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Investigation of a Misophonia and Fluid Intelligence Relationship: Sound Spectrum Variation Impact on Fluid Intelligence Task Responses

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INVESTIGATION OF A MISOPHONIA AND FLUID INTELLIGENCE
RELATIONSHIP: SOUND SPECTRUM VARIATION IMPACT ON FLUID
INTELLIGENCE TASK RESPONSES

A Thesis Presented to the Graduate Faculty
of Fort Hays State University in
Partial Fulfillment of the Requirements for
the Degree of Master of Science


By

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ABSTRACT

Studies of misophonia have not assessed the impact of music and sound complexity on intelligence in individuals with misophonia. Edelstein et al. (2013) have provided work which pools trigger sound characteristics including sound repetitiveness yet does not include a substantial music subcategory. Utilizing the Cattell–Horn–Carroll model of intelligence, the current study explores the nature of music and music complexity on fluid intelligence, as described by Sternberg (2012). The hypotheses for this study focused on the relationship that complexity and music might have with misophonia. The rate of misophonia in the Mechanical Turk population was hypothesized to be 20%. The group with misophonia was predicted to perform worse when exposed to repetitive music and better when exposed to no music or complex music. Fluid intelligence was measured with a reaction speed score from the n-back task of working memory (Jaeggi et al., 2010). Disposition for misophonia was measured with the MisoQuest survey (Siepsiak et al., 2020a). A sample of Mechanical Turk workers participated in an n-back activity while exposed to no music, complex music, or repetitive music. The outcome of the study showed that rates of misophonia in the Mechanical Turk population were lower than hypothesized at under 5%. In supplementary analysis, the participants, categorized as having more misophonia traits, were worse at the n-back task in every condition including no music, complex music, and repetitive music. The outcome of this study can inform the work and educational environment setup.

Keywords: Misophonia, MisoQuest, Mechanical Turk, Fluid intelligence, Music

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INTRODUCTION

Over time scientific investigations have garnered valuable and applicable information for populations to be able to implement technologies improving quality of life (Jaffe et al., 2013; Rull, 2014). Today, the push for advancement in care is increasingly aimed at understanding human behavior, both biologically and psychologically (Altimus et al., 2020). Improvements are necessary for optimizing health and wellbeing across the population. This interest synergizes with another modern goal: personalized treatment (Goetz & Schork, 2018). To provide biologically and psychologically based personalized treatments, investigation into a number of psychological and neuroscientific areas must be conducted (Dutcher & Creswell, 2018).

One of these topics is sound sensitivity (Cavanna & Seri, 2015); in particular the understudied subset of sound sensitivity behaviors, misophonia. Misophonia is defined as a neurobehavioral syndrome that occurs as exposure to a trigger sound results in emotive and physical reactions greater than that expected in the population generally (Edelstein et al., 2013; Jastreboff & Jastreboff, 2001). Some of these sounds may include eating sounds (i.e. slurping, chomping, sucking fluid through a straw) or fidgeting sounds (i.e. foot shuffling, knuckle popping, nail clicking, or pen clicking). People with misophonia experience flashes of negative emotion in response to these specific sounds. The negative emotions often involve anger and can influence the sympathetic/parasympathetic response exchange of the autonomic nervous system. The sympathetic nervous system is defined as the portion of the nervous system which upregulates activity leading to

physiological readiness for acute emergency (National Cancer Institute, n.d.-a). These changes can include faster heart rate and respiration rate. The response by this system triggers the flight-or-flight response, characterized by intense emotion and action. This is the system activated by misophonia. The parasympathetic response is complementary to the sympathetic response. The parasympathetic nervous system is defined as the system responsible for reducing heart rate and respiration rate (National Cancer Institute, n.d.-b).

Misophonia and related conditions are estimated to occur in between 15 and 20% of the population. Such conditions contribute to maladaptive characteristics. Avoidance of serving triggering food or being around people eating triggering foods that create the disliked noises, as well as avoidance of people who typically produce trigger noises are examples of these characteristics. Those with misophonia can also show mimicry with certain sounds. Mimicry occurs when a person with misophonia experiences a trigger sound and makes a similar noise themselves as a coping strategy. These characteristics may decrease quality of life for those with misophonia and those with whom they interact. Additionally, two possible financial consequences of misophonia and other related conditions could be costly with the need for therapeutic intervention, and could also cause negative workplace efficiency, although at this time no research has been found that investigates misophonia as an economic factor. For example, tinnitus, a condition often linked to misophonia and with comparable treatment and incidence, has been recorded as costing some medical organizations over 750 million dollars annually in the UK (Stockdale et al., 2017). This exorbitant cost for tinnitus, a condition with similar

therapeutic treatments as misophonia, is found in a population of sufferers only half as large as those estimated to have misophonia (Stockdale et al., 2017).

To properly examine consequences associated with misophonia, investigation of sound response is important (Schröder et al., 2019). Neural configuration and connectivity associated with peripheral nervous system function, as well as intellectual involvement, has been partially investigated, and it has been found that those with misophonia engage the stimulus filtration portions of the brain, but may have abnormalities in that system. This filtration system is known as the salience network and involves the insula and anterior cingulate cortex. Any impacting conditions on this network will affect stimuli sorting and appropriate engagement of additional neural networks. Yet, with this in mind, too many gaps remain to fully describe the nature of the condition. To better understand the condition and its link with intellectual functioning, the current study will examine two relationships between misophonia and fluid intelligence. The first relationship assessed will be for underlying links between level of fluid intelligence and the presence of misophonia. The second, and most clinically relevant, will assess the functioning of fluid intelligence under complex and simple musical conditions in individuals with and without misophonia. The logic for this investigation follows in the footsteps of other intelligence inquiries (Mani et al., 2013). These findings bring into focus the need to assess stimulus impact on intelligence functioning, in schools and workplaces. People with misophonia may not function at their optimal level with certain background noises, for example. The current study explores the

impact of two forms of music (repetitive and rhapsodic), on fluid intelligence function in individuals with and without misophonia. It is hypothesized that repetitive music will harm the fluid intelligence task performance of those with misophonia to a greater extent than those without misophonia. This will add to the current literature by investigating a link between fluid intelligence and misophonia as well as determining the fragility of intelligence when exposed to complex and repetitive sound stimulus. A review of the literature on sound sensitivities, misophonia and fluid intelligence will follow to provide appropriate background information for the study.

Sound Sensitivities and Misophonia

The term misophonia means hatred of sound and refers to a condition where individuals experience atypically dramatic negative reactions to a trigger sound. The most well-known reaction is that of anger or revulsion (Daniels et al., 2020). This condition is worth investigating due to evidence that it is potentially quite common, and symptoms can substantially interfere with daily living. The severity of the symptoms determines the level of disruption to an afflicted individual. For example, a small misophonic reaction may induce an individual to reduce eye contact with dinner partners. This would be typical of someone who finds chewing sounds to be a trigger. A more extreme reaction would be for the individual to begin eating alone. The symptomology is increasingly understood, yet investigation into the rate of occurrence is somewhat murky. A genetics study indicates the population rates of misophonia could be over 20% (Fayzullina et al., 2015). A clinical group of inpatients in Poland ($N=94$) were assessed using a validated

questionnaire; results from the study found rates nearer to 8-12% (Siepsiak et al., 2020a). Even if rates are as low as 8%, this still indicates a population relevant for study based on almost one person in ten experiencing impairment due to the symptoms.

Misophonia can then be understood as a dislike of sound. However, many conditions can fall under such a generalization. The unique characteristics of misophonia are often best understood within the context of the sound intolerance category of syndromes, disorders, and behaviors.

The Umbrella of Sound Sensitivity and Perception Alteration Syndromes

Altered hearing sensation and perception occurs at two basic points in the auditory process (Kumar et al., 2017). First there is a difference in how the ear or body is transducing sound. This occurs between vibration capture by sensory organs and tissues and the point where sound passes through the auditory nerve to the brain. The second occurs at the perceptual level where the impulses from the auditory nerve are processed and utilized in an altered way at some point in the brain. When only looking into human sound disorders and phenomena, there is substantial variation in location and causes of these unique conditions (Buran et al. 2014; O'Hanlon et al., 2013). Conditions range from hearing loss to autonomous sensory meridian response. Some of these syndromes do not cause distress, but some do. One such neutral syndrome is addressed below.

Autonomous Sensory Meridian Response

Some conditions are entirely part of neural processing as is the case with autonomous sensory meridian response (ASMR) and synesthesia, when information

meant to stimulate one sense actually stimulates more than one in an atypical way (Buran et al. 2014; O'Hanlon et al., 2013). Autonomous sensory meridian response is a newly observed phenomenon (Poerio et al., 2018). Available information describes this condition as a tingling feeling along the body, particularly the spine, induced by auditory stimulation. The triggers for this condition are often sounds that bear similarity to misophonia triggers. Some of these ASMR sounds include clicks, scratching, and mouth sounds. Emotionally, the ASMR condition elicits positive feeling about these trigger noises. This response to auditory stimuli resembles misophonia due to the strong sound-emotion relationship further magnified by the similarity of trigger noises. As the body of research on these phenomena grows, it will become plausible to study any relationship between ASMR and misophonia. Their parallels outweigh their differences at this point. The similarities may indicate that ASMR is the positive aspect of the same syndrome as misophonia (which would be a negative aspect).

Maladaptive Conditions of Decreased Sound Tolerance

Among the variations in sound signaling and processing, one group of disorders present with symptoms are closely related (Jastreboff & Jastreboff, 2001). In fact, the treatment protocol for these pathologies is often the same. These conditions include tinnitus, phonophobia, hyperacusis, and misophonia. Tinnitus once was a blanket term for tinnitus, hyperacusis, and misophonia. Even recent work still can use the terms interchangeably. Tinnitus does, however, have a unique grouped symptomology. It is a condition typically brought on by mechanical damage to the inner ear. The brain responds

to the damage by producing a psychosomatic tone the individual perceives to hear. Phonophobia is often a complementary condition that shares some characteristics with misophonia (Asha'ari & Mat Zain, 2010). Phonophobia is the fear of a sound or sounds and is a condition often confused with misophonia (Jastreboff & Jastreboff, 2001). In this case, the symptomatic difference is between two reaction emotions. For phonophobia, fear is the characteristic response emotion. For misophonia anger is the characteristic response. One of the most influential findings in misophonia research is the importance in determining ways to separate individuals with hyperacusis and misophonia diagnostically. These two conditions are often confused due to similarity of symptom presentation. Hyperacusis, as a pathology, can be described as a maladaptive emotional reaction to the volume of an environmental sound. Typically, this occurs through damage to the ear. The previously described sound disorders are important to the study of misophonia, due to the number of traits that are similar enough to create a potential for misdiagnosis. None is closer than hyperacusis which can present in the same way as misophonia with only a difference in sound trigger to distinguish the one from the other in many assessments. Hyperacusis occurs due to volume of any sound. Misophonia occurs due to the timbre of a specific sound at any volume.

