Vocal Manifestations of Reported Past Trauma

by

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Submitted to the Graduate Faculty of

The School of Health and Rehabilitation Sciences in partial fulfillment

of the requirements for the degree of

Master of Science in Speech-Language Pathology

University of Pittsburgh

2019

UNIVERSITY OF PITTSBURGH

SCHOOL OF HEALTH AND REHABILITATION SCIENCES

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It was defended on

March 19, 2019

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***Introduction*:** The human voice carries a wealth of information about a speaker's physical and emotional states, personality, and perhaps even their past experiences. For many people, these experiences include the endurance of traumatic events, which can have an effect on psychological, physical, and neurobiological development. In turn, one's past experiences of trauma might impact their vocal function and/or quality. The aims of this preliminary study are (1) to identify whether a connection exists between an individual's past experiences and their vocal characteristics, and (2) to explore the extent to which so-called "laryngoresponders" display a unique set of acoustic features compared to "non-laryngoresponders".

***Methods*:** Data were collected from 29 vocally healthy females between 18 and 65 years of age. Participants completed self-report measures wherein they identified their somatic responses to stress, i.e., their *vulnerable body pathway(s)*, allowing them to be characterized either as laryngoresponders or non-laryngoresponders. Additionally, participants completed self-report measures of personality and past traumatic experiences, and provided repeated samples of brief speech recordings for acoustic analysis. Descriptive statistics are reported for all data obtained. Pearson's Product-Moment Correlation tests were performed to determine if acoustic measure change scores were related to scores obtained from the trauma questionnaires, and independent samples t-tests were performed on acoustic measure change scores for self-reported laryngoresponders versus non-laryngoresponders.

***Results*:** No significant relationships were found between acoustic measure change scores and self-reported laryngoresponders, or between acoustic measure change scores and past experiences of trauma. However, laryngoresponders exhibited worse scores in 70.58% of all trauma measures. Unexpectedly low representation of traumatic experiences and laryngoresponders in the present cohort limited statistical power in this study, yet exploratory analyses were fruitful in identifying meaningful trends in the data to pursue in future studies.

***Conclusions*:** The present study serves as a novel and innovative exploration of the relationship between past traumatic experiences and current vocal quality and voice-related somatic complaints. Although acoustic measures of dysphonia may lack sensitivity for identifying past trauma, preliminary findings do support a relationship between voice and trauma, specifically, with regards to the larynx as an underlying "vulnerable body pathway" in which stress can distinctly manifest.

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PREFACE

This document represents the culmination of the past four years of study, and my very first steps into the field of speech-language pathology. It has been humbling and challenging, yet more rewarding and exciting than I could have expected at the outset. Of course, none of this work would have been possible without an abundance of guidance, patience, and encouragement from Dr. Leah Helou. Dr. Helou, I am beyond grateful that you agreed to tackle this project with me, especially as you begin your own new adventures at the University of Pittsburgh. Thank you.

Many thanks to committee members Dr. James Coyle and Dr. Susan Shaiman; collaborators and supporters Dr. Elisa Monti and Dr. Harmony Sullivan; co-data collectors Ms. Kaavya Poola and Ms. Anna Tomiczek; laboratory space-sharers Dr. Will Evans and the Language Rehabilitation and Cognition Laboratory; and all members of the Helou Laboratory for Vocal Systems Anatomy and Physiology Research.

1.0 INTRODUCTION

"The sounds we make, the language we use and the music in our voices reveal much about who we are – the different aspects of our personality, our feeling states, our emotional and psychological blocks and our comfort or discomfort in our bodies." (Austin, 1999).

The human voice is thought by many to act as the "window to personality" (Roy et al., 1997). It can give clues about one's physical condition (Stemple, Roy, & Klaben, 2014), and it reflects both a speaker's current emotional state (Giddens, Barron, Byrd-Craven, Clark, & Winter, 2013; van Lierde, van Heule, De Ley, Mertens, & Claeys, 2009) and their past experiences (Monti, Kidd, Carroll, & Castano, 2017). Additionally, each of us carries a personal history which presumably affects our long-term behavior and interpersonal relationships (D'Andrea, Ford, Stolbach, Spinazzola, & van der Kolk, 2012), our reactions to our environment, many aspects of our personality, and our view of the world (D'andrea & Pole, 2012; van der Kolk, 2014).

For many people, that personal history includes the experience of traumatic events. Especially in the case of early and/or frequent exposure to trauma, these experiences can have a lasting effect on psychological, physical, and neurobiological development (Burke, Finn, McGuire, & Roche, 2017; D'Andrea et al., 2012; Glaser, 2000). Although formal experimental evidence is lacking, both logic and anecdotal evidence lead to the proposal that trauma might also impact vocal function and/or quality. Indeed, this supposition is the foundation for entire research

careers (D'Andrea et al., 2012; Monti & Van Lancker Sidtis, 2018). The intent of this study is to investigate whether there is any relationship between the performance of simple speech tasks and self-reported history of traumatic experiences.

2.0 BACKGROUND

2.1 THE VOICE, ACUTE STRESS, AND STRONG NEGATIVE EMOTIONS

Even if the semantic content of speech is ignored, the acoustic properties of the voice will still convey a wealth of information to a listener (Bachorowski, 1999; Hunt & Tip Kan, 1967). Whereas speech delivers the technical content of a message, voice conveys the more nuanced emotional expression and intention of the speaker (Bachorowski, 1999; Kramer, 1963). Among other vocal mannerisms, vocal emotional cues are conveyed through combinations of pitch, inflection, and intensity characteristics (Allport & Cantril, 1934; Bachorowski, 1999). An observed change in these qualities can reveal the state of a speaker due to stress or a change in emotion. Though the concepts of *stress* and *emotion* are separate entities, for the purpose of this paper, they will be discussed and explored in tandem because they often co-occur (e.g., times of elevated stress are often associated with negative emotion).

A physical or emotional stressor changes a person's internal state of homeostasis (Giddens et al., 2013), and as a result, the body will react to, or compensate for, its present situation. Dietrich and Verdolini Abbott (2007, p 172) propose that "stress should alter muscular, glandular, and vascular functions in the larynx with possible interactive effects on laryngeal function and laryngeal structure." This proposal was bolstered by a few key studies, each eliciting a laryngeal muscular response putatively via activation of the autonomic nervous system. In the first, the stressor of a public-speaking task was used to study the extralaryngeal muscle activity of vocally healthy female participants. In response to this stressor, and in triggering the so-called fight-or-

flight response, increased muscle activity was observed in the infrahyoid and the submental complex via surface electromyography (Dietrich, 2008; Dietrich & Verdolini Abbott, 2012).

In the second of these studies, a cohort of vocally healthy female participants demonstrated increased activation of several intrinsic laryngeal muscles during a physical sympathetic nervous system agonist, the cold pressor task (L. B Helou, Wang, Ashmore, Rosen, & Abbott, 2013). These investigators replicated and expanded on their findings in a follow-up study that involved a social stressor (L. B. Helou, Rosen, Wang, & Verdolini Abbott, 2018). Not only did they again observe increased intrinsic laryngeal muscle activity in the face of stress, but they also showed that the magnitude of that laryngeal stress response could be predicted by both personality traits and autonomic characteristics of the participant. These studies provide some basis for understanding the mechanisms by which stress can manifest in the voice.

Due to the fact that individuals have unique experiences, emotional triggers, and coping mechanisms, considerable variability exists in the way that the body and voice reacts to heightened stress and emotion (Kreiman & Sidtis, 2011). Research concerning acoustic changes during periods of stress have often looked at fundamental frequency (F_0) and intensity, and have shown that conflicting emotions can share vocal hallmarks. Vocal intensity, for example, has been observed to increase when a speaker is expressing anger as well as joy (Kreiman & Sidtis, 2011). Conversely, a more subdued, lower energy emotion like sadness has been associated with a decrease in F_0 and vocal intensity (Kreiman & Sidtis, 2011; Scherer & Banse, 2003). An increase in F_0 is often associated with fear and anger, but also with joy. In a study employing a physically threatening task, Wittels et al., found an significant increase in the F_0 of the male voice during the task (Wittels, Johannes, Enne, Kirsch, & Gunga, 2002), which they attributed to an increase in muscle tension. Conversely, using the stressor of public speaking tasks, a correlation between

stress and a decrease in F_0 and vocal intensity was observed in the female voice (Dietrich & Verdolini Abbott, 2012).

While it is difficult to parse and predict individual acoustic features under stress or in specific emotional states, listeners are surprisingly accurate in their perception of a speaker's emotional state using only vocal cues (Bachorowski, 1999; Scherer, 2003). In a study using both male and female actors, portrayal of simulated emotions were decoded by a listener with accuracy between 40 - 72% of the time, depending on each individual emotion, and when faced with judging a weak or strong intensity of that same emotion, the more intensely portrayed emotion was correctly identified as such (Juslin & Laukka, 2001). This was found to be true particularly during portrayals of anger and fear (Juslin & Laukka, 2001).

One challenge in researching voice, stress, and emotional state is that vocal responses are highly dependent on the type and context of a stressor. Not only that, but each individual is capable of displaying a wide range within, and variation between, the emotional and stress responses. Without more clear-cut definitions of these feelings, and without a common perception or experience for each human, these limitations in research will persist (Kreiman & Sidtis, 2011). Unfortunately, another inherent difficulty in studying stress and strong negative emotions exists. Specifically, manufactured stressors (as are used in research) are not the same as naturally occurring stressors (as in real life). However, efforts to create or study real-life conditions involving highly potent stressors might tax the ethical boundaries of research, and will likely be hampered by resource limitations.

Since there exist many limitations to studying realistic or natural trauma in the present, it is the intent of this study to simply explore what cues remain in our voice as a result of our previous experiences. Despite differences between individuals' response, it is nevertheless understood that

there are recognizable acoustics that convey our current emotional state well enough to be interpreted by a listener. Is it possible, then, that there exist similar hallmarks related to our previous extreme or recurrent emotional experiences?

2.2 THE VOICE AND PERSONALITY

Related to (but distinctly different from) emotional state and stress responses is the topic of personality traits. It is broadly accepted that voices encode aspects of a speaker's personality traits.

As early as 1934, formal studies have shown that conclusions can be drawn about a speaker's age, physical characteristics, and their deep-seated traits or disposition (Allport & Cantril, 1934). Vocal intensity and pitch have been presented as indicators of "vocal dominance" (Tusing & Dillard, 2000), slowed speech rate as an indicator of advanced age (Skoog Waller, Eriksson, & Sorqvist, 2015), pitch and resonance as an indicator of masculinity (Cartei, Bond, & Reby, 2014), and perceived vocal femininity as an indicator of the warmth and competence of a speaker (Jin Ko, Judd, & Stapel, 2009).

