.75) [a,b]	0.75 (1.38) [b]	21.70*
Sadness	0.85 (1.33) [a]	2.78 (2.85) [c]	1.52 (1.98) [a,b]	1.57 (1.71) [a,b]	1.33 (1.72) [a,b]	1.93 (2.10) [a,b]	34.74*
Guilt	1.00 (1.64) [a]	4.93 (4.72) [d]	2.11 (2.59) [b]	2.60 (2.91) [b]	1.74 (2.55) [a,c]	3.00 (2.91) [b,c]	62.82*
Pain	0.08 (0.34) [a]	0.22 (0.85) [c]	0.18 (0.81) [b]	0.11 (0.50) [b]	0.08 (0.31) [a]	0.15 (0.52) [b]	2.65**

Note: * F is significant at $p < .001$; ** F is significant at $p < .05$. Within each row, means with different superscripts are significantly different at the 0.05 level after a Bonferroni correction for multiple comparisons.

Sound Differences

Repeated measures ANOVAs were conducted to examine differences in groups of sounds by cluster membership. We were interested in examining differences in sounds specific to misophonia and hyperacusis, to see if clusters can be differentiated by the types of sounds they report as aversive. Groups of sounds from the DST Scale were created to achieve this goal, and the sum of the aversiveness rating for all the sounds in each group were analyzed. Previous factor analytic work (Cash, 2015) found two five-sound factors on the DST Scale, which were labeled human sounds scale (HSS), which included eating sounds, finger/hands sounds, pen clicking, nails on a chalkboard, vomiting sounds, and loudness sounds scale (LSS), which included large truck/bus driving by, traffic noise heard from inside, car horn, loud music at a concert, ambulance sirens. We examined whether the clusters differed on whether they reported sounds from the HSS or LSS as more aversive. We also created two additional a priori groups of sounds (mouth sounds and loud sounds) based on content validity to assess whether specific sounds were found distressing by different clusters. The six Mouth Sounds were eating sounds, breathing/nose sounds, throat and nose sounds, whistling or humming, consonant or vowel sounds, and whispering. The six Loud Sounds were large truck or bus driving by, loud music at a concert, fire/smoke alarm, ambulance sirens, construction noises, and a vacuum running in the next room.

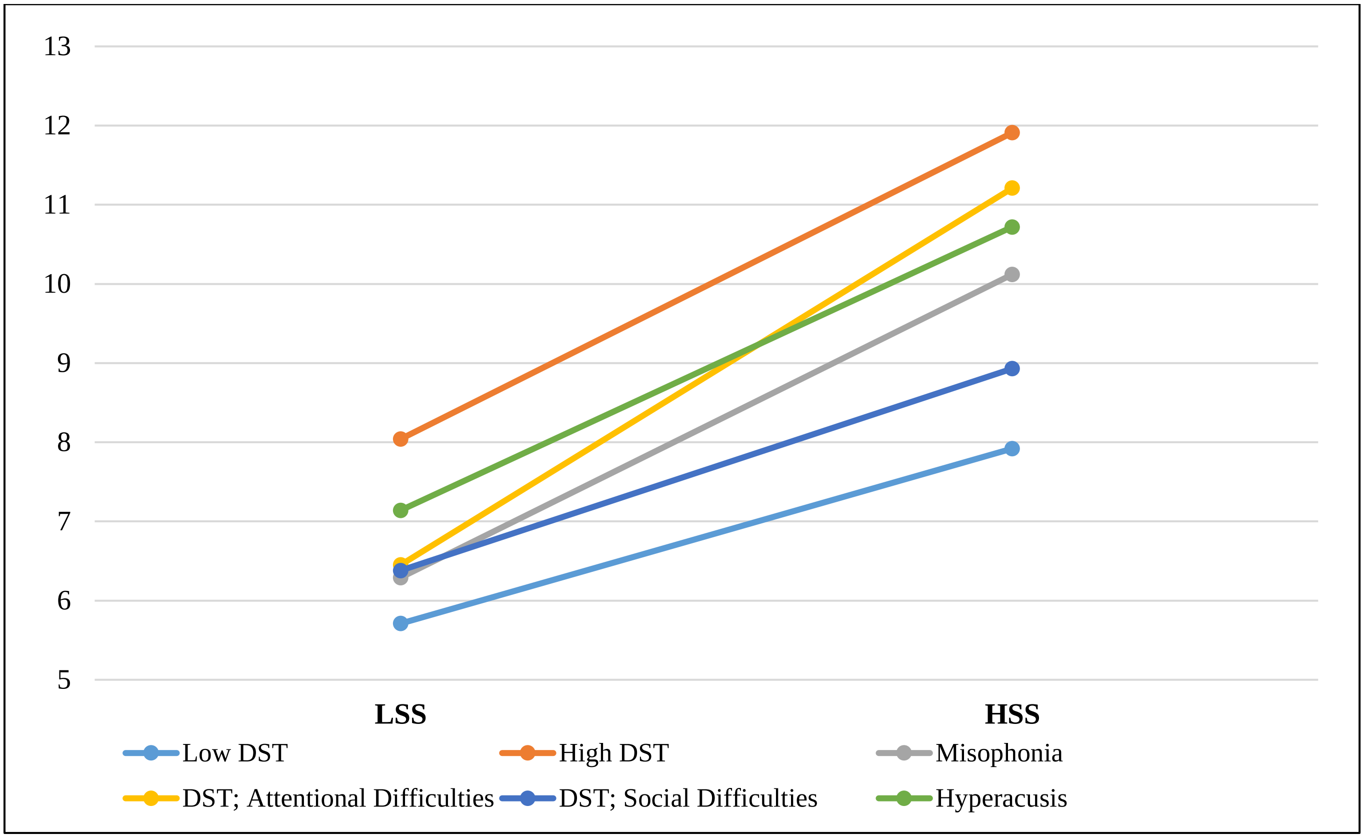
We conducted a repeated measures ANOVA to examine whether clusters differed in their distress to the LSS and HSS sound groups. There was a significant main effect of sound group, $F(1,1563) = 1720.9$, $p < .001$, indicating that participants overall found the human sounds more aversive than the loud sounds. Clusters also differed significantly, $F(5,1563) = 141.2$, $p < .001$, indicating that clusters differed in their reported overall aversiveness to the sounds. However, this was modified by a cluster x sound group interaction, $F(5, 1563) = 27.28$, $p < .001$, such that there are relative differences between clusters and feeling distressed by the LSS and HSS sound groups (see Figure 6).