Theories Associated with Misophonia

Many hallmark theories are in the process of being tested related to the misophonic condition and many more are yet to be tested (Brout et al., 2018; Dozier, 2015; Kumar et al., 2017; Taylor, 2017; Webber et al., 2014). Among them are cognitive

theories of neuroplasticity and behavioristic classical conditioning. The Jastreboffs have studied misophonia in this way. The origins of the Jastreboffs' first conceptualization is heavily influenced by the theory of neuroplasticity, which features prominently in their clinical work on a range of sound disorders (Jastreboff & Jastreboff, 2001). Misophonia is treated somewhat like a bad habit, in the theory of neuroplasticity. Misophonia is viewed as a maladaptive reflex in need of re-training. Reflexes are a prompted behavioral or physiological reaction executed without conscious thought (Pavlov, 2010). Over time, the concept of the neuroplasticity element of misophonia has become a component in a greater theory which merges with work by other clinicians (Dozier, 2015), as the focus of several clinicians has been on applying the broader concept of classical conditioning to misophonia (Dozier, 2015; Jastreboff & Jastreboff, 2002).

Classical conditioning, through associative learning, makes for a useful theory to begin implementing treatments with newly described conditions. The Jastreboff (2002) model of misophonia reasons that the cause of the sound sensitivity syndromes occurs in individuals with unusually active or embellished connections between their auditory processing (hearing), limbic processing (emotion), and autonomic nervous system (which controls organs and glands). This theory may ultimately contribute to categorizing the sound sensitivity conditions as maladaptive incarnations of ASMR. Dozier (2015) focuses on the stimulus-response theory to inform his approaches to the condition and treatments. In his practice, Dozier implements a behavioristic framework attributing misophonia to conditioned responses or reflexes no different from Pavlovian conditioning

(Dozier, 2015; Pavlov, 2010). Though the classical conditioning approach is efficient for treatment, this focused attention may slow investigation into other aspects of the disorder (Palumbo et al., 2018). The focus on immediate care may be preventing the finding of more helpful and specific therapies. Recently, leaky sensory gating and poor cognitive control have been implicated in misophonia stimulus transduction (Zabelina et al., 2015), and may provide different treatment pathways.

Misophonia: Dissenting Perspectives

Interest in misophonia has not translated into agreement over its place in psychology, psychiatry, or audiology (Palumbo et al., 2018). The status of its classification as a disorder does not have unanimous support (Jastreboff & Jastreboff, 2001; Schröder et al., 2013; Taylor, 2017). Not everyone is in consensus about the level of importance misophonia has or where it belongs diagnostically (Taylor, 2017; Webber et al., 2014). One point, brought up by Asha'ari et al. (2010), is that there is an interrelation between misophonia, phonophobia, and hyperacusis. Specifically, misophonia and phonophobia can be brought on by the initial development of hyperacusis which would weaken the independence of origin which helps to define discrete disorders. The Jastreboffs also do not necessarily support the classification of misophonia as independent (Jastreboff & Jastreboff, 2002). These arguments and research into the potential comorbid relationships of these sounds disorders are shaping the future of misophonia treatment (Webber et al., 2014).

Though identification of misophonia as an extension of obsessive-compulsive disorder is a concept waning in popularity, the effects of this research area in misophonia will be present for the foreseeable future (Schröder et al., 2013). Instruments adapted from assessments for obsessive compulsive disorder have been used as a basis and inspiration for early misophonia assessment construction. This relates to the current study as the instrument used, MisoQuest, is based on criteria and items from an Obsessive-Compulsive disorder (Siepsiak et al., 2020a). Going forward, it is worth remembering that many scales for misophonia originate from obsessive compulsive disorder scales. Instruments with such an origin may require further assessment as the body of research expands. Fortunately, other perspectives are also used to investigate misophonia.

The research indicating potential for genetic influence in the development of misophonia is sparse, but has enough merit to support further study (Fayzullina et. al., 2015). In a hereditary case study, a fifteen-member family was found to have a 100% rate of misophonia (Sanchez & Silva, 2018). Twelve members completed self-report questionnaires on their symptoms and on other potentially linked conditions. The questionnaire scores for obsessive compulsive traits, misophonic emotion (e.g., anger, revulsion, anxiety), and depression were recorded at rates above 25%--an incidence greater than expected. Equally as important as the general comorbid traits were the reports of specific trigger sounds. The trigger sounds were not all ubiquitous in the family but fell within the categories determined in prior research (e.g., mouth sounds, pen clicking etc.).

The study does have several weaknesses, in particular the small sample, yet the reasoning for it is relevant. A growing number of conditions and attributes across domains are found to have genetic influences, including misophonia (Fayzullina et al., 2015). Identifying the impact of genetics on any psychological or physiological response is an important enough component to substantiate investigation. At least one large investigation by 23andMe has found an associated gene for misophonia, TENM2 (Baumgartner & Wides, 2019; Fayzullina et al., 2015). TENM2 is one of a family of genes coding for teneurin, which is an important lipid bilayer protein linked to various cellular functions including the development of synapses (connections between neurons in the brain) (Baumgartner & Wides, 2019; Mosca et al., 2012).

The State of Research

As of spring 2021, the literature is only beginning to contain studies of larger samples (Siepsiak et al., 2020a). Disputes over the importance or existence of misophonia as a construct are still not resolved satisfactorily (Taylor, 2017). Jastreboff (2015) noted that the rate of misophonia as a psychiatric pathology (2%) differed in prevalence to the rate of misophonia symptoms. This further complicates the reported rates of incidence. However, new studies with larger sample sizes can begin to counteract the weaknesses of the studies with small sample sizes (Jager et al., 2020). Rouw et al. (2018) surveyed a group of online participants with misophonia ($N=300$). Quek et al. (2018) and Siepsiak et al. (2020a) did two larger studies contributing to the cross-cultural investigation of misophonia. These studies both evaluate misophonia in clinical populations. Their

findings, along with the Amsterdam study of 575 participants with misophonia, are the beginning of more generalizable knowledge (Jager et al., 2020; Quek et al., 2018; Siepsiak et al. 2020a).

As described above, the body of research is relatively new (Asha'ari & Mat Zain, 2010; Schröder et al., 2013; Vanaja & Abigail, 2020). As a consequence, a significant portion of the literature appears to be exploratory science. Few studies cover similar topics that overlap and those that do are currently without substantial support (Daniels et al., 2020; Palumbo et al., 2018). During this initial stage of observation and testing, smaller case studies and focused samples still provide an important base for exploring ideas, but most critically as an introduction to effective treatments that are worth further testing in larger samples (Vanaja et al., 2020). Although it appears to be a jumbled picture, the evidence leading towards an understanding of misophonia will build through replication, incremental study, and studies with larger “*n*” values.

Misophonia in this study is conceptualized as a condition where trigger sounds elicit responding malevolent feelings. Applying such parameters to the construct agrees with previously discussed findings (Daniels et al., 2020). The aspect of interest is the characteristic or characteristics of sounds on a continuum of benign sound to trigger sound. A study conducted by Edelstein et al. (2013) analyzed common trigger noises and looked for themes. They found several important traits among trigger sounds. The most predominant finding was the importance of context for a trigger response. Trigger noises were indicated to be most intense when produced by a person with a close relationship to

the person with misophonia. A related finding indicated that there is a level of control occurring depending on context as trigger sounds did not affect as many people with misophonia when the trigger sounds were made by infants or animals. Interestingly, a category of sounds that was on the list often are used in music: ticking clock sounds, bass sounds, and whistling were noted as trigger sounds. This study indicates that repetitive sounds are worse than non-repetitive sounds and human-made sounds with emotional context are triggering. These findings paired with recorded, heightened, autonomic reactions to non-specifically aversive stimuli support investigation into the broader audiological responses of those with misophonia (Edelstein et al., 2013; Schröder et al., 2019). In continuation of this prior study, the present study adds to the growing body of work focusing on the relationship between diagnosed or self-reported misophonia cases and both biometric and psychometric responses to sound. This study will provide an early investigation into the prevalence of self-reported misophonia among the MTurk population and further examine the reaction to repetitive stimuli other than the specified trigger sounds. This will aid in building a model for the characteristics of a sound categorized as an influential stimulus or, more extremely, a misophonic trigger. Misophonic reactions will instigate a stress response (Edelstein et al., 2013). These responses then have a deleterious effect on intelligence as described earlier with the study on financial hardship in an Indian farming population (Mani et al., 2013).

Fluid Intelligence and Potential Misophonia Associations

Intelligence

Intelligence, according to Sternberg (2012), is the success in dynamic and challenging environments based on some form of learned technique acquired by exposure to the relevant environment. There are many theories that produce an array of models and constructs to explain intelligence. This investigation draws on the Cattell–Horn–Carroll theory of intelligence. This widely accepted theory breaks intelligence into two main categories: crystallized intelligence and fluid intelligence. Crystallized intelligence can be described as experience-based learning and retention of information. It is using facts and prior events to navigate current situations. Fluid intelligence can be employed in novel situations. Fluidity of intellect refers to flexible thought and problem solving. Fluid intelligence helps with novel problems and limited tools. For example, fluid intelligence would involve sticking a laptop battery in the refrigerator if the computer overheats.

In this framework, fluid intelligence is a component of cognitive problem solving (Sternberg, 2012). This type of thinking results in skilled adaptability to novel situations in a daily context. A concrete example of the impact fluid intelligence can have is evidence that it is linked to increased economic and medical wellbeing. This construct is important, yet the abstract nature of it presents researchers with a challenge when measuring for its presence and magnitude in participants.