Interestingly, Allport and Cantril found that even when listeners agree about the features of a speaker, they are not always completely accurate. The idea that many listeners decode the same, if inaccurate, conclusions about a speaker reinforces the idea of *vocal stereotyping*, or the association of certain acoustic characteristics with assumed impressions about the speaker (Allport & Cantril, 1934). This finding was recently reinforced by Helou et al. in a prospective study of personality traits in voice and speech, wherein listeners' judgment of personality traits was

compared to the speakers' self-reported personality traits on a validated personality questionnaire (L. B. Helou, Poola, & van Mersbergen, 2018). While findings conflict on exactly *which* acoustic factors contribute to our judgments, something in the vocal signal clearly shapes listeners' impressions on a regular basis (Allport & Cantril, 1934; Aronson & Bless, 2009; L. B. Helou et al., 2018).

Of more clinical relevance for the field of speech-language pathology, it has also been shown that personality traits are associated with normal and disordered vocal function. First introduced by Roy and Bless, the widely accepted *Trait Theory of Voice Disorders* has repeatedly demonstrated the idea that there are a number of so-called "superfactor" personality traits which predispose a person to specific voice disorders or long-term functional patterns (Roy, Bless, & Heisey, 2000a). Functional Dysphonia, or Muscle Tension Dysphonia (MTD), and vocal nodules are among the voice disorders most frequently explored by this theory, and they are commonly observed in relation to the traits of extroversion, neuroticism, and constraint (Roy & Bless, 2000; Roy et al., 2000a).

Introverts (or, those who score low on a scale of extraversion) who exhibit a high level of neuroticism are considered at particularly high risk for developing MTD (A. House & Andrews, 1987; Roy et al., 2000a; Roy et al., 1997). The broadly accepted logic is that an introvert will show heightened sensitivity to punishment and threats, and the accompanying feature of neuroticism will increase their inclination to practice avoidance tendencies (Dietrich & Verdolini Abbott, 2012), show inhibitory behavior, or react strongly to their situation (Roy, Bless, & Heisey, 2000b). It is predicted that these personality traits will cause this individual to experience increased levels of anxiety and tension (Roy et al., 2000b).

Specific to the voice, introversion (with or without any significant degree of neuroticism) has been associated with a higher degree of extralaryngeal muscle activity (as measure by surface electromyography on the infrahyoid and submental complex) at rest as well as during exposure to an experimental stressor (Dietrich & Verdolini Abbott, 2012, 2014; van Mersbergen, Lyons, & Riegler, 2017). In one such study, the observation of a unique pattern of muscle activation (greater in the infrahyoid than submental) was found to contrast with what was observed in extroverts (Dietrich & Verdolini Abbott, 2012). Importantly, introverts are also said to score more poorly on voice-related quality of life measures (Dietrich & Verdolini Abbott, 2012), and to perceive an increased vocal effort during stress, showing an alignment between their kinesthetic awareness and their vocal performance (Dietrich & Verdolini Abbott, 2007). On the other end of the spectrum, an extravert is motivated by reward and engages in more goal-direct behavior (Dietrich & Verdolini Abbott, 2012). When coupled with a high degree of neuroticism, this person may act more impulsively and demonstrate an excessive degree of voice use, putting them at risk for vocal fold nodules (Roy et al., 2000b).

It has been observed that the personality superfactor of "constraint" may result in an individual voluntarily suppressing their vocal response to stress (Scherer, 1986). Defined as "the degree to which an individual expresses or acts upon their temperamental traits," (van Mersbergen, Patrick, & Glaze, 2008, p. 1406), constraint results in a regulation, or concealment, of the emotional response (Scherer, 1986). This kind of behavioral inhibition might be demonstrated by the holding in of one's breath or increased laryngeal tension, for example (Roy & Bless, 2000; van Mersbergen et al., 2008). Furthermore, some investigators propose that a disconnect between one's volitional behavior and their involuntary physiological reactions might lead to contradictory or

paradoxical responses during stress; namely, an unchanged or reduced F_0 or intensity in speech under stressful conditions (Scherer, 1986; van Mersbergen et al., 2008).

If the way a person interprets and copes with a stressful experience is a function of their personality, then these factors, in conjunction with environmental and situational variables, will ultimately lead to physiological reactions that will affect the voice (Dietrich & Verdolini Abbott, 2007). Taken together, these findings reinforce the idea that expressions of personality in the voice, and use of the voice, are a reflection of past experience. Since personality is a dynamic and changing thing, and that "as we grow and become ourselves, our voices reflect the changes we undergo" (Austin, 2009), it might be useful not only to explore how personality relates to voice, but also to ask what experiences have shaped that person along the way.

2.3 THE VOICE AND TRAUMA

It is estimated that 1 in 4 adults experienced physical abuse during childhood, and that 1 in 5 girls experience sexual victimization, globally ("Child maltreatment," 2017; D'Andrea et al., 2012; D'andrea & Pole, 2012; Felitti et al., 1998). The World Health Organization classifies the various forms of child maltreatment in 4 distinct categories: physical abuse, sexual abuse, emotional or psychological abuse, and neglect ("Child maltreatment," 2017). The common emotional effects of each of these experiences include confusion, terror, helplessness, and the loss of one's sense of self (Austin, 2009). Trauma survivors often experience feelings of overwhelm, emotional numbing and strain, and difficulty in developing interpersonal relationships (ibid).

Survivors may also learn to practice avoidance of certain situations or people, and they frequently engage in denial (ibid).

Physiologically, the post-trauma body reacts very differently as compared to prior to the trauma – as though life is experienced "with a different nervous system" (van der Kolk, 2014). As described by Teicher and Samson, childhood trauma not only influences brain development and functioning, but the impact is related to the severity of the traumatic experience(s), age at the time of the event, gender, and the type of trauma experience (Teicher & Samson, 2016). Additionally, a graded relationship has been found between the amount of exposure to trauma experienced in childhood and the likelihood of risky behaviors (ie. drug use, alcoholism, a higher number of sexual partners), health conditions (ie. cancer, chronic lung and liver disease), and early death in adulthood (Burke et al., 2017; Felitti et al., 1998; Glaser, 2000).

Psychotherapist Diane Austin, whose life work focuses on voice and trauma, reflects that many of her clients experience a change to their voice and verbal expression that occurs very gradually, perhaps even without perception by the client. One example is that of the person living in an unsafe or unhospitable environment who loses a connection to their authentic voice and expression. "Sometimes this silence takes the form of withdrawing into a private world and choosing not to communicate because it is not safe to do so (Austin, 2009, p. 24)," as might be the case of a child who has learned that they will be punished for crying or speaking out. Or perhaps that child has learned that their communication partners (ie. care-givers, adult) will remain unresponsive to their request; "Sometimes the silence is loud; words and feelings come tumbling out but fall on deaf ears or are beaten down and stifled. Needs and feelings remain unmet and the voice becomes inaudible, tight and tense, breathy and undefined, or simply untrue; perhaps lovely to listen to but not connected to the core of the person. In essence, a wounded person often survives

by forfeiting his or her own voice" (Austin, 2009, p. 24). Austin proposes that if one is continually taught that their feelings and needs are unimportant or easily ignored, instead of risking painful and continued rejection, they will learn to ignore or refrain from expressing their feelings and needs.

For some individuals, the benefit of self-preservation far outweighs the high cost of this behavior (e.g. the impact on the laryngeal structure and function, or repression of emotion). Understanding whether or not a patient possesses an awareness about their communication style is highly important to some clinical voice therapists. In her clinical work in voice pathology, Gartner-Schmidt discusses the value of asking patients to identify whether they typically "hold in" their feelings and emotions, or whether they freely "let them out" (Gartner-Schmidt, 2018). While this communication pattern may simply be expected based on their personality (e.g. an introvert might be more likely to hold in their thoughts), Dr. Gartner-Schmidt has learned that this self-awareness, or lack thereof, has significant clinical relevance to the patient's prognosis and to the goals of voice therapy (ibid).

The breath, and connection to the breath, has drawn considerable attention from clinicians, as well. Not only does our goal of emotionally protecting ourselves restrict the freeness/naturalness of our breath, but "as long as breath is not free the voice will depend on compensating strength in the throat and mouth muscles" (Linklater, 1976, p. 23). Furthermore, compromised respiratory function will impact vocal function and acoustics. From a psychological standpoint, holding in the breath will also increase the feelings of anxiety and/or emotional numbing, creating a cycle that can be quite difficult to unravel (Austin, 2009).

A reciprocal relationship can be seen between feelings of stress, anxiety, depression and the voice, making it more difficult to discern which condition (psychosocial or vocal) was

precipitated by the other. It has been observed, however, that voice disorders negatively impact quality of life ratings (Smith et al., 1994), and that psychosocial distress is significant among this population, in some cases even for those patients without any psychological diagnosis (Misono et al., 2014). Misono, et al. observed that the magnitude of distress associated with the presence of voice disorders is comparable to the experience of major medical conditions and traumatic life events, highlighting the impact of a voice disorder on quality of life and mental health (Misono et al., 2014).

In fact, the loss of the voice can often feel like the loss of one's identity. This can be clearly illustrated in the case of the professional voice user, for whom a voice disorder will directly threaten their identity and self-image. The psychological impact of changes to the voice can mimic that of the loss of a loved one, and can similarly involve a grieving process. In the text "Psychology of Voice," patients in highlighted cases reflect on their voice as "the intimate and personal part of myself," (D. C. Rosen & Sataloff, 1997, p. 213) and "my best accomplishment," (D. C. Rosen & Sataloff, 1997, p. 213). Another patient describes acutely believing that "if my voice is gone, I am gone," (D. C. Rosen & Sataloff, 1997, p. 210).

When considering how widespread and impactful trauma can be to the body *and* the person, it might actually seem surprising that that the number of patients with voice complaints is not higher. An outstanding need in the literature is to explore what variables impact whether and how the experience of past trauma manifests vocally.

2.4 THE STRESS RESPONSE AND BODY REGION SPECIFICITY

As previously described, clinical and research evidence supports the idea that vocal signals are reflective of state and trait characteristics. Not only are stress responses, emotional state, and personality traits reflected in the voice, but in some individuals, these responses are thought to render a voice pathological. Dietrich and Verdolini Abbott note within their *Psychological Framework of Stress and Voice* that while stress will "invoke an intertwined psychological, emotional, cognitive, physiological, immunological and behavioral cascade of events that may affect the larynx," (Dietrich & Verdolini Abbott, 2007, p. 160), this situation is not unique to the context of voice disorders.