Bonferroni corrected comparisons (see Table 11) revealed cluster differences in the pattern of feeling distressed by loud sounds (LSS) and human-made sounds (HSS). The “High DST” cluster reported the loud sounds (LSS) as significantly more aversive than the “Hyperacusis” cluster, which in turn found the loud sounds more aversive than the “DST; Attentional Difficulties”, “DST; Social Difficulties”, and “Misophonia” clusters. Finally, the “Low DST” group reported the loud sounds as significantly less aversive than all other groups.

A different pattern emerged for the human-made sounds (HSS) (see Figure 6). The “High DST” cluster reported human sounds as significantly more aversive than all clusters except the “DST; Attentional Difficulties” cluster, which in turn reported human sounds as significantly more aversive than all the other clusters except the “Hyperacusis” cluster. The “Hyperacusis” cluster did not differ significantly from the “Misophonia” cluster on human sounds. The “Low DST” cluster reported significantly less aversiveness to human-made sounds than all other clusters; the “DST: Social Difficulties” cluster reported significantly more aversiveness than the “Low DST” cluster to human-made sounds but significantly less aversiveness than all other clusters.

Figure 6

LSS and HSS Sound Groups by Cluster



A similar repeated measures ANOVA was conducted to examine whether clusters could be differentiated by sound groups created *a priori* for this study (Loud Sounds and Mouth Sounds). These results mirrored those found for the HSS and LSS sound groups. There was a significant main effect of sound group, $F(5, 1563) = 55.35$, $p < .001$, indicating that participants overall found the mouth sounds more aversive than the loud sounds. Clusters differed significantly $F(5,1563) = 138.40$, $p < .001$, indicating that clusters differed in their reported overall aversiveness to the sounds. However, this was modified by a cluster x sound group interaction, $F(5, 1563) = 5.47$, $p < .001$, such that clusters differ in feeling distressed by the Loud and Mouth sound groups (see Figure 7).

Bonferroni corrected comparisons showed significant differences in the pattern of feeling distressed by Loud Sounds and Mouth Sounds. The “High DST” cluster reported Loud Sounds as significantly more aversive than the “Hyperacusis” cluster. The “Hyperacusis” cluster was not significantly different from the “DST; Attentional Difficulties” cluster but found Loud Sounds significantly more aversive than the remaining clusters. The “DST; Attentional Difficulties” cluster did not find Loud Sounds significantly more aversive than the “Misophonia” and “DST; Social Difficulties” clusters. The “Low DST” cluster reported significantly less aversiveness to Loud Sounds than all other clusters.

All clusters found Mouth Sounds more aversive than Loud Sounds, except for the “DST; Social Difficulties” cluster. The “High DST” cluster reported significantly more aversiveness to Mouth Sounds than all clusters. The “Misophonia”, “DST; Attentional Difficulties”, and “Hyperacusis” clusters did not report significantly different aversiveness to Mouth Sounds but did endorse significantly more than the “DST; Social Difficulties” and “Low DST” clusters, which in turn were not statistically different.