Several measures have been developed to measure intelligence generally and to measure specific types such as fluid intelligence, as investigated by Salthouse and Pink

(2008). These measures often trace where in the brain activity occurs (Menon & Uddin, 2010). Some scholars say a component of fluid intelligence is working memory (Salthouse & Pink, 2008). That is a somewhat disputed notion among the academic community (Apšvalka et al., 2019). Newer CHC theorists suggest that fluid intelligence is not the same as working memory, though the two are often so highly correlated that separating them may violate statistical collinearity. Although this is important, the present body of work does not contain adequate support to treat fluid intelligence and working memory as separate constructs. At the very least, the presence of one regularly indicates the presence of the other. This entwined nature of fluid intelligence and working memory is the reason the construct of fluid intelligence will be measured in the current study using a task labeled with working memory.

Misophonia and Fluid Intelligence

The sampling in prior studies could indicate an association between misophonia and intelligence. A study in Florida obtained a sample of individuals with misophonia from a university population (Wu et al., 2014). A higher rate of misophonia was found in this sample, compared to studies sampling from other populations such as those from clinical settings (Siepsiak et al., 2020a). This could be an indicator that misophonia has a relationship with fluid intelligence. Additionally, this would relate to the established link between academic pursuit and fluid intelligence which has been examined (Kaufman et al., 2009). This could indicate an association among academics, fluid intelligence, and misophonia. Should such a connection be revealed, examination into the impact of

underlying structures that simultaneously affect both fluid intelligence and misophonia may be found. Leaky sensory gating is a phenomenon that should be examined as a potential indicator or cause of elevated fluid intelligence and risk factor for misophonia. Leaky sensory gating is a phenomena which has been implicated in creative thought, similar to fluid intelligence problem solving. It is characterized by poor attentional control which allows more environmental information to permeate thoughts which generate creativity. Both leaky sensory gating and fluid intelligence have significant links to the salience network of the brain whereby stimuli are sorted and additional networks are engaged.

There have been some mixed results in studies connecting misophonia and fluid intelligence (Jager et al., 2020). Several researchers argue over the definition of misophonia and additionally do not agree on the types of intelligence that may be associated. This means that intelligence among the population with misophonia may be elevated, average, or below average and vary between forms, because the definitions of intelligence used in the current research are not similar. This perceived discrepancy in definition causes a mistrust in the measures used to determine misophonia. The concern is that the current instruments are not equipped to differentiate between conditions such as hyperacusis, misophonia, tinnitus, and other sound sensitivity conditions. Therefore, the construct validity of misophonia studies may require investigation and refinement. Jager et al. (2020) excluded nearly 30% of their initial pool of potential participants due to the presence of similar conditions. The group further relates that the indeterminate

nature of the sample groups (caused by instruments measuring related syndromes) involved in prior study could weaken the evidence produced. These researchers indicate that prior findings linking misophonia to fluid intelligence may be due to a comorbid or analogous diagnosis, like Asperger's or obsessive-compulsive disorder (Jager et al., 2020; Wu et al, 2014). These findings indicate a need for measurement of reactions to auditory stimuli during cognitive tasks linked to fluid intelligence. The involvement of this type of assessment can start with the n-back task. The n-back task is an exercise whereby participants are exposed to a series of stimuli at short intervals (often a second) and then are prompted to determine if a designated stimulus is the same as one relayed "n" number of stimulus exposures ago.

Misophonia, Intelligence, and Leaky Sensory Gating

Some experiments are building evidence for the nature of misophonic reactions (Anusinha et al., 2018). One study indicates there may be a difference in reaction to misophonic triggers during visual n-back tests and auditory n-back tests. This indicates a difference in disruption based on senses utilized. The use of the n-back for this purpose refines the areas of interest anatomically. The construct validity has changed somewhat over the years. Initially, as the name implies, the n-back task of working memory was set to measure working memory. Since then, the construct of measure has changed to fluid intelligence. These investigations provide substantive evidence for systematic study of performance during working memory tasks under many intensities and qualities of sensory stimulation. The importance of investigating fluid intelligence or intelligence in a

sample with misophonia is relevant. The outcome of study will remove confusion and uncertainty about the prior investigations with uncertain construct validity (Jager et al., 2020).

Music and Misophonia Trigger Sounds

Music, among individuals, is sought after commonly as an entertainment or a strong need, it can be seen as a motivator for behavior (Schäfer, 2016). Music as a motivating force is pervasive in many social environments intentionally modifying behavior and affecting emotional regulation (Schäfer, 2016). Music is readily available and often has strong impacts on emotional states highlights the importance of investigating the overall effects of listening to fluid intelligence. The influence of music in every society and on many people indicates it is a sound that regularly elicits emotional or valent responses.

For example, in an empirical study on the effect of music valence on lottery behaviors, researchers implemented several music environmental conditions which produced more aggressive gambling behavior in participants (Schulreich et al., 2014). Happier music inclined participants to select higher risk opportunities. These results drew attention to the relationship between mood and cognitive or intelligence influenced situations. Opinions and attitudes concerning risk, which are addressed in the cumulative prospect economic theory, can be modified with exposure to musical influence. The happier participants, in the happy music condition, became gutsy and chose to engage in

riskier behaviors with more frequency than the groups with less happy participants and sad music.

The impact of music valence may have on people day-to-day may be even greater than a single study suggests as everyone constantly cognitively engages in action and choice. Another study examined the influence polysensory stimulation can have on stimulus response (Chang et al., 2015). Sight, touch, and smell are all senses that may intertwine and invoke varied responses to a stimulus. For example, substantial variation in the perception of happiness and sadness in a song was based on if the listener had their eyes open or closed. This study found relationship between sight and musical perception. Feelings were more intense when the eyes were open regardless of whether the songs were happy or sad. These findings indicate that environmental experiences that may be perceived as mono-sensory could be poly-sensory fusions with strong cognitive implications.

Five sound characteristics intertwine into the phonic form understood to be music. These important particles of composition include melody, rhythm, dynamics, tempo, and timbre (Hebert & Peretz, 1997). Melody is pitch clusters minimally separated by time-space. Rhythm is sound and silence expressed in alternation through time. Dynamics are the loudness or stress applied to any tone produced. Tempo is the rate or speed music is performed. Timbre is the textural group of tones and overtones produced that is unique to the object making the sound. Of the five elements, timbre may be more elusive to understand conceptually. Timbre is why a violin and a xylophone sound different even if

the pitches they produce are equivalent. This textural element is not emphasized. Focus is commonly on the other four elements for the purposes of music performance education.

Music has an effect on emotion, perception, and action (Chang et al., 2015; Schäfer, 2016; Schulreich et al., 2014). Many components of sound, silence, and organization combine when music is produced (Hebert & Peretz, 1997). Each musical element has a potentially different impact on neural processing. For example: evidence collected by Hebert and Peretz indicates long-term memory encoding and retrieval for melody may be stronger than that of rhythm. Such a variance in impact creates incentive to test as many elements of sound as possible.

Emotion and Music

The neural pathways for emotion and music have been mapped (Schaefer, 2017). These trails are very close together possibly explaining the paired emotional response to music. The current study explores whether there is still a mild generalized sensitivity to sound without specifying any particular emotion. The aim is to build a profile of what misophonic trigger noises can be and what features are most important in their makeup. This includes sounds across auditory domains from environmental noises, person-attributed bodily noises, and music. The emotion attached to music indicates music should be examined as a stimulator and influencer on thought and cognition emotionally and logically. Emotion often pairs with physiological responses such as hormone shifts.

Emotion in Misophonia trigger response

The nature of the emotional response to misophonic triggers indicates a varied hearing to emotion structure in the brain (Moller, 2011). There are two related events in this to misophonia. First, both misophonic triggers and music have repetitive qualities (Margulis, 2013a). This should be compared with music, a sound commonly responsible for intense emotions which is currently understudied as a potentially significant misophonia stimulus. Secondly, humans are commonly the ones producing the music which also fits as a factor in misophonia triggers.

Misophonia Triggers and Music Similarities

Edelstein et al. (2013), investigated the biometric response of individuals with and without misophonia in the presence of an array of trigger sounds. Results indicated that those with misophonia have higher skin conductance responses to sound stimuli. This supports the idea that those with misophonia are more sensitive to many sounds. Examples of the sounds used included: pen clicks, slurping, and chip bag crinkling. These sounds are often repetitive and have a human origin. Importantly, when asked about whether individuals were more concerned with repetitive sounds, over eighty percent of the sample indicated they were more influenced by repetitive sounds. Music can share several similarities with the misophonia trigger noises (Hebert & Peretz, 1997). Music also is commonly human controlled and can have repetition. Furthermore, music is a strong emotional influencer. These attributes make music a good test sound for misophonia. In the current study, two variants of the same tune will be used as sound

stimuli. One song will repeat the same melody with no significant variation. The other song will technically play the same tune, but there will be complex additions and harmonies which will ensure the song does not repeat during the n-back task.

Employed Theoretical Framework

This study works from a reductionist perspective and utilizes both a descriptive and comparative approach. Reductionism is a philosophy that investigates phenomena by looking at the whole of the phenomena of interest and then assessing parts at more refined and basic levels (Barendregt & Van Rappard, 2004). The reductionist perspective, in this study, is implemented when conceptualizing the range of sound stimuli and determining the specific element under examination in this current study, repetitiveness. The comparative nature of the study provides the necessary information to begin constructing part of a model for sound stimulus response in those with misophonia. Reductionism is not always considered the best practice with behavioral research, which has led to concerns about the overemphasis of reductionism in neural and behavioral research (Krakauer et al., 2017). Exploration of observed events within the scope of psychology and neuroscience, often requires a variety of methodologies for accurate evaluation cases. For newer phenomena, such as misophonia, reductionist methods are not without merit. The rigorous structure and strong link between action and biology is a critical initial step which may lead to later expansion of ideas where other perspectives are appropriate (Krakauer et al., 2017).