Some individuals experience gastric pain during times of stress; others develop migraine headaches; others have flares of fibromyalgia; and so on. This "mind-body link" undergirds much of the clinical and theoretical frameworks used to understand so-called "functional disorders" and "medically unexplained symptom complexes." For example, much literature supports the idea that depression, anxiety, and early adverse life events will impact an individual's susceptibility to functional gastrointestinal disorders such as irritable bowel syndrome (IBS) (Chang, 2004; Mussell et al., 2008). To date, though, little is known about how, why, and to what extent one bodily system is vulnerable to stress compared to another system, for any given individual.

One historical school of thought is that the disorder will manifest in a manner that has a symbolic significance or a functional purpose. One case that illustrates this, presented by Baker (2003), is that of a young female student who believed she had developed laryngitis and "loss of voice" for several weeks. Upon further examination, no structural abnormalities existed, and the patient demonstrated normal phonation and vocal fold movement during non-speech tasks (e.g.,

cough). While open to the idea that there might be a psychogenic component to her vocal trouble, it wasn't until a follow up appointment when she considered whether the precipitating event could have happened several months prior to the voice loss. She then reported that, during a sexual assault several months prior, she tried repeatedly to cry out for help but to no effect. After the traumatic incident, this young woman decided not to confront this man or speak out about this incident in order reduce any further consequences. The patient then recalled that her current bouts of dysphonia were precipitated by seeing her attacker once again (Baker, 2003). This is an example of a putatively symbolic manifestation of trauma as voice difficulty.

An alternative school of thought is that this discomfort manifests at a "site of least resistance." If a patient's overall stress load becomes unbearable, physical expression of this conflict may appear where the body is already vulnerable or "weakened" by an unrelated factor. The onset of a patient's voice disorder is commonly related to an upper respiratory tract infection or a cold, but that cold did not likely *cause* the voice disorder. Instead, it is proposed that that system was weakened by an unrelated illness at the time when the patient became overwhelmed by the stress of another origin (Butcher, Elias, & Cavalli, 2007). This left the laryngeal mechanism more vulnerable to reacting to the stress. This school of thought will be referred to as the "vulnerable pathways" hypothesis.

The concept of vulnerable pathways exists in the voice literature. The term *laryngoresponder* is used to explain a person who is predisposed, by either physical make up or personality to express emotional distress through either function or sensation of the larynx or voice (Aronson & Bless, 2009). A recent study observed that "some vocally healthy female adults might very well be classified as "laryngoresponders" in the face of a stressor, whereas others are not similarly vulnerable" (L. B. Helou et al., 2018, p. 18). Helou et al. observed that a small subset of

participants seemed distinctly like “laryngoresponder” as evidenced by massively increased (~25-fold) intrinsic laryngeal muscle activity in response to stressful conditions, though the findings were not elicited through voice or speech tasks, specifically.

A major component of identifying a laryngoresponder rests on that individual’s awareness of their laryngeal sensation. While assessing the self-reported, subjective experiences of patients, it was found that females show a higher rate of body awareness than males for reasons that have not yet been determined. Perhaps the higher degree of body awareness amongst females is a causal factor in their relatively higher incidence (compared to males) of certain functional disorders; ie. gastro-intestinal and vocal (Cabrera et al., 2018). Since functional disorders, by definition, lack a structural explanation (Aronson & Bless, 2009), diagnosis is therefore one of exclusion. Gaining a greater understanding of these disorders, then, is meant to serve patients and clinicians alike.

Specific to ‘laryngoresponder,” it is reasonable to expect that as an increased, or bothersome, sensation that occurs in response to stress becomes habitual - it will impact our vocal expression and health. It is also reasonable to look for any commonalities between those who exhibit this response, and identify any connections between this vulnerability and whether it does or does not correlate to our personality and/or our past experiences.

If personality traits can predispose an individual to certain patterns of vocal use, and if past experiences can influence our personality as well as the ways in which we experience and react to the world, how much do our experiences affect the way we use and experience our voices? What similarities exist between “laryngoresponder” that differentiate them from individuals who do not experiene the larynx as a vulnerable system? The present study seeks to generate preliminary data toward answering these questions, or at least focus the line of inquiry, in a cohort of vocally healthy women.

3.0 RESEARCH QUESTIONS

The purpose of this study was to determine whether and how an individual's past experience of trauma is related to their current vocal characteristics, using participants' self-report experiences of traumatic events, acoustic analysis of speech samples, and self-report of voice-related physical sensations.

Research Questions (RQ) and Hypotheses are as follows:

RQ1: Do short-term acoustic changes relate to the completion of trauma questionnaires, as a function of the degree/amount of self-reported traumatic experiences?

It is hypothesized that positive correlation will exist between the degree of acoustic changes observed during recorded spoken text and the amount of trauma experienced.

RQ2: Do "neck responders", or the participants who report neck, throat, or voice concerns share common acoustic features?

It is hypothesized that those participants who report their voice and/or neck as a recurring source of concern, i.e. "laryngoresponders", will exhibit a descriptively unique profile of vocal acoustics and vocal function in comparison to non-laryngoresponders.

4.0 EXPERIMENTAL METHOD AND PROCEDURES

4.1 EXPERIMENTAL DESIGN

Research Question 1 involves a within-subjects experimental design, where change in the acoustic measures (dependent variables) was examined as a function of scores derived from self-report questionnaires about past experiences of trauma (independent variable). Research Question 2 involved a between-subjects descriptive design, where change in the acoustic measures (dependent variables) were intended to be compared across "laryngoresponders" and "non-laryngoresponders" (independent variable). This independent variable was generated via a binary yes/no classification of whether a participant is a "laryngoresponder" based on a questionnaire purpose-designed for this study. Dependent variables were derived from acoustic signals present in recorded speech samples and include the following: (1) mean fundamental frequency and measures of its variation, (2) mean vocal intensity and measures of its variation, (3) cepstral peak prominence and measures of its variation, and (4) low/high spectral ratio and measures of its variation.

4.2 PARTICIPANTS

Data from 29 healthy cisgender females between the ages of 18-65 years were included in this study. Enrollment was limited to females because known differences exist between males and females concerning their response to, and their handling of stress (Andrea, Dias, Andrea, &

Figueira, 2017; Dietrich & Verdolini Abbott, 2012). Similarly, gender differences exist in regards to functional voice disorders (Andrea et al., 2017; Baker, 2016; Martins et al., 2016) whether that be due to their laryngeal anatomy, the effects of hormones (Andrea et al., 2017), or a host of any other physiological and cultural interactions (Cabrera et al., 2018). This study required that participants were able to read written words aloud and to use the computer sufficiently enough to provide personal data and complete survey tasks.

Recruitment for this study included IRB-approved public advertisements. These advertisements were printed on posters and distributed around the Oakland neighborhood, the University of Pittsburgh campus, and Craigslist. Recruitment materials directed all interested parties to a secure website (Qualtrics) for initial screening. The Initial Screening Form was written to ensure that all inclusion and exclusion criteria are met by potential participants.

The following conditions were determined to be reason for exclusion from participating in this project: difficulty hearing or understanding conversational speech without aids; pregnancy; current lower or upper respiratory illness or seasonal allergies with respiratory manifestation; history of: voice disorders; difficulty breathing or known respiratory disorders (e.g., obstructive lung diseases such as asthma or chronic obstructive pulmonary disease, restrictive lung disease); autonomic dysfunction or dysautonomia (e.g., postural orthostatic tachycardia syndrome, inappropriate sinus tachycardia, vasovagal syncope, neurocardiogenic syncope, orthostatic hypertension or hypotension); asthma.

Participants were asked to report their height and weight, and those with body mass index above 30 (i.e., obese individuals) were also excluded from participation because (1) obesity may impact respiration and the measurement of respiration using our methods, and (2) excessive fatty

tissue may make it difficult to identify landmarks for EMG electrode placement, and is also likely to minimize the strength of biopotential signals that are captured.

Finally, participants completed the Voice Handicap Index (VHI-10) (C. A. Rosen, Lee, Osborne, Zullo, & Murry, 2004), and those with a score greater than 11, which is a known threshold for suspected pathology, were considered ineligible to participate in this study (Arffa, Krishna, Gartner-Schmidt, & Rosen, 2012).

4.3 PROCEDURES

It is important to note that the methods of this thesis proposal were couched within the structure of a larger research study. Thus, participants underwent some tasks that were not directly relevant to the current proposal. A visual outline of all tasks and their relevance to this study is found in Figure 1. Items in green in Figure 1 are those that were performed as part of the larger study but not for the purposes of this thesis. They are included here to provide a complete picture of each subject's experience during their participation in this study.

Initial Screening: After completion of the Initial Screening Form, those individuals who were deemed eligible were given an appointment for research participation.

Experimental Day: Appointments were held in the University of Pittsburgh's School of Health and Rehabilitation Science in Forbes Tower. Once the participant fully understood the expectations for the study, Phase I consent form was offered and executed.

Data Management: All participants were assigned a unique code which was used for labeling all research data and responses. To protect their privacy and comfort, collection of sensitive

information did not exceed the limits of what is absolutely necessary in pursuing the research questions of the present study.

Web-based surveys (screening and questionnaires) were password protected and administered via Qualtrics. Identifiable data was accessed by using computers at the University of Pittsburgh which are protected by a firewall. Any documents containing personal information are stored and locked in Dr. Leah Helou's laboratory within Forbes Tower.

Set-up: Experimental procedures were carried out in a dedicated research laboratory with low ambient noise. To avoid interference with surface EMG signals collected in the broader research protocol, participants were asked to attend with a face free of makeup.

For physiologic data collection (part of the broader research protocol), participants were seated upright and fitted with the following equipment [see Equipment for details]: (1) four sets of surface electromyography (EMG) electrodes positioned on the infrahyoid muscles, trapezius, anterior tibialis, and the submental complex; (2) five electrocardiogram electrodes; (3) two piezoelectric respiratory bands positioned around the upper and lower thoracic cavity; (4) pulse plethysmograph positioned on the nondominant index finger.

For acoustic data collection (directly relevant to the present study), participants were fitted with a Countryman headset microphone connected to a Tascam recorder [see Equipment]. The headset microphone was measured to rest at an angle between 45° and 90° from the lips, at a fixed mouth-to-mic distance of 5 cm, consistent with current recommendations (Awan, Giovinco, & Owens, 2012; Patel et al., 2018). Microphone sensitivity and input level were set the same between each participant, and remained the same within each participant's four speech sample in order to facilitate comparison within and between subjects, specifically with respect to sound intensity measurement (Patel et al., 2018). Noise levels in the room were recorded and checked using

PRAAT, confirming that this value was under the recommended 50 dB SLP (Romak, Heuer, Hawkshaw, & Sataloff, 2017).