Figure 7

Loud and Mouth Sounds by Cluster

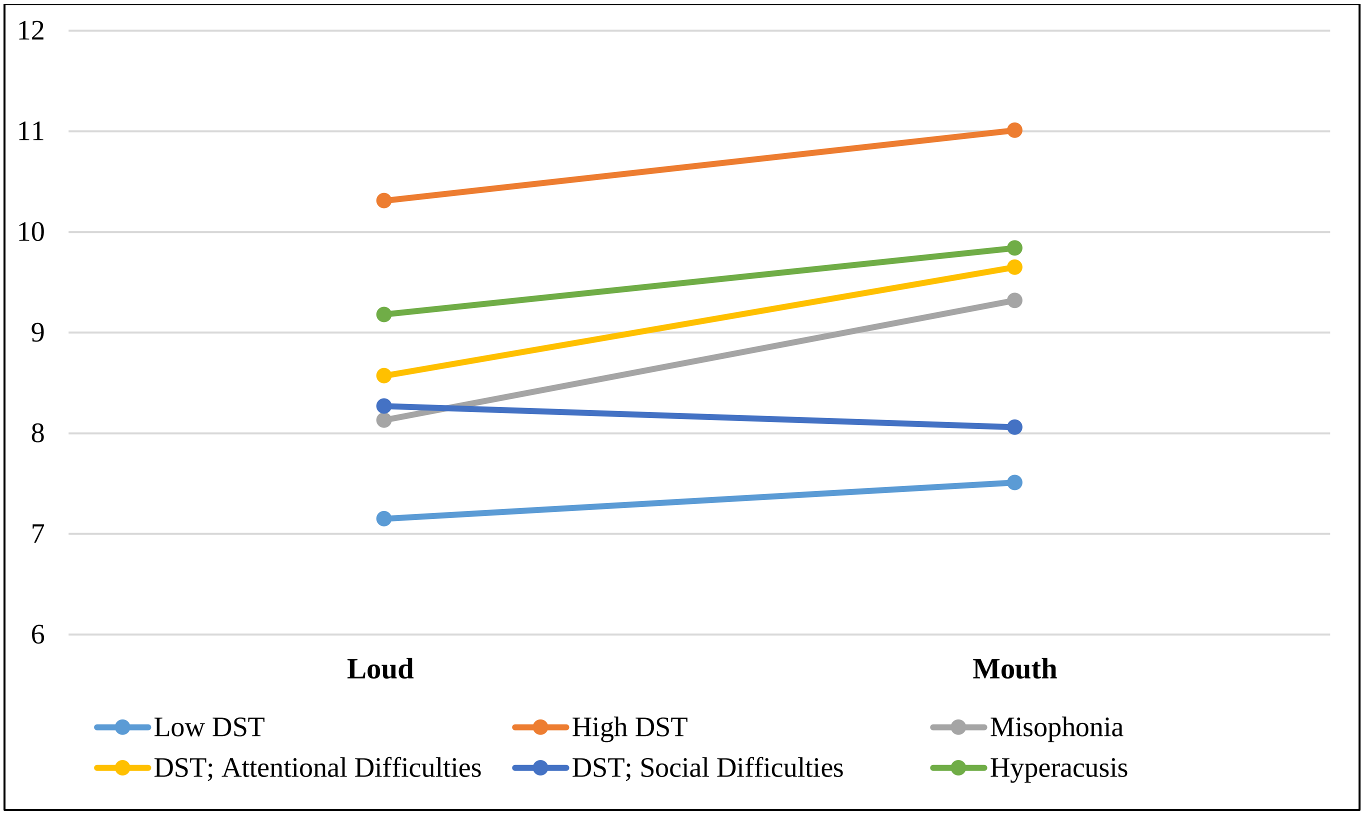


Table 11

Group Differences by Sound

Sound Group M (SD)	Low DST	High DST	Misophonia	DST; Attentional Difficulties	DST; Social Difficulties	Hyperacusis	Test Statistic
LSS Total	5.71 (1.19) [a]	8.04 (2.85) [d]	6.29 (1.87) [b]	6.45 (1.80) [b]	6.38 (1.81) [b]	7.14 (2.34) [c]	52.16*
HSS Total	7.92 (2.23) [a]	11.91 (3.05) [e]	10.12 (2.51) [c]	11.21 (2.64) [d,e]	8.93 (2.46) [b]	10.72 (3.18) [c,d]	117.44*
Loud Sounds	7.15 (1.55) [a]	10.31 (3.51) [d]	8.13 (2.37) [b]	8.57 (2.06) [b,c]	8.27 (2.36) [b]	9.18 (3.10) [c]	66.57*
Mouth Sounds	7.51 (1.54) [a]	11.01 (3.24) [c]	9.32 (2.34) [b]	9.65 (2.22) [b]	8.06 (1.77) [a]	9.84 (2.54) [b]	109.31*

Note: * *F* is significant at $p < .001$; Within each row, means with different superscripts are significantly different at the 0.05 level after a Bonferroni correction for multiple comparisons.

Discussion

Latent Class Analysis

This study sought to empirically identify groups of participants who differed on DST symptoms. The subscales from two of the most common measures for misophonia (MQ; Wu et al., 2014) and hyperacusis (Khalfa, et al., 2002) were used as indicator variables to identify clusters. Based on prior research (Jastreboff & Jastreboff, 2004; Cash, 2015), we hypothesized four groups would be found: normal sound sensitivity, misophonia only, hyperacusis only, and a combination of misophonia and hyperacusis. The four hypothesized clusters were found, plus two additional clusters, with mixed hyperacusis and misophonia characteristics that expressed symptoms differently (attentional and social).

The largest proportion of participants belonged to the “Low DST” cluster (28.6%). This cluster includes individuals who report minimal hyperacusis and misophonia symptoms, and limited sound-related impairment. This analysis also confirmed that hyperacusis and misophonia are highly comorbid in a student sample, as evidenced by the “High DST” cluster having the second largest number of participants (23.9%). This cluster was characterized by participants with a high probability of reporting mild to moderate misophonia-related functional interference, high misophonia and hyperacusis symptoms, and high attentional, emotional, and social impairment due to sounds. The “Misophonia” cluster, which included individuals with a high probability of reporting mild to moderate misophonia-related functional interference, high misophonia symptoms, and a low probability of reporting hyperacusis symptoms or impairment, made up 13.7% of the sample. The “Hyperacusis” cluster was characterized by participants with a moderate to high probability of reporting hyperacusis symptoms, a high probability of reporting no to minimal misophonia-related functional interference, and a high probability of reporting minimal misophonia symptoms, made up 10.1% of the sample.

Results revealed two unexpected clusters in the “DST; Attentional Difficulties” and “DST; Social Difficulties” clusters. The “DST; Attentional Difficulties” cluster included participants with a high probability of reporting mild to moderate misophonia-related functional interference, moderate to high misophonia and hyperacusis symptoms, and a high probability of reporting attentional difficulties due to sounds, and made up 13.2% of the sample. The “DST; Social Difficulties” cluster, which was characterized by individuals with a high probability of reporting mild to moderate misophonia-related functional interference, a moderate probability of reporting both misophonia and hyperacusis symptoms, and a high probability of reporting social difficulties due to sound made up 10.6% of the sample.

Previous research found that 8-9% of a Swedish community sample reported ‘yes’ to being “…sensitive to everyday sounds” and approximately 40% responded being ‘sometimes’ sensitive to everyday sounds (Andersson, Lindvall, Hursti, Carlbring, & Andersson, 2002). Approximately 20% of a large college sample reported clinically significant misophonia symptoms that interfere with their life (Wu et al., 2014), which was defined as individuals reporting a ‘7’ or higher on the MQ Severity Scale. Cash (2015) found that 60.9% of participants reported at least occasional misophonia symptoms and 16.9% reported that sounds cause physical discomfort and pain. Our results show that 13.7% of participants endorsed misophonia only, and 10.1% endorsed hyperacusis only. Further, 23.9% endorsed high levels of both misophonia and hyperacusis, and another 23.8% reported moderate levels of both types of symptoms with specific types of presentations (attentional or social difficulties). Thus, results from previous studies reporting prevalence rates for hyperacusis or misophonia should be interpreted cautiously, as they likely combined individuals with different types of symptom presentations. Our results show that the largest portion of participants have both hyperacusis and misophonia.

It is important to assess for both hyperacusis and misophonia because our findings revealed that a relatively small percentage of our sample (23.8%) report hyperacusis or misophonia in isolation, and a large proportion (47.6%) of the sample reported both misophonia and hyperacusis symptoms. Our data show that a high proportion of individuals are experiencing difficulties with both hyperacusis- and misophonia-specific sounds, as opposed to just one in isolation. However, most studies examining either misophonia or hyperacusis do not consider the comorbidity of the other (e.g., Wu et al., 2014; Fackrell, Fearnley, Hoare, & Sereda, 2015; Zaugg, Thileman, Griest, & Henry, 2016). When studies describe results about misophonia and its associated impairment and related psychological mechanisms, they conclude that these findings are related to misophonia specifically (Wu et al., 2014; Zhou et al., 2017; Potgieter et al., 2019). However, these studies are only assessing misophonia. We found that individuals reporting just misophonia is a much smaller group than what previous research has estimated; in fact, most people have both misophonia and hyperacusis and represent the group most affected by DST symptoms. Previous research estimating prevalence of misophonia should be interpreted cautiously, and future research should assess for both hyperacusis and misophonia given that they are more prevalent together than in isolation.