Such an approach appears best when considering the prior work on misophonia and its characteristics (Schröder et al., 2019). The prior literature has examined misophonia from several approaches including the neurobiological and survey self-reports (Schröder et al., 2019; Wu et al., 2014). Progress in understanding misophonia has been focused on therapy, comorbidity, symptoms, neural behavior and incidence as reported by Cavanna and Seri (2015). Research on misophonia is sparse on several topics, though it is expanding in general. The literature has not thoroughly examined the response to the many common environmental sounds such as wind, rain, music or motors (Schröder et al., 2019). Utilizing a comparative framework, this study will begin to uncover the nature of the misophonia and sound relationship and build toward a detailed model of the relationship between misophonia and sound triggers. A comparative approach is appropriate for this study based on the incomplete assessment of misophonia sound response. with respect to sound stimulus, neurobiology, and psychological profile (Schröder et al., 2019).

There has been little inquiry into the nature of how those with misophonia transduce the wider spectrum of sound. One possibility is the findings associating misophonia with peripheral nervous system variation and salience network linkages (Schröder et al., 2019). This current study we are implementing focuses on a single element of emotionally charged sound (repetitiveness) to begin building a base for the characteristics of misophonic stimulus and neutral stimulus outside of established trigger sounds. Prior findings have generally characterized response to trigger, benign, and

irritating sounds like the work by Schröder et al. (2019). Results from the work of Schröder et al. indicate that sound stimulus responses in those with misophonia may differ from those without misophonia. Furthermore, investigations with stimuli other than trigger sounds have been sparse. This current study aims to begin a systematic identification of sound characteristics that may be influential across a spectrum of sound stimuli. Sound stimulus during the fluid intelligence task will further clarify existing theories about the sensitivity of hearing in those with misophonia symptoms (Schröder et al., 2019). Measurement of reactivity to musical sound repetition will broaden or refine the scope of potential impactful sounds to those with misophonia. The current study will address several gaps. Firstly, sampling for rates of occurrence in online populations is underdone (Lourenco and Tasimi, 2020). Secondly, a relationship between fluid intelligence and misophonia will be investigated. Thirdly, two types of music stimulus (repetitive, and rhapsodic) will be applied as a stressor for assessing the impact musical complexity has on fluid intelligence task completion in individuals with misophonia. Each element is an addition to research that has not previously been investigated.

Research Objective

The current study demonstrates whether music is a stimulus that impacts fluid intelligence function in individuals with misophonia more than the general population. Additionally, this study generated data for the role of repetitive versus rhapsodic music on both individuals with misophonia and without misophonia during working memory tasks. Through these analyses, several questions were answered including: 1) What was

the rate of misophonia in a Mechanical Turk population; 2) Was there a different response to musical complexity on functionality during fluid intelligence tasks in individuals with misophonia and those without.

The results from this study could inform workplace and educational environmental design decisions by individual students and workers as well as educators and managerial professionals. The thesis outcomes could provide usable evidence of the effect music complexity has on fluid intelligence task scores. This evidence could also provide information on the toll various auditory environments can have on intelligence performance in individuals with misophonia.

Hypotheses

The hypotheses of the study were as follows:

Rate of Misophonia Incidence

Hypothesis one. Misophonia will be recorded in the sample population at rates within statistical expectation for a condition estimated to occur in 15-20% of the population.

Environmental Element Impact

Hypothesis two. The individuals testing in heavily noise-polluted environments were expected to have reaction time scores on the n-back task that could be predicted from the MisoQuest score.

There are three sound stimulus conditions in the design: no music, simple music, complex music.

Hypothesis three. The individuals testing in heavily noise-polluted environments will have lower accuracy and reaction time scores on the n-back task than in quiet environments.

N-back Reaction Speed Score

Hypothesis four. The misophonia group will score higher on reaction time for the fluid intelligence task in the music free condition than the group without misophonia or the groups with misophonia and the simple or complex sound conditions.

Hypothesis five. The misophonia group will score lower on the reaction scores of fluid intelligence task in the rhapsodic music condition than the non-misophonia group.

Hypothesis six. The misophonia group will score lower on the fluid intelligence task reaction speed score in the simple music condition as compared to the non-misophonia group.

Hypothesis seven. The misophonia group will score lower on the fluid intelligence task reaction speed score in the simple music condition than in the complex music condition.

Hypothesis eight. There will be a positive relationship between the misophonia score and the reaction speed of the fluid intelligence task in the music free condition. There will not be a positive relationship between misophonia score and fluid intelligence task score in either the simple condition or the complex condition.

N-back Accuracy

Hypothesis nine. The misophonia group will score higher on accuracy for the fluid intelligence task in the music free condition than the group without misophonia or the groups with misophonia and the simple or complex sound conditions.

Hypothesis ten. The misophonia group will score lower on the accuracy of fluid intelligence task in the rhapsodic music condition than the non-misophonia group.

Hypothesis eleven. The misophonia group will score lower on the fluid intelligence task accuracy score in the simple music condition as compared to the non-misophonia group.

Hypothesis twelve. The misophonia group will score lower on the fluid intelligence task accuracy score in the simple music condition than in the complex music condition.

Hypothesis thirteen. There will be a positive relationship between the misophonia score and the accuracy of the fluid intelligence task in the music free condition. There will not be a positive relationship between misophonia score and fluid intelligence task score in either the simple condition or the complex condition.

These findings may demonstrate that the group with misophonia have higher general n-back task scores, which can add support to the theory that fluid intelligence is elevated in individuals with misophonia. The findings may also demonstrate that the repetition of music, or exposure to music more greatly affect the performance of the misophonic group, which would support the theory that leaky gating may be associated

with sound sensitivity conditions like misophonia. Furthermore, the repetitive music may harm n-back performance more due to the similarity between repetitive music and repetitive nature of trigger noises already described (Margulis, 2013a). Additionally, assessment of prevalence of misophonia in the Mechanical Turk working population could further establish a baseline of expected population rates in an epidemiological sense. These questions have been proposed as untapped areas of inquiry in academic discussion over the last several years (Cavanna & Seri, 2015).

Method

Participants

For this study, 245 participants ($N = 245$) were recruited from the Mechanical Turk (MTurk), a crowd-sourcing task site (Moss et al., 2020). A study that has sampled from MTurk populations report consistent percentages for the major demographics over time. With these figures in mind, expected sample demographics reflect a substantially more diverse sample than would be expected in a study performed with community samples from the local region (U.S. Census, 2010). This MTurk study included 63% male participants, 35.9% female participants, 0.4% non-binary, and income was represented somewhat proportionally. Income breakdowns for five ranges of the sample revealed that most participants earned within the lower three categories. The participant percentages for household income included 22.5% of participants with lower incomes (under \$20,000), 32.6% of participants with incomes over \$40,000 but under \$59,999, 19.9% of participants with incomes over \$60,000 but under \$79,999, 15.9% of participants with incomes over \$80,000 but under \$99,999, and 9.1% of participants with household income of \$100,000 or more. In order to better engage participation by those who would be in the misophonia group, advertising aimed at them was to be employed. As previously mentioned, estimates of misophonia in the population, 15%, require a larger sample size to increase validity (Siepsiak et al., 2020a). Of sampled participants, 81% reported living in the United States with the largest group, 11.6%, reporting residence in the state of California. Within the sample 15.6% reported living outside the United States.

Participants ages were predominantly under 40 years old with 30.1% between 19 and 28 years of age, 43.5 % between 29 and 38 years of age, 15.6 % between 39 and 48 years of age, 8% between 49 and 59 years of age, 2.9% were 60 years old or more.

Design

This comparative study used a 2 (misophonia and non-misophonia) x 3 (no sound, repetitive music, and rhapsodic music) factorial ANOVA design. Accuracy and speed of task completion in the n-back test were the dependent variables to determine the impact of the group difference (misophonia, no misophonia), and the treatment with random order assignment (no music, repetitive music, and rhapsodic music). Separate 2X3 ANOVAs were conducted for each of the two dependent variables.

Measures and Materials

Fluid intelligence was measured using an n-back task of working memory (Jaeggi et al., 2010). In a prior study, this task has been found to have predictive value for fluid intelligence. The task required participants to view a series of objects and produce recall of objects viewed at a defined time (i.e., writing the letter they saw three objects ago). Trials consisted of exposure to twenty letters. Each visual exposure lasted for 500 milliseconds. The response window duration was for 3000 milliseconds after the stimuli response. The reaction times are recorded in milliseconds and were assessed as group mean scores during analysis. Incorrect responses are separated into two categories. The first occurs when the participant signals the presence of a letter seen immediately prior to the most recent letter stimulus when it is false. This is known as a “False Alarm.” The

other incorrect response occurs when the participant misses the opportunity to indicate that a presented stimulus letter was previously presented immediately before the last stimulus. This is referred to as a “Miss.” The errors and speed were used as straight measures during analysis.

The sound conditions employed during the n-back task include a condition without sound, a condition with a repetitive recording of *Twinkle Twinkle Little Star*, and a complex or rhapsodic music condition with an excerpt from Mozart’s variations (Mozart, 1781). The tunes were set for the same duration and both share the same melodic structure and instrumentation. These attributes remove potential conflicting factors such as duration effects, melodic variation influence, valence difference preferences, and timbre difference. Potential auditory confounds are addressed in the following section.

Confounding variables

Accompanying the tasks were questions about environmental noise and to confirm exposure to auditory stimulus for each task from their device speakers (See Appendix E). The environmental noise question used a 0-10 point scale and asked, “On a scale from 0-10 with 0 being silent and 10 being very loud, how loud would you rate the environment you are in right now?” An additional question about distracting environment was asked to assess the level of environmental contamination a participant experiences. This question was also on a 0 – 10 scale with 0 being not distracting and 10 being extraordinarily distracting. The technology check question was yes/no and framed thusly,

“During the previous task could you hear noise from your device’s speaker(s)? (Y/N)”.

These possible confounding variables were correlated with the score on the dependent variable, fluid intelligence, to see if they had an effect. If they do, they would be included as co-variates in the main analyses.