At this stage in the study, the participants were fitted with equipment spanning 5 of the 6 "zones" of the body as illustrated in the Experimental Day Setup, with 1 zone (the leg zone) not being placed with any experimental equipment. To avoid the possibility that participants would attend to and report more sensation in any given zone as a function of having equipment fitted to it, the remaining zone was fitted with "sham equipment" in the form of a single electrode situated beneath a Velcro band at the mid-point of the right tibialis anterior. Thus, all body zones of interest had some real or alleged recording equipment attached. A comparison of Experimental Day Setup and the Physical Report Form shows how the body zones of the figurine used to collect descriptive data via the Physical Report Form corresponded with equipment placement in this experimental setup.

Equipment placement and calibration (via maximum voluntary contraction tasks) were performed and verified according to procedures described for the larger study. Because some elements of the larger study are not relevant to the thesis, a second investigator (e.g., Dr. Helou or a research assistant) was always on hand to help with attending to those additional features. At each stage of the study, signal quality of all physiologic and audio recording measures were verified by the researcher(s). After equipment had been tested and accurate placement had been confirmed, participants were given a period of 2 minutes to relax and regain accurate baseline measures.

Procedures:

Data Acquisition: After the set-up phase was complete, data acquisition and recording were initiated and remained ongoing until the conclusion of the study. This, and all subsequent stages of the experiment, are depicted in the Experimental Procedures flowchart (Figure 1).

Speech Sample: Participants were asked to read the six sentences of the *Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V)* (Kempster, Gerratt, Verdolini Abbott, Barkmeier-Kraemer, & Hillman, 2009), and then provide a spontaneous speech sample based on one of the cartoon prompts shown in the Speech Sample Stimuli. The first of these speech samples was recorded immediately after administration of the consent form, and just prior to setup of physiologic data equipment. This was established in order to capture one baseline speech sample prior to any potential interference of the equipment. The full speech sample took up to 3-4 minutes to obtain, including instructional time.

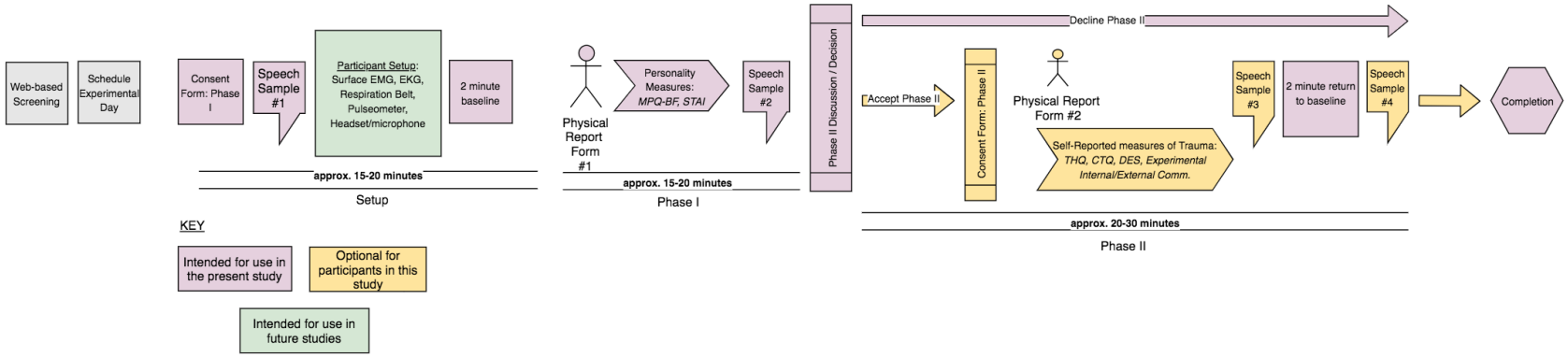


Figure 1: Experimental Procedures

Physical Report Form: Participants then completed the Physical Report Form. Consisting of a simply drawn human figure, participants were asked to identify specific vulnerable systems, or physical areas where they experienced a habitual response to stress or heightened emotion. Please see the Physical Report Form for the entirety of the administration script.

Participants were briefly shown examples of other completed Physical Report Forms, and they were encouraged to make individual and creative use of their own document. In addition to the verbal instruction provided by researchers, these examples were intended to demonstrate that participants were welcome to draw, highlight, or write any concerns on this form. Participants were given freedom with the amount of time that they would like to spend on this task, but most took approximately 3 minutes to complete the form.

Trait measures: Participants completed a computer-based administration of the *Multidimensional Personality Questionnaire – Brief Form (MPQ-BF).* The *MPQ-BF* is a 155-item questionnaire which evaluates participants on 14 different variables, three of which are superfactors (Positive Emotionality, Negative Emotionality, and Constraint) and 11 of which are subscales of personality (e.g., Stress Reactivity, Social Warmth) (Patrick, Curtin, & Tellegen, 2002).

Participants also completed the 20 question portion of the *State and Trait Anxiety Inventory (STAI)* (Spielberger, Lushene, & Jacobs, 1983; Spielberger & Reheiser, 2009) regarding one's trait characteristics. Trait anxiety, as measured by the *STAI,* refers to the anxiety which manifests itself over time, rather than situationally. Participants rate *certain feelings* (e.g. "I feel pleasant" or "I feel that difficulties are piling up so that I cannot overcome them") on a 4-point scale, from "Almost Never" to "Almost Always". A greater score on the anxiety scales indicates a greater

degree of this trait anxiety. Research has shown this measure to be valid and reliable in both research and clinical settings (Barnes, Harp, & Jung, 2002).

Total administration time for the *MPQ-BF* and *STAI* was approximately 15-20 minutes, though it varied by participant. These tools were used to provide information about each participant's self-reported personality traits.

Speech Sample: A second speech sample was then recorded following our previously described procedures. On average, the data-collection portion of Phase I took approximately 20-30 minutes to obtain.

Phase II Discussion/Decision: At this point in the study, all participants were presented with the option of completing additional questionnaires specifically aimed at their childhood experiences and any previous traumatic history. It was anticipated that this step, referred to as Phase II in Figure 1, might trigger an emotional response from the participant. In an attempt to gather baseline data without the participant (a) feeling anticipatory anxiety or worry about upcoming tasks or (b) mentally preparing and thus become desensitized to the subject matter, study recruitment and initial consent were specifically designed to minimize these possibilities. As such, participants were provided with the option of proceeding to Phase II of the study only at this point and not earlier in the experimental session. This discussion included the information found in the Phase II Consent Form Script.

Once participants understood the additional tasks and associated risks of Phase II, if they chose to continue, a Phase II Consent Form was then offered and executed. If any participant had declined to continue, they would have been thanked for their time and the experiment would have ended according to the procedures described in the Phase I Completion Script.

Phase II:

Physical Report Form: Every Phase II participant was asked to revise the Physical Report Form to indicate whether they were experiencing any new (or newly appreciated) sensations during the remainder the session. The expectation was that the Physical Report Form was amended and updated as needed throughout the duration of the Phase II questionnaires (Figure 1). This was designed to provide an opportunity to add any newly remembered physical problems, those concerns that they may not have felt comfortable sharing earlier, or regions of discomfort that might have been acutely triggered during their session.

Self-Reported measures of Trauma: Participants in Phase II completed the following tasks (Figure 1): web-based administration of the *Childhood Trauma Questionnaire – Short Form (CTQ)* (D. P. Bernstein et al., 2003), the *Trauma History Questionnaire (THQ)* (Hooper, Stockton, Krupnick, & Green, 2011), and the *Dissociative Experiences Scale (E. M. Bernstein & Putnam, 1986)* according to their respective protocol.

The *CTQ*-short form is a 28-item self-report questionnaire which measures experiences of abuse and neglect that may have occurred prior to the age of 18. It is a shortened version of the *Childhood Trauma Questionnaire* – originally 70 questions. Use of the short form version is supported as a quick screening tool which can be used with both clinical and non-referred populations (D. P. Bernstein et al., 2003). In addition to providing a "total" score of the amount of trauma exposure for a given participants, the *CTQ* provides subscales regarding emotional abuse and neglect, physical abuse and neglect, and sexual abuse. In addition to these subscales, the *CTQ* includes a minimization-denial subscale which assesses the individual's propensity for denying their traumatic experiences. Each of these were used in analyses for the current study.

The *THQ* is a 28-item self-report questionnaire which measures the amount of trauma an individual has experienced, including the time beyond the age of eighteen. This measure asks participants to provide details on the kinds of trauma they have experienced, as well as the number of times that these experiences occurred and their age(s) at the time. Questions range from asking about incidence of sexual or physical assault, natural disasters, injury, or violence (e.g. "Has anyone ever tried to take something form you by using force or thread of deadly force, such as a stick up or mugging?" or "Have you ever had a spouse, romantic partner, or child die (including abortion or miscarriage)?").

All descriptive information was gathered at the time of this test's administration, however, only the total number of traumatic experiences were included in further analyses. The *THQ* may be used to as a method of "reliably capturing lifetime exposure to diverse traumatic experiences among a range of populations" (Hooper et al., 2011). Because there are no norms or standardized scales for something as complex as trauma, this is not an available feature of this tool.

The Dissociative Experiences Scale (*DES)* is a 28-item self-report tool which measures various types of dissociation. Dissociation is a psychiatric construct related to how one separates from normal mental processes. The DES captures normal dissociative experiences such as daydreaming, as well as abnormal and potentially problematic experiences such as depersonalization (when one's thoughts or feelings seem detached from reality or from their own identity or experience). Participants are asked to rate how often they experience something similar to a hypothetical scenario (e.g. "Some people have the experience of driving a car and suddenly realizing they don't remember what has happened during all or part of the trip"). Higher scores on the *DES* indicate a higher degree of dissociation, or the degree to which an individual distances

themselves from their thoughts and experiences. The *DES* includes subscales regarding depersonalization (e.g. not recognizing oneself in the mirror), absorption (e.g. becoming overly involved in a memory or a movie), and amnestic dissociation (e.g. blocking out certain experiences or episodes (E. M. Bernstein & Putnam, 1986; Olsen, D. Clapp, R. Parra, & Beck, 2013).