In addition to providing evidence about misophonia and hyperacusis prevalence rates and comorbidity, these LCA results provide insight into the ways that individuals with DSTs express symptoms differently. The “DST; Attentional Difficulties” and “DST; Social Difficulties” clusters were unexpected and provide evidence that individuals cope with and express DST symptoms differently. Both clusters had similar probabilities of reporting misophonia-related interference and misophonia symptoms. The two clusters' primary distinction was that the "DST; Attentional Difficulties" cluster had a higher probability of reporting attentional and emotional difficulties to hyperacusis, and the "DST; Social Difficulties" cluster had a higher probability of reporting social difficulties.

Given that the main descriptive difference between the "DST; Attentional Difficulties" and "DST; Social Difficulties" clusters is in the way sound-related impairment is expressed, an examination of the subscales that differentiate these clusters is warranted. The HQ Social scale is designed to measure social behavioral consequences of hyperacusis (Khalfa et al., 2002), and assesses how lifestyles may be affected. The question that loads highest on the HQ Social scale asked, "do you have difficulty listening to conversations in noisy places?". This question seems to be more hyperacusis-specific whereas the remaining five questions tap into avoidance of social situations. The "DST; Social Difficulties" cluster reveals that there is a subset of DST individuals presenting with primary behavioral avoidance and social dysfunction.

The HQ Attentional scale examines attentional deficits and cognitive effects of noisy conditions (Khalfa et al., 2002). The two questions that loaded highest onto the HQ Attentional scale score were "do you have trouble reading in a noisy or loud environment?" and "do you have trouble concentrating in noisy surroundings?". Individuals who experience sound-related cognitive impairment likely have a more difficult time allocating additional resources to coping with these sounds (Baguley et al., 2013). Individuals in the "DST; Attentional Difficulties" cluster also had a moderate probability (0.56) of experiencing sound-related emotional impairment. This probability was the second highest among the clusters, following the "High DST" cluster. The combination of both attentional and emotional impairment may be driving the increased psychological impairment associated with the “DST; Attentional Difficulties” cluster, which will be described in the next section. This cluster appears to respond to sounds with distraction and cognitive difficulties, whereas individuals in the “DST; Social Difficulties” cluster is more socially avoidant to situations that involve distressing sounds. These results identify a cluster of individuals that express DSTs through attentional and emotional impairment. In sum, the latent class analysis shows that there are unique clusters of individuals with different DST and associated behavioral expressions, severity, and associated impairment. The next section investigates the meanings of each cluster by examining psychological and clinical characteristics associated with each of them.

Psychological Differences Between Clusters

Hyperacusis and misophonia are considered distinct conditions but share similarities in functional impairment and coping strategies, and there is assumed to be high comorbidity between them (Jastreboff & Jastreboff, 2004), although most studies only assess misophonia. Once clusters were identified, we assessed how they differed psychologically, to identify similarities and differences associated with hyperacusis, misophonia, and their comorbid presentation. We hypothesized that both the hyperacusis and misophonia clusters would be associated with increased anxiety, depression, neuroticism, anger symptoms, posttraumatic stress symptoms, and general sensitivity, and a decreased ability to regulate emotions compared to the normal sensitivity group, and the combined hyperacusis and misophonia cluster would be associated with the greatest psychological impairment. In addition to our hypothesized clusters, there were two unexpected clusters, about which we made no hypotheses, that included individuals with both hyperacusis and misophonia and specific difficulties related either to social or attentional domains.

Our hypotheses were broadly supported. Overall results revealed that the “High DST” cluster exhibited greater symptoms than all other clusters on the DST related measures, hearing-related functional impairment, anxiety and depression, somatosensory amplification, social phobia, emotion regulation, and anxiety sensitivity. The “Low DST” cluster was for the most part significantly lower than all other clusters on all of these measures. When the “High DST” cluster was not significantly higher than the next highest mean, that mean belonged to the “Hyperacusis” cluster more often than not, followed by the “DST; Attentional Difficulties” cluster. Similarly, if the “Low DST” cluster was not significantly lower than the next lowest mean, it typically belonged to the “DST; Social Difficulties” cluster, followed by the “Misophonia” cluster. The overall findings support the hypotheses that people with hyperacusis alone and misophonia alone would exhibit more symptoms on a wide variety of measures compared to a normal sound sensitivity group, and that individuals reporting comorbid hyperacusis and misophonia would suffer the greatest number of symptoms. The results are also consistent with a continuum of symptom severity across clusters, in which the “High DST” cluster has the greatest impairment and decreases across subsequent clusters, with the “Low DST” cluster being the least severe.

Hyperacusis and misophonia are two conditions that are defined differently in the literature but share similarities, necessitating a comparison of the two. The “Hyperacusis” and “Misophonia” clusters represent the “purest” form of the two conditions, without symptoms of the other. These two clusters had significant psychological differences between them. The “Hyperacusis” cluster was more impaired overall, reporting significantly greater posttraumatic stress symptoms (PTSS), anxiety, depression, and emotional reactivity (Total Emotions) than the “Misophonia” cluster. On measures that there was not a significant difference between the two clusters (DERS, ASI, MAI), the "Hyperacusis" cluster was higher, indicating greater psychological difficulty. Further, this cluster's reported means on all variables were more closely related to the "High DST" cluster than the "Misophonia" cluster. The "Misophonia" cluster was higher (indicating better functioning) than the "Hyperacusis" cluster on all facets of personality (TIPI), though only significantly higher on emotional stability.