To determine the participants’ misophonic status, the study employed the misophonia questionnaire, *MisoQuest* (Siepsiak et al., 2020a; See Appendix F). The survey uses 14 items and has had superb, reported reliability ($\alpha = 0.96$). These items are based on a five-point Likert scale with (1 = I definitely do not agree; 2 = I do not agree; 3 = Hard to say; 4 = I agree; 5 = I definitely agree). Of particular value were the items which separate misophonia from other conditions. An example from Siepsiak et al., (2020): “I find some quiet sounds unbearable” separates misophonia from tinnitus (Table 1). Scoring for this study was based on prior research (Siepsiak et al., 2020b). The recommended cutoff is for a score of 61 points or more out of a total of 70 points. The purpose of the instrument is to assess the presence of misophonia in the individual answering the questionnaire. This test has dichotomous results and is not intended to determine intensity of symptoms.

Demographic information was also recorded through a series of questions. These demographics assessed population characteristics that included: income, age, sex, and geographic region of residence (See Appendix G).

The individuals who participated in the study were part of two waves of responses. The first wave did not have any advertising targeting misophonia. The second

wave did have advertising that targets individuals with misophonia. Each wave was constructed so sampling would be equal across regions and without replacement. There are two reasons for the dual wave. Firstly, one portion of the dual wave was designed to attempt to reach an increased number of respondents that would be classified in the misophonia group. This was accomplished by targeted advertisement for one sample attempt. This was done to ensure adequate sample of individuals with misophonia. The second reason for two waves was to sample the population without misophonia targeted advertisement for population characteristic descriptive assessment.

Procedure

Participants who selected the Human Intelligence Task (HIT) on MTurk selected the survey and were taken to the informed consent page (See Appendix A; Appendix B). Once participants assented electronically, they were instructed to turn on a speaker device and find a quiet environment if possible. Following this, they were provided directions for the n-back task on the Psytoolkit platform (Stoet, 2010; 2017; See Appendix C). Following a practice session of the task they were exposed to each of the three n-back tasks in randomized order. To screen for contamination, participants provided responses to questions assessing the noise pollution present in the participant's environment. This assessment used a 0-to-10 ranking of environmental sound pollution, "On a scale of 0-to-10 with 0 meaning no sound pollution and 10 meaning extreme sound pollution, how would you rate the sound pollution in your current environment?" Two additional questions were used to assess the success of the treatment stimuli. One question

ascertained speaker volume with an open-ended short answer response, “What volume level is your speaker set to?” A second question asked the participant to indicate if they heard a sound during each n-back trial, “Did you notice sound coming from your speakers during this n-back trial? (Y/N)”.

In the interest of participant protection, individuals who chose to participate were provided a URL to the survey on Qualtrics where they then completed the questionnaire and answered demographic questions. These participants were provided a debriefing at the conclusion of the study (See Appendix I). This included providing information for support services in the event of an adverse reaction a participant may experience. The only identifiable information acquired from the participants were completion codes that enabled proper monetary compensation via MTurk. All APA guidelines for ethics were followed (American Psychological Association, 2017; See Appendix J).

Results

Preliminary Analyses

A power analysis was run to determine sample size for the study. A small effect size with .80 power and an alpha of .05 were used to estimate the sample needed for power. The necessary N for this study was 215. This was determined with the Cohen power primer table (Cohen, 1992).

Main Analyses

Hypothesis One

The MisoQuest misophonia rate in the sample was not found to be at the expected prevalence of 15-20%. The sample recorded a rate of 4.7% ($n = 12$). This finding does not support the first hypothesis.

The low rate of participation from the group qualifying as having misophonia impacted the planned subsequent analyses. To increase power while attempting to maintain the purpose of the study, a median split of participants into two groups: those scoring lower on the MisoQuest Questionnaire and those scoring higher on the MisoQuest questionnaire was implemented. The following analyses were performed with these two groups.

Hypothesis Two

Reaction Score Could Be Predicted Mostly From MisoQuest Score. A regression was run to ascertain the extent to which environmental confounds affected the variables of interest. In hypothesis two, it was predicted that reaction speed score (Y) could be predicted mostly from MisoQuest misophonia score (X1), but background noise or environmental loudness level (X2), speaker volume (X3) and distractedness level (X4) were also assessed. A simultaneous regression analysis was used to test this hypothesis. The data were screened to test the assumptions of a multiple regression including the assumption of multicollinearity. Results suggest that all assumptions were met; collinearity diagnostics for tolerance and VIF indicated that multicollinearity was not an issue when assessing the predictor variables. All predictor variables were entered simultaneously. Overall, the regression model testing these predictors was significant [F

(4,244) = 1.8, $p = 0.129$; $r = .17$; Adjusted $R^2 = .01$]. About 17% of the variance in reaction score can be explained by these predictors.

When assessing each predictor individually, the results suggest that MisoQuest score is a significant predictor of reaction speed score [$t(239) = 2.44$, $p = .02$; $\beta = .16$]. The squared semi-part that estimated how much variance in reaction speed score was uniquely predicted from MisoQuest score was $sr^2 = .156$. Thus, about 16% of the variance in reaction speed score was uniquely predicted from MisoQuest score.

Hypothesis Three

Individuals Testing in Heavily Noise-polluted Environments Would Have Lower Reaction Speed Scores on the N-back Task Than in Quiet Environments. The regression additionally was run to examine the impact of environmental factors on reaction speed. Environmental loudness was not a significant predictor of reaction speed score [$t(239) = -.536$, $p = .59$; $\beta = -.05$]. The squared semi-part that estimated how much variance in reaction speed score was uniquely predicted from environmental loudness was $sr^2 = .034$. Thus, about 0.3% of the variance in reaction speed score was uniquely predicted from environmental loudness. Environmental distractedness also was not a significantly predictor of reaction speed score [$t(239) = -.05$, $p = .96$; $\beta = -.004$]. The squared semi-part that estimated how much variance in reaction speed score was uniquely predicted from environmental distractedness was $sr^2 = .003$. Thus, about .03% of the variance in reaction speed score was uniquely predicted from environmental distractedness. Speaker volume was not a significant predictor of reaction speed score [t

(239) = -1.00, $p = .32$; $\beta = .17$]. The squared semi-part that estimated how much variance in reaction speed score was uniquely predicted from speaker volume was $sr^2 = .064$. Thus, about 0.6% of the variance in reaction speed score was uniquely predicted from speaker volume.

Together these findings suggest that distractedness, speaker volume, and environmental loudness were not significant predictors of reaction speed score for this sample when together. However, MisoQuest score uniquely predicts more of the variance in reaction speed score than environmental loudness or distractedness. The findings support the treatment of the reaction time, accuracy, music exposures, and misophonia condition as without conflicting interaction variables. It was predicted in the third hypothesis that individuals testing in heavily noise-polluted environments will have lower reaction speed scores on the n-back task than those in quiet environments. The reaction speed scores of those in the heavily noise polluted environments were seen to not have statistically significant differences in n-back task than those in quiet environments. This refutes the third hypothesis. Null hypothesis retained.

Hypothesis Four-Eight

A between-subjects 2x3 factorial ANOVA was conducted. Due to the low sampling of participants that qualified as having misophonia according to MisoQuest score, the ANOVA was conducted based on a median split of the sample group. The dependent variable was reaction speed on the fluid intelligence task. Two independent variables 1) misophonia (misophonia and no misophonia) and; 2) three levels for musical

complexity (simple, complex, and without music) were tested to assess for differences in reaction speed on the n-back task. The factorial ANOVA for reaction speed addresses hypotheses four through eight.

Hypothesis Four: The Misophonia Group Will Score Higher on Reaction Speed for the Fluid Intelligence Task in the Music Free Condition Than the Group Without Misophonia or the Groups with Misophonia and the Simple or Complex Sound Conditions. This hypothesis was not supported. Participants in the complex music condition ($M = 750.26$, $SD = 229.69$) did not have better reaction speed on the working memory task than participants in either the simple music condition ($M = 744.20$, $SD = 254.91$) or the null music condition ($M = 716.81$, $SD = 191.78$).

Hypothesis Five: The Misophonia Group Will Score Lower on Reaction Speed for the Fluid Intelligence Task in the Complex Music Condition than the Non-misophonia Group. This hypothesis was supported. Participants with low misophonia scores below the median ($M = 696.66$, $SD = 199.45$) scored better (lower) on reaction speed score than participants with high misophonia scores above the median ($M = 783.15$, $SD = 254.92$).

Hypothesis Six: The Misophonia Group Will Score Lower on the Fluid Intelligence Task Reaction Speed Score in the Simple Music Condition as Compared to the Non-misophonia Group. This hypothesis was supported. Participants with low misophonia scores below the median ($M = 696.66$, $SD = 199.45$) scored better (lower) on

reaction speed score than participants with high misophonia scores above the median ($M = 783.15$, $SD = 254.92$).

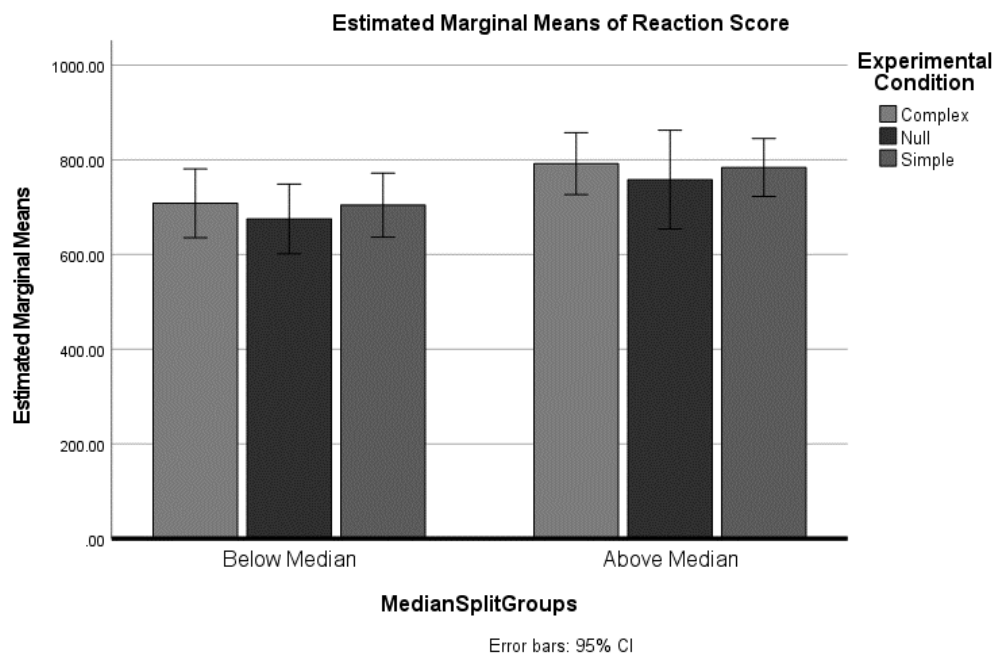
Hypothesis Seven: The Misophonia Group Will Score Lower on the Fluid Intelligence Task Reaction Speed Score in the Simple Music Condition than in the Complex Music Condition. This hypothesis was supported. Participants in the complex music condition ($M = 750.26$, $SD = 229.69$) did not have better reaction speed on the working memory task than participants in either the simple music condition ($M = 744.20$, $SD = 254.91$) or the null music condition ($M = 716.81$, $SD = 191.78$).