Participants also answered a short series of original questions regarding their experiences and perspective on communication via questions about "Ideal" Internal and External Communication. These exploratory questions look at how a person would characterize their internal and external communication during difficult or traumatic time. For the purpose of these questions, *internal communication* encapsulates communication with oneself, and acknowledgement of feelings or emotions. *External communication* refers to ones' communication with others. The questions outline the ideal communication scenario surrounding a traumatic or difficult experience, and the participant notes the proportion of their experiences which have been similar to the given "ideal situation" on a continuous 100 mm undifferentiated visual analog scale. These questions were designed to help direct and develop questioning during subsequent iterations of this study. Administration time for these tools was between approximately 15 and 20 minutes.

Speech Sample: A third speech sample was then recorded according to our previously described procedures, followed by a repeat 2-minute relaxation period.

Final Speech Sample: Finally, a fourth speech sample was recorded following the previously established procedures.

Procedure Conclusion for All Participants: At the conclusion of this study, all equipment was removed from the participant's body. They were thanked for their time and given their previously

agreed upon compensation ($10 for two hours of participation plus an additional $10 per each subsequent hour) thus concluding the experiment.

4.4 EQUIPMENT

Physiologic data collection, including surface electromyography (EMG) electrodes, electrocardiogram electrodes, piezoelectric respiratory bands, and pulse plethysmograph, was performed using the Advanced Psychophysiology Teaching Kit and Isolated 8 Channel Biopotential iWire recording module (iWorx Systems, Inc., Dover, New Hampshire). Acoustic data was collected using Tascam 192kHz/24 bit-compatible studio-quality linear PMC recorder (TEAC America, Inc., Montebello, CA), and a Countryman E60W5T2SL Springy E6 Omnidirectional Earset with 2-mm Cable (Countryman Associates, Inc., Menlo Park, CA). A University of Pittsburgh issued desktop computer (Dell, 64-bit operating system, x62-based processor, running Windows 10 education) housed in the Language Rehabilitation and Cognition Lab (Forbes Tower) was used for all survey data acquisition. A designated, lab-issued laptop computer (Dell, Latitude 5590 BTX running Windows 10 Pro 64 bit) was used for physiologic data acquisition. This laptop was equipped with Labscribe 2 (iWorx Systems, Inc., Dover, New Hampshire) for physiologic data acquisition. Acoustic analyses were completed with the Analysis of Dysphonia in Speech and Voice (ADSV) program in the Computerized Speech Lab (CSL) (KayPENTAX, NJ). Praat (Praat Version 6.0.40, Amsterdam, The Netherlands) was used for editing of speech samples. Surveys and participant information was gathered via Qualtrics (Qualtrics, Seattle, WA). Trauma survey data reduction and scoring was performed using SAS

(SAS Institute Inc., North Carolina, USA). Linear Mixed Effects models were performed using Matlab (Mathworks version 2018b, Natick, MA, USA), and all other statistical analyses were performed using Statistical Package for the Social Sciences (SPSS, IBM Corp, Armonk NY) for Windows (version 25b).

5.0 ANALYSIS

5.1 ACOUSTIC ANALYSIS

Acoustic analyses were performed to determine the Dependent Variables for Research Question 1 and Research Question 2. This was completed within the Analysis of Dysphonia in Speech and Voice (ADSV) program in the Computerized Speech Lab (CSL) (KayPENTAX). The following selections were chosen from within each of the four speech samples provided by the participants: the steady-state portion of the sustained vowel /ɑ/, the third sentence of the CAPE-V sentences "We were away a year ago", and a spontaneous speech sample taken from the picture description task ("Cookie Theft" and "Cat Rescue"). During analysis, each speech sample was listened to in its entirety in order to determine the presence of any incidental background noise, consonant aspiration, and the accuracy of editing and data selection for analysis. In such instances, contaminated data were omitted from analysis. All data were collected in excel and password protected.

Analysis for the sustained vowel /ɑ/ was completed in the "Sustained Vowel" protocol within ADSV. A two second selection was chosen from the most steady, medial portion of each vowel (Patel et al., 2018). Once this selection has been highlighted, "apply automatic data selection" and "compute/display new ADSV results" were selected. Acoustic variables provided by ADSV, and those used in further analyses of the sustained vowel can be found in Table 1.

Table 1: Acoustic variables

***ADSV* Provided Variables for Connected Speech and Sustained Vowel**	**Variables used for further analyses**
Cepstral Peak Prominence (CPP) CPP Standard Deviation CPP Max CPP Minimum Low-to-High Spectral Ratio Low-to-High Spectral Ratio Standard Deviation Low-to-High Spectral Ratio Minimum Low-to-High Spectral Ratio Maximum CPP Fundamental Frequency (F_0) CPP FO Standard Deviation Cepstral Spectral Index of Dysphonia (CSID) CPP/Average CPP/Average Standard Deviation Regression slope Regression Slope Standard Deviation Cepstral Intensity Cepstral Intensity Standard Deviation	Cepstral Peak Prominence (CPP) CPP Standard Deviation Low-to-High Spectral Ratio Low-to-High Spectral Ratio Standard Deviation CPP Fundamental Frequency ($F_{0)}$ CPP FO Standard Deviation Cepstral Spectral Index of Dysphonia (CSID)

For analysis of a connected speech sample, the CAPE-V sentence “We were away a year ago” was completed in the “All Voiced Sentence” protocol within ADSV. After highlighting the space between voicing onset and offset, “apply automatic data selection” and “compute/display new ADSV results” were selected. Audio playback was used to ensure proper selection. Acoustic variables provided by ADSV, and those used in further analyses of the CAPE-V sentence “We were away a year ago” can be found in Table 1.

Analysis for the extemporaneous speech sample was completed in the “All Voiced Sentence” protocol within ADSV (Awan, 2018). These speech samples were recorded off of the prompt to

describe either the “Cookie Theft” or “Cat Rescue” pictures. Participants were asked to describe or otherwise speak about the pictures for 30 seconds. Recordings were edited to remove distracting sounds including, but not limited to, incidental outside noise (ie. prompt to continue speaking, a door slamming) or incidental participant noise (ie. a laugh or cough), pauses or moments of silence exceeding 0.05s, and heavily aspirated consonants. Acoustic variables provided by ADSV, and those used in further analyses of the extemporaneous speech samples can be found in Table 1.

As indicated by Table 1, the acoustic variables used to answer the research questions addressed in this paper include the following; CPP, CPP F_0, L/H Spectral Ratio, CSID and the standard deviation of each of these measures, for a total of 7 acoustic variables. Cepstral Peak Prominence (CPP) is an acoustic measure of dysphonia, or the degree of breathiness, hoarseness, or strain in a voice (Awan, Roy, Jette, Meltzner, & Hillman, 2010; Awan, Roy, & Jiang, 2010). In contrast to traditional practices of using jitter or shimmer to measure perturbations of amplitude or frequency in sustained vowels, CPP can be measured on connected speech samples (Awan, Roy, & Dromey, 2009; Heman-Ackah et al., 2003; Ludlow, Kent, & Gray, 2017). As such, use of CPP is currently part of the recommended protocol for measuring the “global relationship of periodic versus aperiodic energy in a signal” (Patel et al., 2018).

Low-to-High Spectral Ratio (L/H ratio) is another measure of dysphonia. Specifically, it is a measure of spectral tilt which calculates the ratio of low frequency (<4000 Hz) spectral energy vs. high frequency spectral energy (>4000 Hz) (Watts & Awan, 2011). In “normal” voices, the L/H ratio tends to be higher (greater energy in low frequencies) than in dysphonic voices, or voices with a more breathy quality (greater energy in high frequencies) (Hillenbrand & Houde, 1996).

CSID is an objective measure of dysphonia severity which includes aspects of spectral and cepstral analyses (Stemple et al., 2014). CSID which can be determined on either sustain vowel or continuous speech, and it has been found to correlate well with auditory-perceptual judgements of

dysphonia (Awan & Roy, 2005; Awan et al., 2009; Awan, Roy, Jette, et al., 2010; Peterson et al., 2013).

5.2 SELF-REPORT TRAUMA SURVEY ANALYSIS

Analysis of self-report questionnaires regarding past experiences of trauma was performed in order to determine the Independent Variables for Research Question 1. Scores and subscales were calculated for each participant as determined by the test instruction. These are reported and defined in Section 6.3. Necessary calculations were performed in SAS and SPSS.

Question 1 and Question 3 from the "Ideal" Internal and External questions were included in analyses. Participant feedback clearly stated that it was difficult for many to differentiate the intent of Question 1 and 2 (Internal) and Questions 3 and 4 (External), thus seemingly repetitive questions were excluded. Results are reported in Table 9.

5.3 PHYSICAL REPORT FORM ANALYSIS

Each Physical Report Form was analyzed to determine the Independent Variable for Research Question 2. The initial plan was to separate those participants with neck, throat, or voice concerns from those without neck, throat, or voice concerns, and then assign the classification of either "laryngoresponder" or "non-laryngoresponder". It became necessary to instead refer to this group as "neck responders". Neck responders were too many (n=26) for this approach to be useful for statistical analysis. Instead, participants were placed in either the "Front Neck Responder"

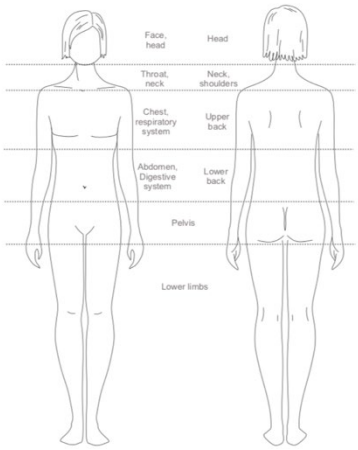
(*n*=12) or "Non-Front Neck Responder" group, and either the "Laryngoresponder" (*n*=6) or "Non-Laryngoresponder" group, according to which specific physical area or habitual system "of concern" was indicated by the participant.

The Physical Report Form itself was separated into 6 horizontal planes. In analysis, each of those planes was further separated by the *front* and *back,* when applicable (see Table 2). The section on the front of the form titled "throat, neck" was divided into either a "front of neck" or a "larynx/throat" response. This delineation was made according to the text description provided by the participant or the specificity of their drawing. If it was not immediately clear whether the participant was indicating the throat or the neck alone, participants were asked for clarification at the conclusion of the study. For every indicated area, the participant would receive a rating of "0" for non-responder, or "1" for responder.

As part of the administration script, participants received instruction midway through their participation (at the start of Phase II*)* to report whether—and if so, where—they were feeling an episodic discomfort or stress response. Participant inclusion of such experiences was minimal, and none of these responses reflected areas of import for this study. Furthermore, as research questions were more concerned with the body's habitual response to stress, rather than any episodic discomfort, analysis for the present study did not include these responses.