Hyperacusis and misophonia are associated with psychological impairment, both when they occur comorbidly, and in isolation. These results provide evidence that DSTs can be differentiated psychologically, such that hyperacusis is associated with more severe psychopathology than misophonia. The "Hyperacusis" and "Misophonia" clusters were not significantly different on any measures of misophonia (MQ Total, MQ – Emotions & Behaviors Scale, MQ – Sounds, MQ – Severity), suggesting that misophonia is not occurring in isolation as frequently as previously reported (Jager et al., 2020; Wu et al., 2014). It may be that misophonia rarely occurs without hyperacusis, and thus previous research reporting conclusions about the relationship between misophonia and mental health symptoms are misleading, because hyperacusis was not accounted for in these studies (Edelstein et al., 2013; Wu et al., 2014). The relationships found between misophonia and poor mental health in previous studies may be driven by comorbidity with hyperacusis symptoms. Future research needs to assess hyperacusis and misophonia conjointly in order to more clearly identify the relationships between DSTs and psychopathology.

The "DST; Attentional Difficulties" and "DST; Social Difficulties" clusters were both unexpected and offer insight into expressions of DSTs. On a measure of social phobia (FSS-S), there were not statistically significant differences between clusters, but the "DST; Attentional Difficulties" cluster reported a higher mean than the "DST; Social Difficulties" cluster. The

"DST; Social Difficulties" cluster included individuals with a high probability of reporting social difficulties due to sound, while the "DST; Attentional Difficulties" cluster included people with a high probability of reporting attentional problems related to sound. This result is contrary to expectations, and suggests that individuals in the "DST; Social Difficulties" cluster experience social issues specific to sound and are not generally socially anxious. The specific sound-related social impairment captured includes fear of noise, social consequences of noise-related avoidance, and ability to function in noisy social environments (Khalfa et al., 2002). The impairment experienced by this cluster is related to sounds, and the FSS-S, which assesses global social issues, would not be sensitive to the specific sound-related impairment experienced by this cluster.

The "DST; Attentional Difficulties" cluster reported significantly greater PTSS and emotional reactivity than the "DST; Social Difficulties" cluster. Research suggests that impairment in attention regulation may predate trauma exposure, acting as a risk factor for posttraumatic stress symptoms and PTSD (Aupperle, Melrose, Stein, & Paulus, 2012). A similar model of susceptibility may be occurring in individuals with attentional difficulties and DSTs. Participants in the "DST; Attentional Difficulties" cluster may have existing inhibition and attentional difficulties and have difficulty disengaging from the sounds that elicit an emotional reaction, causing further impairment. DSTs are psychologically different. Some individuals cope by socially avoiding, whereas others have attentional difficulties. Therefore, it may be that someone who socially isolates to avoid human-made sounds would benefit more from treatment that targets avoidance behaviors and emotion regulation, and an individual with attentional issues would benefit from treatment that targets distress tolerance, emotion regulation, and acceptance-based strategies. Understanding how DSTs can be differentiated psychologically is necessary to inform intervention, as people with distinct behavioral expressions of DSTs benefit from different treatment approaches.

The clinical correlates and psychological mechanisms revealing the greatest differences between clusters include posttraumatic stress symptoms, anxiety, depression, emotion regulation difficulties, anger symptoms, and anxiety sensitivity. The reported means of our study's measures are in line with the existing literature examining misophonia (Cash, 2015; Jüris et al., 2013; Wu et al., 2014). However, these studies reported overall sample means and did not explicitly account for hyperacusis when reporting results. Our overall sample means are similar to the extant literature (Cash, 2015), but the means in our DST-associated clusters are higher than the overall sample means reported in these studies. The measures of somatosensory amplification, social phobia, and personality dimensions differentiated between DST-associated clusters and the "Low DST" cluster but did not differentiate highly between DST clusters. This study offers a preliminary look at how DSTs can be distinguished psychologically and recommends that future research assesses both hyperacusis and misophonia. Previous work concludes that misophonia is associated with significant psychological impairment (Wu et al., 2014). However, these conclusions are premature because the current study shows that the greatest level of impairment was associated with the combination of hyperacusis and misophonia, followed by the hyperacusis only cluster. Examining one DST without consideration of the other ignores crucial information about the nature of DSTs. Specifically, hyperacusis and misophonia are occurring together more often than previously documented (Jastreboff & Jastreboff, 2004), and their combination may be driving the significant impairment reported by published studies. Identifying the specific psychological difficulty or behavioral expression an individual with DSTs experiences can provide useful clinical data pertinent for intervention. As previously discussed, an individual with attentional difficulties related to sound may benefit from a different intervention than someone who experiences social issues. DST conditions are nuanced, and their severity occurs on a continuum warranting more careful assessment in future research to understand them more completely.

Our sample was an unselected student sample, so it was expected that most participants would report non-clinical levels of psychological impairment and mental health symptoms. However, many people in DST-associated clusters reported levels of mental health symptoms comparable to clinical samples, suggesting that DSTs are associated with significant clinical concerns. One example of this involves PTSD symptoms, as illustrated by mean scores on the PC-PTSD-5 (PTSS) by cluster. A score of three or higher on this measure is considered a positive screen for PTSD (Prins et al., 2015). Although the mean score of 3 was not exceeded in any of the clusters, the "High DST" and "Hyperacusis" clusters both reported means greater than two, corroborating findings in the literature that there is a strong association between individuals with DSTs and posttraumatic stress symptoms (Fagelson, 2007; Taylor, 2017; Wu et al., 2014). Similarly, cutoff scores for the HADS total scale are $\geq$ 15 for uncertain cases, and $\geq$ 19 for definitive cases of anxiety and depression. The "High DST" cluster exceeded the cutoff of 15 ($M = 16.85$, $SD = 6.20$). All DST clusters ("High DST", "Hyperacusis", "Misophonia", "DST; Attentional Difficulties", "DST; Social Difficulties") reported mean scores higher than samples of individuals diagnosed with hypochondriasis and panic disorder (Ms = 28.52, 27.47; Martínez, Belloch, & Botella, 1999) on a measure of sensitivity to uncomfortable bodily sensations (SSAS).