Hypothesis Eight: There Will Be a Positive Relationship Between the Misophonia Score and the Reaction Speed of the fluid intelligence task in the music Free Condition. There Will Not be a Positive Relationship Between Misophonia Score and Fluid Intelligence Task Score in Either the Simple Condition or the Complex Condition. This hypothesis was not supported. Participants in the complex music condition ($M = 750.26$, $SD = 229.69$) did not have better reaction speed on the working memory task than participants in either the simple music condition ($M = 744.20$, $SD = 254.91$) or the null music condition ($M = 716.81$, $SD = 191.78$).

In the ANOVA conducted for reaction speed, results indicate a significant main effect of misophonia [$F(5, 244) = 6.88$, $p = .009$, partial $\eta^2 = .03$]. Participants with low misophonia scores below the median ($M = 696.66$, $SD = 199.45$) scored better (lower) on reaction speed score than participants with high misophonia scores above the median ($M = 783.15$, $SD = 254.92$). The main effect of sound condition was found to be non-

significant [$F(5, 244) = .358, p = .70, \text{partial } \eta^2 = .003$; See Figure 1]. Also, the interaction effect was non-significant [$F(5, 244) = .002, p = .998, \text{partial } \eta^2 < .000$].

Reaction Speed ANOVA



Hypotheses Nine-Thirteen

A between-subjects 2x3 factorial ANOVA was conducted. Again, the low sampling of participants that qualified as having misophonia according to MisoQuest score, caused the ANOVA to be conducted based on a median split of the sample group. A significant main effect of misophonia was found [$F(5, 265) = 16.30, p < .001, \text{partial } \eta^2 = .056$]. Additionally, another significant main effect of sound condition was found [$F(5, 265) = 3.38, p = .035, \text{partial } \eta^2 = .025$]. There was also a non-significant interaction

effect [$F(5, 244) = .002, p = .998, \text{partial } \eta^2 < .000$]. Qualifying this analysis is an overall trend for low partial η^2 values.

Hypothesis Nine: The misophonia group will score higher on accuracy for the fluid intelligence task in the music free condition than the group without misophonia or the groups with misophonia and the simple or complex sound conditions. This hypothesis was not supported. Low misophonia scorers ($M = 7.07, SD = 7.01$) scored better on accuracy than participants with high misophonia scores regardless of condition ($M = 12.14, SD = 9.14$).

Hypothesis Ten: The misophonia group will score lower on the accuracy of fluid intelligence task in the rhapsodic music condition than the non-misophonia group. This hypothesis was not supported. Participants in the complex music condition ($M = 10.77, SD = 8.91$) did not have better accuracy on the working memory task than participants in either the simple music condition ($M = 10.23, SD = 8.82$) or the null music condition ($M = 6.52, SD = 6.40$).

Hypothesis Eleven: The misophonia group will score lower on the accuracy of fluid intelligence task in the simple music condition than the non-misophonia group. This hypothesis was supported. Across all conditions the misophonia group scored more poorly than the non-misophonia group ($M = 7.07, SD = 7.01$) scored better on accuracy than participants with high misophonia scores ($M = 12.14, SD = 9.14$).

Hypothesis Twelve: The misophonia group will score lower on the fluid intelligence task accuracy score in the simple music condition than in the complex

music condition. This hypothesis was not supported. The misophonia group in the simple music condition ($M = 11.78, SD = 9.58$) scored better on accuracy than participants with higher misophonia in the complex condition ($M = 13.93, SD = 9.02$).

Hypothesis Thirteen: There Will Be a Positive Relationship Between the Misophonia Score and the Accuracy of the Fluid Intelligence Task in the Music Free Condition. There Will Not be a Positive Relationship Between Misophonia Score and Fluid Intelligence Task Accuracy in Either the Simple Condition or the Complex Condition. This hypothesis was partially supported. The group higher in misophonia had worse error scores in the music free condition ($M = 7.83, SD = 6.41$), simple music condition ($M = 11.78, SD = 9.58$), and complex music condition ($M = 13.93, SD = 9.03$).

In this ANOVA results indicate a significant main effect of misophonia [$F(5, 265) = 16.30, p < .001, \text{partial } \eta^2 = .056$]. Participants with low misophonia scores ($M = 7.07, SD = 7.01$) scored better on accuracy than participants with high misophonia scores ($M = 12.14, SD = 9.14$). A significant main effect of sound condition was found [$F(5, 265) = 3.38, p = .035, \text{partial } \eta^2 = .025$]. Participants in the complex music condition ($M = 10.77, SD = 8.91$) did not have better accuracy on the working memory task than participants in either the simple music condition ($M = 10.23, SD = 8.82$) or the null music condition ($M = 6.52, SD = 6.40$). These main effects were accompanied by a non-significant interaction effect [$F(5, 244) = .002, p = .998, \text{partial } \eta^2 < .000$].

Additional Analyses

Due to the resetting of threshold in the main analysis, a split analysis of participants with upper and lower third MisoQuest scores was run. The intent was to intensify any differences between those scoring low on misophonia and those with higher MisoQuest scores. Results from these analyses were not significantly different from the median split analyses.

Discussion

Hypothesis One

In the first hypothesis, it was expected that the rate of misophonia found in the Mechanical Turk sample would be around 20%. This was expected due to prior population genetics study (Fayzullina et al., 2015). The current study did not directly support a rate of misophonia expected. One potential explanation for this outcome is that the instrument used to measure misophonia, MisoQuest, was developed under a more clinical environment (Siepsiak et al., 2020a). This may mean the instrument is most appropriate for identification of clinical level misophonia and not misophonia traits along a continuum. Future studies might use instrumentation designed to measure traits and categorize by levels for other studies looking at misophonia and intelligence performance.

Hypothesis Two

It was expected that individuals testing in heavily noise-polluted environments would have reaction speed scores on the n-back task that could be predicted from the MisoQuest score. This hypothesis was supported. The association between reaction speed

and MisoQuest score was examined in a regression analysis. The portion of reaction speed found to be associated with misophonia score was approximately 16%. The strong association between the two may be due to stability of the constructs measured. Both misophonia and fluid intelligence are traits that are thought to have resilient features when measured under various conditions (Jaeggi et al.,2010).

Hypothesis Three

Initially, it was predicted that individuals testing in heavily noise-polluted environments would have lower reaction speed scores on the n-back task than in quiet environments. A regression was run to ascertain the impact that environmental factors could have on reaction speed scores. The individuals testing in heavily noise-polluted environments did not have lower speed and reaction time scores on the n-back task than those in quiet environments. There are at least two potential reasons for a result such as this. It is possible that the reactions speeds of participants were not impacted by environmental sounds due to resilience inherent in individuals that participate in the Mechanical Turk platform. Individuals that may be bothered by loud sounds during tasks like this one might not choose to engage in these activities. Another possibility is that this is linked to the stability of measure associated with traits like fluid intelligence and misophonia and similar to hypothesis two (Jaeggi et al.,2010).

The misophonia group did not score higher on the working memory task in the music free condition than the group without misophonia. This result was also true in the simple (repetitive) and complex (rhapsodic) sound conditions.

Hypothesis Four

Originally it was predicted that the misophonia group would score higher on reaction speed for the fluid intelligence task in the music free condition than either the group without misophonia or the groups with misophonia and the simple or complex sound conditions. A factorial ANOVA was run to compare misophonia and sound conditions with respect to reaction speed score. Hypothesis four was unsupported. The misophonia group scored lower on the working memory task in the complex music condition than the non-misophonia group and did score better in the group without music, but the results were not statistically significant. Such a result may indicate that small differences in reaction speed may need to be treated differently in measurement.

Hypothesis Five

It was expected that the misophonia group would score lower on the reaction speed scores of the fluid intelligence task in the complex music condition than the non-misophonia group. This hypothesis was supported. The factorial ANOVA for reaction speed score was further examined for this hypothesis. The group with higher misophonia traits did not score as well as those with lower misophonia traits in the complex music condition. Originally, the reasoning for this outcome was tied to the suggestion that misophonia would increase sensitivity to sound across the board. This hypothesis does indicate that those with misophonia would do worse on fluid intelligence tasks in environments with complex sounds than those without misophonia.

Hypothesis Six

The misophonia group was predicted to score lower on the fluid intelligence task reaction speed score in the simple music condition as compared to the non-misophonia group. This hypothesis was supported. The factorial ANOVA for reaction speed score was investigated for this hypothesis. Those with higher misophonia scores did not react as quickly in the simple music condition as those with lower misophonia scores. Though this hypothesis was supported, the overall results may indicate different reasons behind the outcomes than were conceived originally.

Hypothesis Seven

The higher misophonia trait group was expected to score lower on the fluid intelligence task reaction speed score in the simple music condition than in the complex music condition. This hypothesis was unsupported. Again, the factorial ANOVA for reaction speed score was examined for this hypothesis. Those with higher misophonia traits scored lower in the complex condition, but the difference was not significant. This outcome indicates that those with misophonia might not be impacted by complexity of sound.