Table 2: Physical Report Form divisions

1 F	Face
1 B	Head
2 F1	Larynx/Throat
2 F2	Front of Neck
2 B1	Back of Neck
2 B2	Shoulders
3 F	Chest, Respiratory system
3 B	Upper Back
4 F	Abdomen, Digestive System
4 B	Lower Back
5	Pelvis
6	Lower Limbs



5.4 STATISTICAL ANALYSIS

Descriptive statistics were obtained for all variables measured. In addition, for **RQ1,** Pearson's correlation coefficient was performed to determine if acoustic measure change scores (average values of the dependent variables derived from Speech Samples #1-2 vs Speech Sample #3) were related to scores obtained from the trauma questionnaires. If assumptions were violated, Spearman's Correlation Coefficient was substituted. Bonferroni corrections for multiple tests were made as appropriate.

For **RQ2**, independent samples t-tests were performed on acoustic measure change scores (average values of the dependent variables derived from Speech Samples #1-3 vs Speech Sample

#4) for self-reported laryngoresponders versus non-laryngoresponders. If assumptions were violated, the Mann-Whitney test were substituted. Bonferroni corrections for multiple tests were made as appropriate.

6.0 RESULTS

6.1 PARTICIPANTS

Interested individuals responded to recruitment materials via email, and they were promptly sent a screening survey. Of the fifty-one individuals who completed the screening survey, eleven participants were deemed ineligible on one or more eligibility requirements. Forty contacts were deemed eligible for participation, and they were offered a selection of participation appointments via email. Eleven participants were lost to scheduling difficulty or ceased correspondence. Only two participants (6.89%) who responded to community advertising completed the study. The remainder of the participants learned of the study through advertising on the University of Pittsburgh campus or via word-of-mouth.

Ultimately, twenty-nine participants confirmed participation and attended their respective appointment time. When given the option to either conclude or continue participation, all twenty-nine participants chose to proceed with Phase II and complete the entirety of our study. Table 3 shows participant demographic information including age, gender, height, weight, body-mass index (BMI), and race. All participants fall within the normal range for BMI as required by inclusionary criteria as defined by the World Health Organization (See Table 4) ("Global Database on Body Mass Index ", 2006).

Table 3: Participant demographics

PARTICIPANTS	AGE (YEARS)		HEIGHT (INCH)		WEIGHT (LBS)		BODY MASS INDEX		RACE
	Mean (SD)	Range (Min-Max)	Mean (SD)	Range (Min-Max)	Mean (SD)	Range (Min-Max)	Mean (SD)	Range (Min-Max)	Caucasian
N = 29	25.2 (8.8)	19.2 – 56.3	65.1 (2.5)	60 -70	139.6 (22.6)	108-180	23.2 (-2)	17.6 – 31.2	100%

Table 4: Body Mass Index Classification

	CUT-OFF SCORE / RANGE	*N* (% OF TOTAL SAMPLE)
Underweight	< 18.50	1 (3.45%)
Normal	18.5 – 24.99	20 (68.96%)
Overweight	≥ 25.00	8 (27.59%)
Obese	≥ 30.00	0

According to World Health Organization Classification Criteria (2000).

6.2 PARTICIPANT GROUPS BY PHYSICAL RESPONSE

Physical Response Forms were analyzed to identify each participant's self-reported physical manifestation of stress. Equipment for physiologic data collection was evenly placed throughout the body to avoid drawing the participant's focus on any one area, particularly the larynx. Distribution of responses across vulnerable body systems is illustrated in Table 5. Completed Physical Report Forms can be found in Physical Report Forms.

In this study, we were primarily interested in those participants who identified the neck as a vulnerable body system. Twenty-six participants (89.65%) identified as such, making it necessary to further specify, using the larynx as the vulnerable body system of interest. Six

participants (20.7%) identified as such, and thus comprise the laryngoresponders group. Laryngoresponder response was accompanied by free-text descriptions including the experience of a "sore throat," "swallowing trouble," "uncomfortable feeling in throat," and "my throat clenches" during stressful times. Since the presence of a voice disorder might predispose a participant to this response, participants scoring higher than 11/30 points on the VHI-10 (the clinical cutoff for normal voice complaints) (Arffa et al., 2012; C. A. Rosen et al., 2004) were excluded from participation in this study.

Because the number of laryngoresponders was too small to allow for good statistical analysis of findings, we identified another way to explore our data. Twelve participants (41.4%) indicated that their general "front of neck" region was a vulnerable area, either generally or in the context of stress response and negative emotionality. This group, referred to as Front Neck Responders, includes those Laryngoresponders, as well as participants with a more widespread response (i.e., drawing that covered the full front of the neck and shoulders and non-laryngeal specific descriptions). Accompanying free-text descriptions for this included "neck feels hot," and "neck pain, knots, tension."

It should be noted that this study was designed to minimize the participants' explicit focus on the neck and laryngeal regions, and participants were encouraged to consider each region of the body when completing their Physical Report Form. (See Table 5 for a detailed breakdown of results.) Those vulnerable systems with a higher percentage of participant response include the following; abdomen and digestive system responders (82.8%), back neck responders (72.4%), shoulder responders (69%), chest and respiratory responders (69%), and head responders (58.6%). Many of these reported responses are 'classic' stress responses, such as heart palpitations, racing heart, or headaches.

Table 5: Physical Report Form results

VULNERABLE SYSTEMS IDENTIFIED	*n* (%)	SELECT PARTICIPANT EXPLANATIONS:
Abdomen, Digestive System	24 (82.8%)	*"my stomach clenches" "stomach ache" "'pit' in stomach" "GI distress" "IBS"*
Back Neck	21 (72.4%)	*"stiffness""sore neck" "tension"*
Shoulder	20 (69.0%)	*"tightness" "trap. Tension"*
Chest, Respiratory	20 (69.0%)	*"chest tight" "heart racing" "shallow feeling in chest" "heaviness in chest" "heart palpitations"*
Head	17 (58.6%)	*"migraines" "throbbing headache" "headache"*
Front Neck	**12 (41.4%)**	***"pain" "neck feels hot"***
Face	12 (41.4%)	*"clenched jaw" "red face" "blush"*
Lower Back	11 (37.9%)	*"lower back tension" "lower back cramping"*
Lower Limbs	11 (37.9%)	*"legs cramping" "difficult to keep feet still"*
Hands / Upper Limbs	10 (34.5%)	*"sweaty hands" "hands shake"*
Upper Back	8 (27.6%)	*"knots in back"*
Larynx	**6 (20.7%)**	***"sore throat," "swallowing trouble," "uncomfortable feeling in throat," "my throat clenches"***
Pelvis	4 (13.8%)	*"' itchy' hip joints," "pelvic floor muscle spasms"*
Full Body	1 (3.4%)	*"eczema," "psoriasis"*

6.3 SELF-REPORTED TRAUMA: DESCRIPTIVE FINDINGS

The independent variables for Research Question 1 were derived from self-report surveys concerning past traumatic experiences. Surprisingly given the past experiences of the psychological consultants for this study (Elisa Monti, PhD and Harmony Sullivan, PsyD), only 3.45% (*n*=1) of our twenty-nine participants had a history significant for physical abuse, and only 6.90% (*n*=2) had a history significant for sexual abuse as determined by the dichotomized scores for these measures.

Overall, results from trauma questionnaires showed a decidedly low amount of traumatic experiences within this participant group in comparison to reports that one in six (16.67%) women has experienced significant sexual abuse in her lifetime (Tjaden & Thoennes, 2006), or estimates from the United Nations that one in three children (33.33%) experience physical abuse, while one in four girls (25%) is expected to experience sexual abuse, (Anda et al., 1999; Felitti et al., 1998; Teicher & Samson, 2016; United Nations, 2006). Thus, these variables could not be assessed statistically.

Descriptive findings organized by measure are reported in the following sections. Data are reported for all participants (n=29) as well as our primary group of interest, the laryngoresponders (n=6).

6.3.1 *Childhood Trauma Questionnaire – Short Form*

As a self-report screening tool for experiences that occurred before the age of 18, the *Childhood Trauma Questionnaire-Short Form (CTQ)* quantifies each of the participants' experiences of emotional, physical, and sexual abuse or neglect. One variable we derived from the *CTQ* cutoffs is the sum of Adverse Childhood Experiences (ACE) (similarly to (Felitti et al., 1998)) measure, which quantifies on a reduced four-point scale (where 0 is no trauma and 1 or more is the number of self-reported trauma categories) how many adverse events an individual experienced during their childhood. These results are given in Table 6 and Figure 2. 48.28% (n=14) of participants did not experience adverse events in childhood. Those individuals with ACE scores of 0 included 16.67% (n=*1)* of the laryngoresponders group, and the 56.6% (n=13) of the non-laryngoresponders group. 52.72% (n=15) of all participants reported some degree of adverse

childhood experiences; these comprised 83.33% (*n*=5) of the laryngoresponders, and 43.4% (*n*=10) of the non-laryngoresponders group. Further divisions of ACE can be found in Table 6.

Dichotomized scores are also provided for whether or not the participant reported a significant degree of any of the following experiences on the CTQ; physical abuse, sexual abuse, emotional abuse, physical neglect or emotional neglect. The dichotomized scores for the *CTQ* determine whose scores of abuse and neglect are above a concerning threshold. It does not mean that those who do not have this designation have had absolutely none of these experiences. The decision to use dichotomized scores in this paper arose from the fact that nearly all participants had a uniform, very low degree of these kinds of abuse. For example; the mean score of physical abuse for all participants was 5.34 (*sd* = 0.89, range 5-9), and the mean score of sexual abuse for all participants was 5.48 *(sd=1.95,* range 4-13). These results are given in Table 6 and Figure 3.

While no laryngoresponders had any experience of physical or sexual abuse, 4.35% non-laryngoresponders (*n*=1) reported physical abuse, and 8.70% (*n*=2) reported sexual abuse during childhood. 50% (*n*=3) of laryngoresponders reported emotional abuse, compared to only 26.09% (*n*=6) of non-laryngoresponders. Physical neglect was fairly uncommon for both laryngoresponders (16.67%, *n*=1) and non-laryngoresponders (13.04%, *n*= 3), and the percentage of laryngoresponders who experienced emotional neglect (83.3%, *n* = 5) was greater than any other category of reported childhood trauma.