The "High DST" cluster includes people with clinical levels of associated psychological symptoms, which is consistent with the previous paragraph discussing clinical correlates. Higher levels of emotion regulation difficulties and problematic symptoms of anger and anxiety sensitivity are associated with higher DSTs. The means of the “High DST” (M = 100.29), “Hyperacusis” (M = 92.75), and “DST; Attentional Difficulties” (M = 89.71) clusters on the Difficulties in Emotion Regulation Scale (DERS) exceeded that of a clinical sample of individuals with anxiety, mood, obsessive-compulsive, and trauma-related disorders (M = 89.33; Hallion, Steinman, Tolin, & Diefenbach, 2018). Kotler, Iancu, Efroni, and Amir (2001) assessed the Multidimensional Anger Inventory (MAI) in a sample of individuals diagnosed with PTSD (M = 84.9), anxiety disorders (M = 61.81), and controls (M = 60.7). Mean MAI scores in the “High DST” (M = 80.65) and “Hyperacusis” (M = 76.22) clusters were similar to the PTSD group, and the “DST; Attentional Difficulties” cluster’s mean (M = 74.24) fell in between the PTSD and anxiety disorders groups. Anxiety sensitivity was assessed using the ASI-3. Mean ASI for the “High DST” cluster (M = 26.78) exceeded that of individuals diagnosed with social anxiety disorder (M = 25.05), generalized anxiety disorder (M = 22.38), and PTSD (M = 22.69; Rifkin, Beard, Hsu, Garner, & Björgvinsson, 2015). The “High DST” cluster experiences clinical levels of associated mental health symptoms and clinical correlates. The psychological experience of individuals with high DSTs is not limited only to sounds; these people experience high levels of psychopathology that warrant further exploration.

The remaining measures differentiated between DST-associated clusters and clusters with limited DST symptoms, though means were not comparable to clinical groups like the measures previously discussed. Results from a measure of social phobia (FSS-S) and somatosensory amplification (SSAS) revealed significant differences between DST-associated clusters and the “Low DST” cluster but did not differentiate much between the DST-associated clusters themselves. There were few differences between clusters on Big Five facets of personality

(TIPI), except for emotional stability, in which the “High DST” cluster was significantly lower (suggesting greater impairment) than all other clusters. There were not significant differences between the remaining personality factors, but individuals with fewer DST symptoms tended to have higher scores on this measure, suggesting better overall functioning and supporting a continuum of DST symptoms and increased psychopathology. Somatosensory amplification and social phobia may be a good way to distinguish individuals with limited/no DSTs and those with DST symptoms but does not differentiate well between individuals who experience different levels of DST symptoms. Based on these findings, a useful method to differentiate between the severity of DST clusters is by examining anxiety, depression, and posttraumatic stress symptoms, as high scores on these measures were more closely related to the “High DST” cluster.

A comparison of current results to the clinical literature (Hallion et al., 2018; Rifkin et al., 2015) reveals that the “High DST” cluster experiences clinical levels of symptoms on psychological measures and clinical correlates. The impairment experienced by individuals in the “High DST” cluster is clinically relevant and suggests that people with comorbid hyperacusis and misophonia likely also suffer from high levels of psychopathology. The measures of somatosensory amplification, social phobia, and personality functioning did not differentiate significantly between DST clusters. DSTs are likely not expressions of extreme personality traits or social phobia. It seems that they are rather manifestations of underlying psychological difficulties in which more DST symptoms are associated with increased difficulty with emotion regulation, anxiety sensitivity, anger symptoms, anxiety, and depression. Clinicians should assess for DSTs when individuals experience mental health symptoms. For example, an individual diagnosed with PTSD may experience greater psychological impairment because they experience emotional reactions to both PTSD triggers and DST-specific sounds. Assessment of DSTs in clinical settings is warranted in order to capture the full clinical experience of individuals and to determine how underlying difficulties with DST symptoms and psychopathology may be impacting emotion regulation.

Emotion and Sound Differences Between Clusters

Emotions

The final aim of this study was to examine whether hyperacusis and misophonia could be differentiated based on the types of sounds that elicit a reaction and the resulting emotional reaction. Previous work suggests that typical misophonic reactions include anger and disgust (Edelstein et al., 2013), and fear and pain are commonly associated with hyperacusis (Tyler et al., 2014). We hypothesized that the emotions of fear and pain would be more frequently reported in people with hyperacusis, and anger and disgust would be more often reported in individuals with misophonia. We further hypothesized that the DST combination cluster would report a greater number of emotions than the other clusters. Another method to differentiate hyperacusis and misophonia is the type of sound that elicits a reaction. Whereas hyperacusis is a response to the loudness of ordinary sounds, misophonia is typically a response to specific, human-made sounds. Using a measure that assesses reactions to hyperacusis- and misophonia-specific sounds (Cash, 2015), we hypothesized that hyperacusis-specific sounds would be more frequently reported as aversive by individuals in the hyperacusis cluster, and misophonia-specific sounds would be more frequently reported as aversive by individuals in the misophonia cluster.

Our hypotheses were partially supported and mirror previously discussed results in which greater DST symptoms are associated with more pathology. The “High DST” cluster reported a significantly greater frequency of all emotions, except anxiety. The “High DST” and

“Hyperacusis” clusters were not significantly different in their reported experience of anxiety. Overall results support the hypothesis that the combination cluster would report the greatest frequency of emotions. The clusters with greater DST symptoms and psychological difficulty reported a greater number of emotions, consistent with research suggesting that greater psychopathology is associated with greater emotional intensity and frequency (Nock, Wedig, Holmberg, & Hooley, 2008). Difficulties in emotion regulation and increased neuroticism may predispose individuals to experience negative emotions more frequently and then experience greater symptomology. It may be the case that a similar process is occurring in individuals with greater DST symptoms. Future research should examine the relationship between frequency of negative emotions in response to DST-specific sounds and different psychological mechanisms and correlates to identify specific pathways that may be driving the relationships between pathology and DST symptoms.

The hypotheses that anger and disgust would be more frequently reported by the misophonia cluster, and fear and pain would be more frequently reported by the hyperacusis cluster, were partially supported. These hypotheses presuppose that these emotional reactions would be specific to either misophonia or hyperacusis (Edelstein et al., 2013; Tyler et al., 2014). However, the “High DST” cluster, which is comprised of individuals with the highest hyperacusis and misophonia symptoms, reported significantly more frequent experiences of all four of these emotions than all other clusters. The results for the “Hyperacusis” and “Misophonia” clusters show that DSTs are not easily differentiated by the expected type of emotional reaction elicited. Previous studies reporting that misophonia is associated with anger and disgust (Edelstein et al., 2013; Wu et al., 2014) did not assess for hyperacusis. The reported emotional experience may be the result of hyperacusis or the combination of hyperacusis and misophonia instead. Instead of examining the specific emotions, a better way to differentiate between DSTs is to examine the overall reported frequency of emotions to aversive sounds. The “High DST” cluster reports more negative emotions overall and also reports the greatest level of impairment. These relationships are more robust than the relationship between a specific emotion and a DSTs and suggest that overall reported emotions are a better indicator of those with more impairing DST symptoms.