Hypothesis Eight

A positive relationship between the misophonia score and the reaction speed of the fluid intelligence task in the music free condition was expected. No positive relationship between misophonia score and fluid intelligence task score in either the simple condition or the complex condition was expected. This hypothesis was partially supported. Further exploration of the factorial ANOVA for reaction speed score was

conducted for this hypothesis. There was no significant positive relationship between misophonia and reactions speed for the music free condition. The same lack of positive relationship occurred for the other conditions, both simple and complex. The indication that reaction speed was overall worse might hint at neural regions implicated in the n-back task.(Miró-Padilla et al., 2020). Individuals with higher misophonia traits might have differences in motor networks that can be differentiated by both the reaction speed and the accuracy scores. The next step might be to construct designs that parse out fluid intelligence related to speed, error, input, and decision-making as separate constructs. This style of design might pinpoint the specific locations of variation occurring in those with higher misophonia traits.

Hypothesis Nine

Originally, it was predicted that the high misophonia trait group would score higher on accuracy for the fluid intelligence task in the music free condition than either the group with low misophonia traits or the groups with higher misophonia traits and the simple or complex sound conditions. A factorial ANOVA was run to compare misophonia and sound conditions with respect to reaction accuracy. Hypothesis nine was unsupported. Those with higher misophonia traits scored worse on accuracy than those with lower misophonia traits scored in each sound condition. It is possible this could be due to random sampling, though investigation into the reactions and processing should be considered.

Hypothesis Ten

It was expected that the misophonia trait group would score lower on the accuracy of the fluid intelligence task in the complex music condition than the low misophonia trait group. A factorial ANOVA was run to compare misophonia and sound conditions with respect to reaction accuracy. Hypothesis ten was unsupported. The group with higher misophonia scores was not more accurate than the group with lower misophonia scores in the complex music condition. The cause of this may relate to sensory gating (Zabelina et al., 2015). The inability to block complex sound may have a greater cognitive, though not emotional, cost for those with misophonic traits than those with fewer misophonic traits.

Hypothesis Eleven

The higher misophonia trait group was predicted to score lower on the fluid intelligence task accuracy score in the simple music condition as compared to the low misophonia trait group. A factorial ANOVA was run to compare misophonia and sound conditions with respect to accuracy. Hypothesis eleven was supported. The group with higher misophonia traits were less accurate in the simple sound condition than the group with lower misophonia traits. This outcome does point to a difference in processing of information between those with higher misophonia inclination and those with lower misophonia inclination. This outcome may be due to disruption caused by auditory stimuli as predicted, but alternate explanations should also be considered. There could be a generalized motor disruption among those with misophonia traits that formed as a consequence of the misophonia pathways. This type of interference could be caused by

mimicry compensatory behaviors. There may be a small amount of constant inclination towards motor mimicry for environmental sounds that impacts reflexive motor efficiency in the n-back task (Kumar et al., 2021).

Hypothesis Twelve

The misophonia group was expected to score lower on the fluid intelligence task accuracy score in the simple music condition than in the complex music condition. A factorial ANOVA was run to compare misophonia and sound conditions with respect to accuracy. Hypothesis twelve was unsupported. The higher misophonia trait group scored more accurately in the simple sound condition than in the complex sound condition as was expected, but this result was not significant. This statistical insignificance might be due to the method of measurement. Alternatively, the difference may mean that there is a small span of difference between sound conditions that is meaningful but constrained by physiologically dependent upper and lower limits ((Miró-Padilla et al., 2020). This would also explain the low effect sizes noted across the analyses.

Hypothesis Thirteen

A positive relationship between the misophonia trait score and the accuracy of the fluid intelligence task in the music free condition was expected. No positive relationship between misophonia trait score and fluid intelligence task accuracy score in either the simple condition or the complex condition was expected. A factorial ANOVA was run to compare misophonia and sound conditions with respect to accuracy. Hypothesis thirteen was partially supported. There was no positive relationship between misophonia trait

scores and any of the three sound conditions: no sound, simple sound, and complex sound conditions. This may be due to general disruption caused by misophonia pathway development. The intensity of the misophonia circuit may have caused typical relay development for fluid intelligence to be downregulated or disrupted (Kumar et al., 2021).

In general, it was found that those with more misophonia traits did not do as well on the fluid intelligence task than those with fewer misophonia traits. This may mean that those with misophonia underutilize some or all the areas involved in completing the n-back task. This evidence could direct further investigations into more specific neurological areas to determine where altered connectivity occurs. One such area to investigate may be the dorsolateral prefrontal cortex, as it is known as an important part of decision making and is linked to the n-back task (Miró-Padilla et al., 2020). Another path to investigate is how individuals might be compensating. If those with misophonia score worse on fluid intelligence, then the next question is to investigate if they are compensating in a specific way. Furthermore, the original idea in this study was that there may be an association between higher fluid intelligence and misophonia (Fayzullina et al., 2015; Kaufman et al., 2009 ; Wu et al., 2014). The current study does not support such a relationship, but perhaps looking at other factors such as resilience or creativity may provide more explanation for perceivable associations.

The context for this study may have a substantial impact on the results. This study was originally designed as a laboratory experiment. The onset of the 2020 COVID-19 pandemic changed the design as it was reformatted for online distribution. The use of

Mechanical Turk was employed as a means of accessing a population safely and with opportunity at a reasonable recruitment size. The change in design has opened the study up to several internal validity threats. One such threat was attrition. In our study the rigorous need to exclude participants greatly changed the valid sample available. These reductions, though necessary in this case, display potential problems in measuring remotely and measuring via web. Of these problems, foremost are the contamination variables. Though these were accounted for in screening analysis and found to be nonsignificant, the possibility of impact on the outcomes increases when considering the small differences in reaction speed. Remedies for these weaknesses might include designs with more statistical power and fewer conditions. Interestingly, the lack of impact of environment on results may mean that studies in online environments with complex tasks may be usable in the future. This may be due to the increase in web interactions due to the pandemic.

Further lines of inquiry

Follow-up studies could be designed with a focus on smaller portions of the research question or new lines of investigation. With this current topic, sampling of the target population through support groups and other specialized organizations would provide a more powerful sample. In addition to the change in sampling, the task instruments may be used for more extended periods. More assessment data per participant may yield improved accuracy of cognition measurement. Another consideration for the measurements regards the reaction speed. It could be important to

apply a log transformation or factor out a neural reaction constant when measuring millisecond speeds (Miró-Padilla et al., 2020). Such a modification could highlight true differences that may be diluted in this current study. Additionally, the inclusion of additional validated measures might provide a clear picture of the processes involved in misophonia and environmental sounds. The distribution of scores on MisoQuest describe a bell curve which, when considering the construction of the items, might indicate a spectrum. Changing to a spectrum perspective on misophonia might be most appropriate for future studies. Other additions might include recording ambient noise decibel in other iterations of this study.

Though the hypotheses were largely only partially unsupported, this study does provide evidence of key information for this topic and this methodology. The topic evidence supports the existence of intense misophonia at population rates below 5%. The absence of support for a misophonia rate of 15-20% could be due to several causes. The MisoQuest instrument was developed in a clinical setting (Siepsiak et al., 2020a). This instrument, as mentioned, might target clinical levels to an extent which excludes its appropriateness for the current research questions.

The lack of impact that environmental conditions have on the tests of intelligence suggest that either the Mechanical Turk population is resilient against environmental effects or that perhaps there is a trend toward working in quiet environments among Mechanical Turk workers.

New study questions could be focused on increasingly specific neural areas such as the dorsolateral prefrontal cortex, decision making networks, and motor networks (Miró-Padilla et al., 2020.; Kumar et al., 2021). Alternative measures to fluid intelligence could include measures of creativity, musicality, and resilience as each of these traits could be impacting outcomes for those with misophonia.

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Appendix A

Recruitment message

Greetings and salutations! My name is Leslie Watson, and I am a graduate student in the Department of Psychology at Fort Hays State University in Hays, KS. I would like to invite you to participate in a research study. This experiment's purpose is to examine task execution under several environmental stimuli.

Should you elect to participate, you will be asked to perform several tasks and answer a series of questions. Initially, you will be asked several questions about the environment you are in (to account for distractions) and provided with directions to turn on your device speakers. Then you will be asked to perform a task while listening to provided sounds on your device. Finally, you will be given a survey to fill out asking questions about your experiences with sounds and asking some standard demographic questions.

You will be compensated \$2.50 for your time and participation in this study. Your help would be greatly appreciated in this research project. If you would like to participate you will be asked to fill out a consent form related to the study. You will then be asked to complete a survey. If you choose to participate, the study will take approximately 15-25 minutes. If you have any questions about the study or would like to learn more information about the study before deciding to participate, please feel free to contact me (Leslie Watson) or my faculty adviser (Dr. Carol Patrick).

Leslie Watson

lawatson2@mail.fhsu.edu

Dr. Carol Patrick

clpatrick@fhsu.edu

Appendix B

Informed Consent

RESEARCH PARTICIPATION CONSENT FORM

Department of Psychology, Fort Hays State University

Title of Study: Mechanical Turk Sounds and Memory Study

Name of Researcher(s): Leslie Watson

Contact Information: lawatson2@mail.fhsu.edu

Name of Faculty Supervisor & Contact Information: Dr. Carol Patrick
(clpatrick@fhsu.edu)

You are being asked to participate in a research study. It is your choice whether or not to participate. Your decision whether or not to participate will have no effect on you.

WHAT IS THE PURPOSE OF THIS STUDY?

The purpose of this experiment is to examine the impact of environmental stimuli on an individual's completion of a memory task. Furthermore, we are interested in examining what factors might potentially influence skills in individuals with various sound transduction inclinations.

WHAT DOES THIS STUDY INVOLVE?

If you decide to participate in this study, you will be asked to perform one task four times (once to practice). Then you will be asked to answer several demographic questions about yourself and to complete survey questions about your experiences with sounds. You will not be required to provide your name or any other identifying information. If you decide to participate in this study, you will be asked to click continue to indicate you give your consent to participate. After completing the survey, you will be given a debriefing statement. The length of time of your participation is approximately 15-25 minutes. Approximately 600 participants will be in this study.

ARE THERE ANY BENEFITS FROM PARTICIPATING IN THIS STUDY?

This research could be used to ascertain the level of impact environmental factors can have on task completion depending on sensitivities across populations.