Table 6: Adverse Childhood Experiences & dichotomized scores (*CTQ)*

	ALL PARTICIPANTS		LARYNGORESPONDERS		NON-LARYNGORESPONDERS	
Adverse Childhood Experiences	***n* (%)**		***n* (%)**		***n* (%)**	
0	14 (48.28%)		1 (16.67%)		13 (56.6%)	
1	6 (20.69%)	52.72%	2 (33.33%)	83.33%	4 (17.39%)	43.40%
2	5 (17.24%)		2 (33.33%)		3 (13.043%)	
3	3 (10.32%)		1 (16.67%)		2 (8.69%)	
4	1 (3.45%)		0		1 (4.34%)	
Dichotomized scores: Indicates experience of the following	***n* (%)**		***n* (%)**		***n* (%)**	
PHYSICAL ABUSE	1 (3.45%)		0		1 (4.35%)	
SEXUAL ABUSE	2 (6.90%)		0		2 (8.70%)	
EMOTIONAL ABUSE	9 (31.03%)		3 (50.00%)		6 (26.09%)	
PHYSICAL NEGLECT	4 (13.79%)		1 (16.67%)		3 (13.04%)	
EMOTIONAL NEGLECT	13 (44.83%)		5 (83.33%)		8 (34.78%)	
Subscales	**Mean Score (SD)**	**Range (Min-Max)**	**Mean Score (SD)**	**Range (Min-Max)**	**Mean Score (SD)**	**Range (Min-Max)**
TOTAL SCORE	33.93 (9.97)	25 – 67	36.26 (6.80)	25 - 43	33.26 (10.66)	25 – 67
MINIMIZATION	10.21 (2.78)	3 – 15	9 (2.61)	6 – 13	10.52 (2.79)	3 – 15

The final scale that was derived from the *CTQ* was the minimization scale. This is a scale of denial, or minimization of trauma. It was determined by looking at three different questions on the questionnaire; “There was nothing I wanted to change about my family”, “I had the perfect childhood”, and “I had the best family in the world.” People who make these claims *and* report childhood abuse or neglect are thought to be minimizing their trauma. Minimization has been found to be fairly common in the general population (MacDonald et al., 2016). Our laryngoresponders group had a mean score of 9 (*sd*=2.61) and the non-laryngoresponders group had a mean score of 10.52 (*sd=2.79).* The overall spread of scores (laryngoresponders 6-13, non-

laryngoresponders 3-15) overlapped quite a bit, suggesting no dramatic differences between groups on this measure.

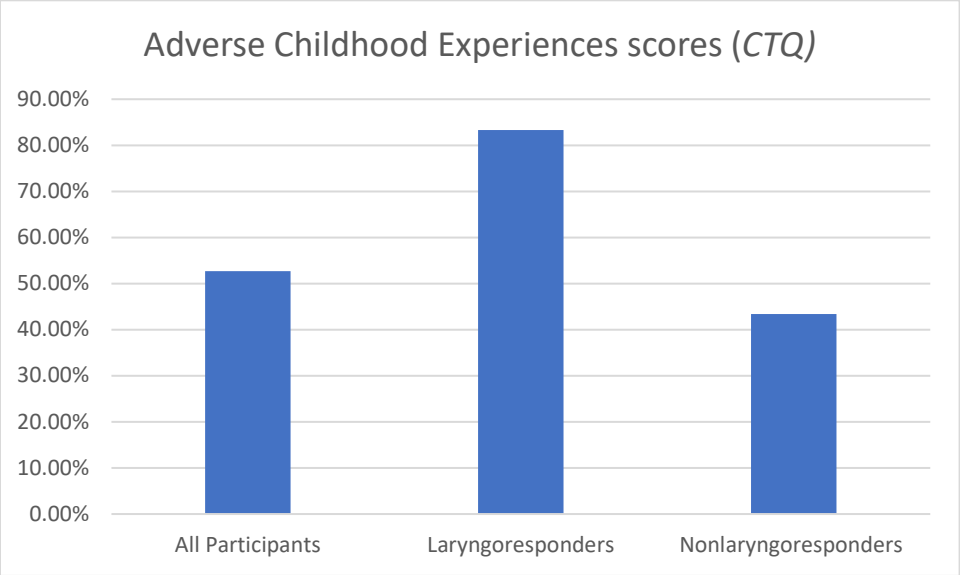


Figure 2: Adverse Childhood Experiences (*CTQ*)

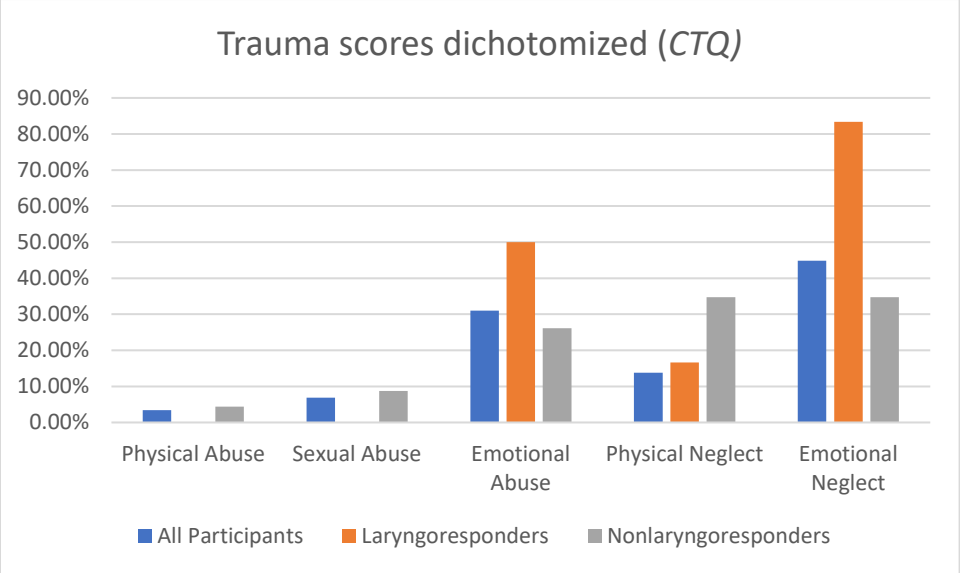


Figure 3: Trauma scores, Dichotomized (*CTQ*)

6.3.2 *Trauma History Questionnaire*

The Trauma History Questionnaire (*THQ*) is a self-report measure via which individuals share details about their exposure to different types of experiences. As is the case for the *CTQ*, multiple measures can be derived from the *THQ*. For this analysis, we included only the details about the types of trauma to which participants had previously been exposed. The *THQ* differs from the *CTQ* in that the experiences reported are not limited to childhood. Like the *CTQ*, it asks questions about sexual assault and physical violence, but it also captures the trauma of loss (e.g. the death of a loved one). Details about the participants' age at the time of the incident and whether or not experiences were repeated were collected from participants but not included in this analysis.

Descriptive statistics for total scores on the *THQ* are presented in Table 7. Laryngoresponders had a mean of 4.17 (*sd*=2.40) total traumatic experiences, while non-laryngoresponders had a mean of 3.35 (*sd*=2.29). Laryngoresponders also scored slightly higher than the non-laryngoresponders on in the areas of sexual assault (laryngoresponders mean = 0.50, s*d* =*084,* non-laryngoresponders mean 0.48 s*d*= 0.85), threat of physical assault (laryngoresponders mean = 0.50, *sd* = 0.84*,* non-laryngoresponders mean = 0.26, *sd*=0.54), and loss (laryngoresponders mean = 0.83, *sd* = 0.75, non-laryngoresponders mean = 0..61, *sd* = 0.58).

Table 7: ***Trauma History Questionnaire***

	ALL PARTICIPANTS		LARYNGORESPONDERS		NON-LARYNGORESPONDERS	
	Mean Score (SD)	**Range (Min-Max)**	**Mean Score (SD)**	**Range (Min-Max)**	**Mean Score (SD)**	**Range (Min-Max)**
TOTAL	3.52 (2.29)	0 .00– 8.00	4.17 (2.40)	2.00 – 8.00	3.35 (2.29)	0 .00– 8.00
SEXUAL ASSAULT	0.48 (0.83)	0.00 – 3.00	0.50 (0.84)	0.00 – 2.00	0.48 (0.85)	0.00 – 3.00
THREAT OF PHYSICAL ASSAULT	0.31 (0.60)	0.00 – 2.00	0.50 (0.84)	0.00 – 2.00	0.26 (0.54)	0.00 – 2.00
LOSS	0.66 (0.61)	0.00 – 2.00	0.83 (0.75)	0.00 – 2.00	0.61 (0.58)	0.00 – 2.00

6.3.3 *Dissociative Experiences Scale*

The Dissociative Experiences Scale *(DES)* measures various types of dissociation. It should be noted that the results of the *DES* are intended solely for comparison between groups, and as another means of exploration. As there is no intention to diagnose a dissociative disorder using these data, all scores should be interpreted with caution. Descriptive findings are presented in in Table 8.

Laryngoresponders had a *DES* total mean score of 14.23 (*sd* = 7.64), while non-laryngoresponders scored lower with a mean score of 10.06 (*sd* = 5.41). Laryngoresponders score higher on scale of absorption with a mean score of 24.07 (*sd = 14.87)* where non-laryngoresponders had a mean score of 15.36 (*sd* = 7.70). On a scale of depersonalization, laryngoresponders had a mean score of 4.44 (*sd* = 5.13), while nonlaryngoreasponders scored higher with a mean score of 5.69 (*sd* = 7.78). On a scale of amnestic dissociation, laryngoresponders had a mean score of 6.04 (*sd* = 6.91), while non-laryngoresponders scored lower with a mean score of 4.35 (*sd*=3.34). Absorption was the subscale on which the two groups

differed most drastically. This is also observed on another measure of dissociation which will be discussed subsequently.

A clinical cutoff score is also provided for the *DES.* This score is more appropriate for use with psychiatric populations, and thus has not been included in these analyses.

Table 8: ***Dissociative Experiences Scale***

	ALL		LARYNGORESPONDERS		NON-LARYNGORESPONDERS	
	Mean Score (SD)	**Range (Min-Max)**	**Mean Score (SD)**	**Range (Min-Max)**	**Mean Score (SD)**	**Range (Min-Max)**
Total Score	11.44 (6.80)	2.86 – 28.93	14.23 (7.64)	8.21 – 28.93	10.06 (5.41)	2.86– 22.9
Depersonalization	5.29 (7.35)	0.00 – 25	4.44 (5.13)	0.00 – 11.67	5.69 (7.78)	0.00 - 25
Absorption	17.66 (10.55)	5.56 – 52.22	24.07 (14.87)	10.00 - 52.22	15.36 (7.70)	5.56 – 36.67
Amnestic Dissociation	5.09 (4.63)	0.00 – 18.75	6.04 (6.91)	0.00 - 18.75	4.35 (3.34)	0.00 – 12.50

6.3.4 "Ideal" Internal & External Communication

Two exploratory questions regarding "ideal" internal and external communication were administered. Participants were asked to indicate how closely their own experiences related to verbally delivered examples of "ideal" communication scenarios in the face of traumatic experiences. An "ideal" example was given for both "internal communication" and "external communication," (see "Ideal Internal and External Communication). The participants used a

continuous 100 mm undifferentiated visual analog scale to share the proportion of their experiences which have been similar to the given "ideal situation." Higher scores indicate healthier—i.e., closer to the "ideal scenario"—communication experiences in the face of trauma. Descriptive statistics are presented in Table 9.