The reported frequency of fear and pain was lower than that of anger and disgust. Pain, in particular, was the least frequently reported emotion. The average number of times the “High DST” cluster reported pain was 0.22 out of 40 sounds, meaning that on average only about 1 in 5 participants in the “High DST” cluster reported pain to one sound. In the “Low DST” cluster, the reported mean for pain was 0.08. Pain is an emotion that is not frequently experienced in response to sounds. Future research should examine how emotional reactions change across different sounds, and also account for the intensity of the elicited emotional reaction. For example, fear and pain may be experienced more intensely for fewer sounds, but this intensity could drive significant impairment.

Sounds

The literature suggests that DSTs can be differentiated based on the type of sound that is found distressing (Jastreboff & Jastreboff, 2004; Wu et al., 2014). We assessed this hypothesis using two different sound scales. Two sound groups, included a human sounds scale (HSS) and a loudness sounds scale (LSS), were developed based on a factor analysis of the sounds on the DST Scale (Cash, 2015). In addition, two sound groups were created a priori, labelled loud sounds (large truck driving by, construction, fire alarm, etc.) and mouth sounds (eating, breathing/nose sounds, throat/nose sounds, whispering, etc.). The “High DST” cluster reported the loud sounds (LSS) as significantly more aversive than all other clusters, and the “Low DST” group reported the loud sounds as significantly less aversive than all other clusters. The “High DST” cluster reported human sounds (HSS) as significantly more aversive than all clusters except the “DST; Attentional Difficulties” cluster, and the “Low DST” cluster reported significantly less aversiveness to human-made sounds than all other clusters. Results for the a priori sound groups (loud sounds and mouth sounds) generally mirrored those found for the HSS and LSS sound groups. These results provided partial support for our hypotheses and suggest that examining hyperacusis-specific sounds may be beneficial to differentiate between “pure” hyperacusis and misophonia, but examining differences between these two clusters for misophonia-specific sounds is not supported.

The lack of differentiation by sounds between hyperacusis and misophonia is especially salient when we consider that individuals found human-made/mouth sounds overall more aversive when compared with the loud sounds. This is especially interesting because a couple of the loud sounds (fire alarm, ambulance) included in the scale are designed to be aversive by their very nature. Most people find mouth sounds aversive, and distress elicited by these sounds is not something that is unique to misophonia. Misophonia may become problematic when the elicited emotional response cannot be regulated, which instead suggests that misophonia may be a problem specific to emotion regulation, rather than a reaction to specific sounds.

The reported aversiveness to different types of sounds may have less to do with the inherent aversiveness of the sounds, and is instead based on an individual’s experience with that sound and the coping strategy they expect to be available. Individuals reporting distress to sounds often use coping strategies to manage their reaction or block out the sound entirely (Jastreboff & Jastreboff, 2004). Some report using headphones and listening to music when encountering aversive sounds in order to minimize the subsequent emotional reaction (Edelstein et al., 2013). Coping strategies like using headphones or listening to music are easily accessible, and it is more socially acceptable to use them when people encounter loud noises (large truck/bus, construction noises, ambulance sirens) than when they encounter human-made/mouth sounds in different social environments. For example, it may not be appropriate for someone to use headphones or get up and leave the table when they are eating dinner with their family. Future studies should assess whether different coping strategies are used for different types of sounds, and how this is related to symptom severity and functional impairment in misophonia and hyperacusis.

An unexpected finding was that the “DST; Social Difficulties” cluster reported greater aversiveness to loud sounds than to mouth sounds, but did not report the same effect for the HSS and LSS. To better understand this result, it is helpful to identify the types of sounds included in each of the sound groups. The loud sounds group assessed aversiveness to a large truck/bus driving by, a loud concert, fire alarm, ambulance sirens, construction noises, and a vacuum heard from the other room. The mouth sounds group assessed aversiveness to eating, breathing/nose sounds, throat/nose sounds, whistling, consonant sounds, and whispering. The HSS sound group included sounds that are generally more aversive and not specific to mouth sounds (e.g., pen clicking, nails on a chalkboard, vomiting), so this could have driven the mean up higher than what this cluster reported for mouth sounds. A potential explanation for this difference could be related to the specific difficulty that differentiates this cluster. The “DST; Social Difficulties” cluster is characterized by a high probability of experiencing social difficulties due to sound, so this cluster may find the loud sounds more aversive than the mouth sounds due to the increased difficulty they have functioning in noisy social environments (Khalfa et al., 2002). The combination of increased social difficulty captured by the loud sounds sound group and decreased sensitivity for the mouth sounds sound group could explain the interaction found in this cluster.

Limitations and Future Directions

This study has a few notable limitations. The latent class analyses used in this study relied to some extent on researcher subjectivity. Further, since no studies to our knowledge have used latent class analysis to identify clusters of DSTs, the indicator variables were created using the most widely used DST measures currently available (Khalfa, 2002; Wu et al., 2014). Neither of these measures have been normed, so calculations for the latent class indicator variables used the standard deviations based on this study's sample means. The best fitting solution was chosen using accepted criteria for LCA (Vermunt & Magidson, 2016). Despite following best practices and recommended criteria, determining best fit for LCA relies on judgment, which can make replication difficult in some instances (van de Schoot, Sijbrandij, Winter, Depaoli, & Vermunt, 2017). This study was transparent in describing its methods, making replication easier.