WILL YOU BE PAID OR RECEIVE ANYTHING TO PARTICIPATE IN THIS STUDY?

Participants will be compensated monetarily with \$2.50 for their time and participation in the study.

WHAT ABOUT THE COSTS OF THIS STUDY?

Participating in this study has no cost associated other than the time you will spend completing the surveys.

WHAT ARE THE RISKS INVOLVED WITH BEING ENROLLED IN THIS STUDY?

It is unlikely that participation in this project will result in harm to participants. It is unlikely that you are at risk for psychological, physical, social harm or any risk that is more than minimal. However, tasks and survey questions included in this study may require concentration or cause psychological distress to some participants. Participants may skip any questions they do not feel comfortable answering and may withdraw from the study at any point without penalty. You may contact the researcher, faculty supervisor, and/or the Office of Scholarship and Sponsored Projects. Please see below for contact information for these resources.

PRIVACY PROTECTION

No names or identifying information will be asked. Your data will be identified by an ID number that will not be associated with your name. This data is collected only for research purposes. Data files which do not contain your identifying information will be kept in electronic format. Responses to survey questions will be entered into a computer program and stored for 3 years, after which the data will be deleted. This is in accordance with standard practice. The only individuals who will access the database are the student researcher and faculty advisor. Results of the survey will be shared with the scientific community through presentation and publication. When results are shared, information will be presented in aggregate form and will contain no names or identifying information.

OTHER IMPORTANT INFORMATION:

- **Withdrawal from the study:** You may choose to stop your participation in this study at any time without penalty. If you chose to do so, please exit out of the internet window.
- **Funding:** Partial funding for this project was obtained from the Fort Hays State University Graduate Scholarly Experience grant program.

WHERE CAN QUESTIONS ABOUT THIS STUDY BE DIRECTED?

Questions about this study should be directed to either Dr. Carol Patrick (clpatrick@fhsu.edu) or the principal investigator, Leslie Watson (lawatson2@mail.fhsu.edu). If you have questions, concerns, or suggestions about human research at FHSU, you may call the Office of Scholarship and Sponsored Projects at FHSU (785) 628-4349 during normal business hours 8am-5pm Central Standard Time.

CONSENT

I have read the above information about this study. By continuing, I agree to participate in this study. I understand that I can change my mind and withdraw my consent at any time. By continuing, I understand that I am not giving up any legal rights and I am between the ages of 18 and 65.

Please click continue to progress to the study.

Appendix C

N-back Task

<https://www.psychtoolkit.org/experiment-library/nback2.html>

N, B, C (no match), B (match), C (match), Q (no match)

Appendix D

Music (rhapsodic music)

<https://musopen.org/music/2664-12-variations-on-a-french-nursery-theme-k-265300/>
and Sheet

Appendix E

Noise pollution and speaker technology questions

At what volume level do you have your speakers set (0-100)?

Did you hear Audio from your device speakers during your task?

1. Yes
2. No
3. Not Sure

On a scale of 0 to 10 with zero indicating silent and 10 indicating extremely loud, how loud would you rate your environment during the game activity?

Loudness Level bar scale 0-10

On a scale of 0 to 10 with zero indicating 'not distracting at all' and 10 indicating 'extremely distracting,' how distracting was your environment during the game activity?

Distraction Level bar scale 0-10

Appendix F

MisoQuest

MISOQUEST – A QUESTIONNAIRE FOR ASSESSING DECREASED SOUND TOLERANCE

authors: Siepsiak, M., Śliwerski, A., Dragan, W. Ł

Some people are less sensitive to certain sounds, while other people are more sensitive to certain sounds. Are there any sounds which you find particularly burdensome? Please indicate how much you agree or disagree with the following statements using the following scale:

- 1 – I definitely do not agree
- 2 – I do not agree
- 3 – Hard to say
- 4 – I agree
- 5 – I definitely agree

1	Some sounds bother me so much that I have difficulty controlling my emotions.	1	2	3	4	5
2	Unpleasant sounds make me feel overwhelmed.	1	2	3	4	5
3	I become anxious at the mere thought of an unpleasant sound.	1	2	3	4	5
4	I believe that my reactions to sounds are exaggerated, but I can't get rid of them.	1	2	3	4	5
5	When I hear unpleasant sounds, I start sensing emotions in my body (e.g. I sweat, feel pain, feel pressure, my muscles tens).	1	2	3	4	5
6	I start feeling anger the moment I see a thing/animal/person that might make an unpleasant sound at any time.	1	2	3	4	5
7	I put a lot of effort into controlling emotions when I hear an unpleasant sound.	1	2	3	4	5
8	If I can, I avoid meeting with certain people because of the sounds they make.	1	2	3	4	5
9	I find some sounds made by the human body unbearable.	1	2	3	4	5

10	I feel that my mental state worsens if I cannot leave a place where there's an unpleasant sound.	1	2	3	4	5
11	I often think about how to drown out unpleasant sounds.	1	2	3	4	5
12	Some unpleasant sounds make me instantly angry.	1	2	3	4	5
13	I am scared that unpleasant sounds may impact my future.	1	2	3	4	5
14	When meeting with other people, I am sometimes irritated because of unpleasant sounds that are present.	1	2	3	4	5

Appendix G

Demographics

What is your age?

In what state in the U.S., or what country do you live currently?

Which category includes your total annual household income in 2019 before taxes and withholdings (i.e. total gross income)?

1. Under \$20,000
2. \$40,000 to \$59,999
3. \$60,000 to \$79,999
4. \$80,000 to \$99,999
5. \$100,000 or more

What is your gender?

1. Male
2. Female
3. Other (Specify)

Appendix H

N-back Permissions and experiment link

<https://us.psychtoolkit.org/c/3.3.2/terms>

<https://www.psychtoolkit.org/faq.html>

<https://www.psychtoolkit.org/faq.html#permission>

Appendix I

Debrief

Thank you for your participation in this research study! Now that your participation is completed, we will describe the specific nature of the study to you, why it was important, provide resources to answer any of your questions, and provide you with the opportunity to make a decision on whether you would like to have your data included in this study.

What you should know about this study

This study measured fluid intelligence (flexible thinking) under auditory stress conditions (music complexity) in individuals with the sound sensitivity misophonia and those without that sound sensitivity. You were exposed to one of three sounds during the completion of the n-back task (which is used here to measure fluid intelligence). The conditions used in the study included: no music, repetitive music, and non-repetitive music. The technological questions you were asked about the sounds in your environment and technological specifications will be used to make sure there were no confounding noises (or account for any present) in the environment you were in during the task. The 14 questions asking about your responses to noise are used to determine if criteria for misophonia are met. The demographic questions were to assess how closely the participant sample matches what we would expect when compared to the mTurk workforce.

We hope that this study will further aid in optimization of working and educational environments for the general population and to guide occupational interventions for individuals impacted by misophonia.

Please do not disclose research procedures and/or purpose to anyone who might participate in this study in the future as this could affect the results of the study.

If you would like to receive a summary of the findings when it is completed, please feel free to contact the researcher or search the FHSU Master's Thesis Database: <https://scholars.fhsu.edu/theses/>.

Right to withdraw data

Whether you agree or do not agree to have your data used for this study, you will still receive \$2.50 for your participation.

You may choose to withdraw the data you provided prior to debriefing, without penalty or loss of benefits to which you are otherwise entitled. Please click the "Submit" button below if you do, give permission to have your data included in the study. Please click the "Withdraw" button below if you do not give permission to have your data included in the study.

If you have questions

The main researcher conducting this study is Leslie Watson, a graduate student at Fort Hays State University's Department of Psychology. If you have questions later, you may contact Leslie Watson at lawatson2@mail.fhsu.edu or Dr. Carol Patrick at clpatrick@fhsu.edu. If you have any questions or concerns regarding your rights as a research participant in this study, you may contact the Institutional Review Board (IRB) Chairperson at IRB@fhsu.edu Leslie Paige at lpaige@fhsu.edu or 785-628-4349..

Concerns

If you feel upset after having completed the study or find that some questions or aspects of the study were distressing, talking with a qualified clinician or counselor may help. If you feel you would like assistance, please contact a mental health service near you. Additionally, provided are further support contacts.

National Suicide Prevention Lifeline
(800) 273-8255

National Suicide Prevention Lifeline (Spanish)
(888) 628-9454

Crisis Text Line
Text HELLO to 741741

National Domestic Violence Hotline
(800) 799-7233

Veterans Crisis Line
(800) 273-8255

Selection of either button found below indicates that you have been debriefed and have had all of your questions answered or have received appropriate contact information.

- Submit**
- Withdraw**

Appendix J

IRB Approval Letter



**FORT HAYS STATE
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OFFICE OF SCHOLARSHIP AND SPONSORED PROJECTS

DATE: May 7, 2021

TO: Leslie Watson, B. A.

FROM: Fort Hays State University IRB

STUDY TITLE: [1756146-1] Impact of Music Complexity on Fluid Intelligence in Individuals with and without Misophonia

IRB REFERENCE #: 21-0153

SUBMISSION TYPE: New Project

ACTION: DETERMINATION OF EXEMPT STATUS

DECISION DATE: May 7, 2021

yj

Thank you for your submission of New Project materials for this research study. The Fort Hays State University IRB Administrator has determined that this project is EXEMPT FROM IRB REVIEW according to federal regulations.

Please note that any changes to this study may result in a change in exempt status. Any changes must be submitted to the IRB for review prior to implementation. In the event of a change, please follow the Instructions for Revisions at <http://www.fhsu.edu/academic/gradschl/irb/>.

The IRB administrator should be notified of adverse events or circumstances that meet the definition of unanticipated problems involving risks to subjects. See <http://www.hhs.gov/ohrp/policy/AdvEvtGuid.htm>.

We will put a copy of this correspondence on file in our office. Exempt studies are not subject to continuing review.

If you have any questions, please contact Leslie Paige at IRB@fhsu.edu. Please include your project title and reference number in all correspondence with this committee.

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Thesis: Investigation of a Misophonia and Fluid Intelligence Relationship ^{Sand Spectrum Variation Impact on Fluid Intelligence Task Response.}

Author: Leslie Watson-DiVittore

Signature: 

Date: 5/20/2022