This study's methods should be replicated, and the use of different latent class indicators would also be interesting to assess how it affects cluster membership. For example, despite being the instrument most commonly used to measure hyperacusis, the HQ has been criticized due to its reported low reliability (0.67; Greenberg & Carlos, 2018), and additional work has revealed statistical and validity concerns (Fackrell et al., 2015). In spite of the HQ's use in the literature, other questionnaires exist and should be examined because they may have better statistical support. Future research could assess whether using a measure to assess hyperacusis such as the IHS reduces the L^2 statistic and provides a better model fit (Vermunt & Magidson, 2005; 2016). Conducting analyses such as an ROC curve analysis (Zou, O'Malley, & Mauri, 2007) with DSTs could provide insight into the sensitivity and specificity of the predictive ability of these measures. Identifying optimal cutpoints of symptom severity and frequency (Serlin, Mendoza, Nakamura, Edwards, & Cleeland, 1995) would strengthen future research and allow more in-depth exploration into the classification of DSTs.

This study uses a cross-sectional research design, which limits the ability to examine temporal relationships. Emotional reactions often change over time (Haidt, 2003), and people use different strategies to modulate their emotional response (Edelstein et al., 2013). Future research should collect longitudinal data to assess how aversiveness and emotional reactions to sound change over time and across settings. The field will gain better understanding about how DSTs are expressed differently across individuals and provide further insight into unique behavioral expressions of DSTs and coping behaviors. Another limitation of this study is the exclusive use of quantitative measures. Some work (Edelstein et al., 2013) has examined qualitative experiences of individuals with misophonia. Future research would be wise to assess open-ended responses in people with misophonia, hyperacusis, and a combination of symptoms to assess similarities and differences between them.

This study examined the relationship between emotional reactions to specific sounds, but did not assess how multiple emotions could be associated with the same sound. For example, anger and disgust often occur together (Haidt, 2003), and it may be the case that combinations of emotions better differentiate “pure” hyperacusis and misophonia than a single emotion. Future research should account for mixed emotions someone may experience in response to a specific sound in order to understand these conditions more comprehensively.

Conclusion

This study is the first to our knowledge to examine hyperacusis and misophonia conjointly to examine similarities and differences between these DST conditions. We empirically identified clusters of individuals with different DST symptoms and examined how these clusters differed psychologically. The largest cluster of participants (28.6%) reported no or low DST symptoms. Of the five clusters reporting DST, the largest (23.9%) reported symptoms of both hyperacusis and misophonia, suggesting that comorbidity of DSTs is a common occurrence. Two of the identified clusters were not predicted ("DST; Attentional Difficulties, "DST; Social Difficulties") and offer insight into the ways that individuals with DSTs express symptoms differently. An examination of psychological differences between clusters reveals that individuals with the greatest DST symptoms had significantly greater psychological impairment (e.g., PTSS, anxiety, depression, emotional reactivity, anger symptoms, anxiety sensitivity, emotion regulation ability). The results represent a continuum of symptom severity across clusters, in which the "High DST" cluster has the greatest impairment and decreases across subsequent clusters, with the "Low DST" cluster being the least severe. Interestingly, the "Misophonia" cluster, which represents those with "pure" misophonia, endorsed less psychological impairment than most DST clusters. This finding is in contrast with the existing literature that reports high level of symptoms associated with misophonia and calls the results of these studies into question. Finally, clusters were assessed to examine whether they could be differentiated based on aversiveness ratings to hyperacusis- and misophonia-specific sounds and the emotional reaction elicited. The sounds and emotions typically associated with misophonia and hyperacusis are not useful methods to differentiate between clusters of individuals reporting misophonia or hyperacusis only. This study provides an empirical basis for the characterization of DSTs and offers a preliminary look into unique expressions of DST conditions.

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Appendix

Measures

DST and related measures

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
- Annoyance
- Guilt
- Fear
- Anxiety
- Physical pain
- 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

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 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.

Hearing Handicap Inventory for Adults (HHIA)

INSTRUCTIONS: The purpose of the scale is to identify the problems your hearing loss may be causing you. Check YES, SOMETIMES, or NO for each question. DO NOT skip a question if you avoid a situation because of your hearing problem. If you use a hearing aid, please answer the way you hear **WITHOUT** your aid.

		Yes (4)	Some-times (2)	No (0)
S-1.	Does a hearing problem cause you to use the phone less often than you would like?			
E-2.	Does a hearing problem cause you to feel embarrassed when meeting new people?			
S-3.	Does a hearing problem cause you to avoid groups of people?			
E-4.	Does a hearing problem make you irritable?			
E-5.	Does a hearing problem cause you to feel frustrated when talking to members of your family?			
S-6.	Does a hearing problem cause you difficulty when attending a party?			
S-7.	Does a hearing problem cause you difficulty hearing/understanding coworkers, clients, or customers?			
E-8.	Do you feel handicapped by your hearing problem?			
S-9.	Does a hearing problem cause you difficulty when visiting friends, relatives, or neighbors?			
E-10.	Does a hearing problem cause you to feel frustrated when talking to coworkers, clients, or customers?			
S-11.	Does a hearing problem cause you difficulty in the movies or theater?			
E-12.	Does a hearing problem cause you to be nervous?			
S-13.	Does a hearing problem cause you to visit friends, relatives, or neighbors less often than you would like?			
E-14.	Does a hearing problem cause you to have arguments with family members?			
S-15.	Does a hearing problem cause you difficulty when listening to TV or radio?			
S-16.	Does a hearing problem cause you to go shopping less often than you would like?			
E-17.	Does any problem or difficulty with your hearing upset you at all?			
E-18.	Does a hearing problem cause you to want to be by yourself?			
S-19.	Does a hearing problem cause you to talk to family members less often than you would like?			
E-20.	Do you feel that any difficulty with your hearing limits or hampers your personal or social life?			

S-21.	Does a hearing problem cause you difficulty when in a restaurant with relatives or friends?			
E-22.	Does a hearing problem cause you to feel depressed?			
S-23.	Does a hearing problem cause you to listen to TV or the radio less often than you would like?			
E-24.	Does a hearing problem cause you to feel uncomfortable when talking to friends?			
E-25.	Does a hearing problem cause you to feel left out when you are with a group of people?			

Total # of points______ / 100
Total # of points for SOCIAL / 48 = ______
Total # of points for EMOTIONAL / 52 = ______

0 (no handicap) to 100 (total handicap)
0-16% = No handicap
18-42% = Mild-Moderate Handicap
44%+ = Significant Handicap

Clinical correlate measures

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.

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

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.

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.

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.

Difficulties in Emotion Regulation (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