For each of these questions, laryngoresponders scored lower than non-laryngoresponders in both scenarios. That is, laryngoresponders reported that a lower proportion (*m = 58.82, sd = 21.62)* of their experiences were similar to the "ideal" internal communication scenario lower than non-laryngoresponders (*m* = 66.05*, sd* = 28.68). Likewise, laryngoresponders reported that a lower proportion (*m = 48.00, sd = 26.55)* of their experiences which were similar to the "ideal" external communication scenario lower than non-laryngoresponders (*m* = 67.26*, sd* = 25.66).

Table 9: Internal/External Communication descriptive data

	ALL PARTICIPANTS		LARYNGORESPONDERS		NON-LARYNGORESPONDERS	
	Mean Score(SD)	**Range (Min-Max)**	**Mean Score (SD)**	**Range (Min-Max)**	**Mean Score (SD)**	**Range (Min-Max)**
Ideal Internal Communication	64.56 (27.18	14 - 100	58.82 (21.62)	29 - 82	66.04 (28.68)	14 - 100
Ideal External Communication	63.28 (26.58)	10 – 100	48.00 (26.55)	20 - 85	67.26 (25.66)	10 - 100

6.3.5 *Multidimensional Personality Questionnaire – Brief Form*

The *MPQ-BF* was utilized to gain insight into several aspects of each participants' personality. It is a 155-item measure, which evaluates participants on 14 different variables, 3 of which are superfactors (Positive Emotionality, Negative Emotionality, and Constraint), and 11 of which are subscales of personality (e.g., Stress Reactivity, Social Warmth). Scores for each

participant were categorized into high/medium/low as per the *MPQ-BF* scoring guide. A designation of 'high' or 'low' means that that individual's score was greater than one standard deviation above or below the standardized mean. We then looked at the distribution of these scores within our three groups: all participants, laryngresponders, and non-laryngoresponders.

Notably, 100% (n=6) of the laryngoresponder's scores fell within the same range on the following variables: *well-being* (having a cheery disposition, an optimistic outlook, and living an interesting, exciting life)*, harm avoidance (*does not enjoy adventurous activities)*,* and *constraint* (evaluates levels of caution, traditional values and avoidance of danger). Each of our laryngoresponders fell within the medium range for each of these listed values. The non-laryngoresponders demonstrated a similar distribution, with the highest number of participants falling in the medium range.

The greatest difference between the laryngoresponders and non-laryngoresponders was seen on the *absorption* scale. Absorption is described as "a propensity for imaginative and self-involving experiences" (Patrick et al., 2002). The person who scores high on this scale might be more easily drawn into imaginative thoughts and visceral re-experiencing of past event. 50% (n=3) of the LR group scored high in absorption, in contrast to 17.4% (n=4) non-laryngoresponders, suggesting that it is more likely for a laryngoresponder to demonstrate this quality of absorption.

Despite these select differences, participants' personality scores are broadly distributed in a similar manner. No conclusions can reasonably be drawn as to whether significant personality differences exist between the laryngoresponder and non-laryngoresponder groups. Assuming personality traits are distributed similarly across groups, we would rule out personality as a driving factor in observed differences on various trauma measures.

Table 10: MPQ-BF descriptive findings

	ALL			LARYNGORESPONDERS			NON-LARYNGORESPONDERS		
Variable	High	Med	Low	High	Med	Low	High	Med	Low
	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**
Well-Being	3 (10.3%)	21 (72.4%)	5 (17.2%)	0	6 (100%)	0	3 (13.0%)	15 (65.2%)	5 (21.7%)
Social Potency	9 (31%)	19 (65.6%)	1 (3.4%)	2 (33.3%)	4 (66.7%)	0	7 (30.4%)	15 (65.2%)	1 (4.3%)
Achievement	16 (55.2%)	13 (44.8%)	0	4 (66.7%)	2 33.37%)	0	12 (52.2%)	11 (47.7%)	0
Social Closeness	9 (31.0%)	15 (51.7%)	5 (17.2%)	1 (16.7%)	4 (66.7%)	1 (16.7%)	8 (34.8%)	11 (47.8%)	4 (17.4%)
Stress Reaction	9 (31.0%)	17 (58.6%)	3 (10.3%)	1 (17.6%)	4 (66.7%)	1 (16.7%)	8 (34.8%)	13 (56.5%)	2 (8.7%)
Aggression	2 (6.9%)	15 (51.7%)	12 (41.4%)	0	3 (50.0%)	3 (50.0%)	2 (8.7%)	12 (52.5%)	9 (39.1%)
Alienation	8 (27.6%)	21 (72.4%)	0	3 (50.0%)	3 (50.0%)	0	5 (21.7%)	18 (78.3%)	0
Control	9 (31.0%)	18 (62.1%)	2 (6.9%)	3 (50.0%)	3 (50.0%)	0	6 (26.1%)	15 (65.2%)	2 (8.7%)
Harm Avoidance	3 (10.3%)	24 (82.8%)	2 (6.9%)	0	6 (100%)	0	3 (13.0%)	18 (78.3%)	2 (8.7%)
Traditionalism	1 (3.4%)	12 (41.4%)	16 (55.2%)	0	4 (66.7%)	2 (33.3%)	1 (4.3%)	8 (34.8%)	14 (60.9%)
Absorption	7 (24.1%)	17 (58.6%)	5 (17.2%)	3 (50.0%)	2 (33.3%)	1 (16.7%)	4 (17.4%)	15 (65.2%)	4 (17.4%)
Positive Emotionality	9 (31.0%)	20 (69.0%)	0	2 (33.3%)	4 (66.7%)	0	7 (30.4%)	16 (69.6%)	0
Negative Emotionality	7 (24.1%)	18 (62.1%)	4 (13.8%)	2 (33.3%)	3 (50.0%)	1 (16.7%)	5 (21.7%)	15 (65.2%)	3 (13.0%)
Constraint	1 (3.4%)	26 (89.7%)	2 (6.9%)	0	6 (100%)	0	1 (4.3%)	20 (87.0%)	2 (8.7%)

6.3.6 *State-Trait Anxiety Index (STAI)*

The trait portion of the *State-Trait Anxiety Inventory* is a 20-item measure which assesses trait anxiety. Laryngoresponders (mean score =42.50) and non-laryngoresponders (mean score =42.65) had nearly the same mean score. Designations of "no or low anxiety", "moderate anxiety" and "high anxiety" were assigned in order to more fully evaluate these results. Descriptive statistics for trait anxiety are presented in Table 11. Findings are meant to be exploratory and should be evaluation with caution, as there is no interest in diagnosing an anxiety disorder with this population.

Table 11: Trait Anxiety (*STAI)*

	ALL		LARYNGORESPONDERS		NON-LARYNGORESPONDERS	
	Mean Score (SD)	**Range (Min-Max)**	**Mean Score (SD)**	**Range (Min-Max)**	**Mean Score (SD)**	**Range (Min-Max)**
Trait Anxiety	42.62 (10.28)	24 – 69	42.50 (8.34)	34 – 52	42.65 (10.90)	24 – 69
		***n* (%)**		***n* (%)**		***n* (%)**
	High	10 (34.48%)	High	3 (50%)	High	7 (30.43%)
	Med	15 (51.72%)	Med	3 (50%)	Med	12 (52.18%)
	Low	4 (13.79%)	Low	0	Low	4 (17.39%)

6.3.7 Change in Acoustics

Linear Mixed Effects (LME) models were employed to determine whether there were any statistically significant changes in acoustics between samples. Using Speech Sample 1 as the referent against which Speech Samples 2 and 3 were compared, the LME assessed whether statistically significant differences existed as a function of time point for any of the acoustic measures. Acoustic variables included were CPP F_0, CPP F_0 SD, CSID, CPP, CPP SD, Low-to-

High Spectral Ratio, and Low-to-High Spectral Ratio SD (refer to Section 5.1 for descriptions of these measures). These measures were calculated for the speech samples selections "We were away a year ago" (of the CAPE-V) and extemporaneous speech samples, for a total of 14 LME analyses. Results for these analyses can be found in Table 12 and Table 13. Sustained vowel phonation was excluded from this stage of analysis due to lack of ecological validity for that task, as well as an overabundance of data.

As anticipated, no statistically significant differences were seen between the two baseline speech samples (SS1 and SS2). The only statistically significant differences as a function of time point were between SS1 and SS3, the latter of which was taken just following completion of the trauma questionnaires. A statistically significant change in CPP F_0 SD obtained from the CAPE-V (t= 1.99, DF=83; $p<0.05$) was observed. Extracted from the extemporaneous speech sample, the following variables were also found to have statistically significant changes between speech samples 1 and 3; CPP dB (t= -2.1, DF=82; $p<0.05$), L/H SR (t= *-3.75*, DF=82; $p<0.05$,), and L/H SR SD (t=4.49, DF=82; $p<0.05$).

Table 12: We Were Away A Year Ago (CAPE-V), Linear Mixed Model

ALL PARTICIPANTS	SPEECH SAMPLE 2			SPEECH SAMPLE 3		
	Mean (SD)	**T-stat (DF)**	**p-value**	**Mean (SD)**	**T-stat (DF)**	**p-value**
CPP FO (Hz)	203.64 (18.79)	0.47 (83)	0.64	199.77 (19.36)	-0.96 (83)	.0340
CPP FO SD	34.92 (14.03)	0.63 (83)	0.53	38.61 (15.29)	1.99 (83)	***0.048***
CSID	20.43 (9.32)	-0.99 (83)	0.33	21.19 (15.91)	-0.70 (83)	0.48
CPP (dB)	5.54 (1.09)	-0.44 (83)	0.66	5.71 (1.04)	0.64 (83)	0.52
CPP SD	3.01 (0.39)	1.01 (83)	0.28	3.06 (0.37)	1.6 (83)	0.11
L/H Spectral Ratio	34.24 (2.22)	-0.19 (83)	0.85	34.04 (2.39(	-0.59 (83)	.0560
L/H Spectral Ratio SD	5.64 (0.89)	0.36 (83)	0.72	5.64 (0.92)	0.36 (83)	.0720

Compared to Speech Sample 1 as Referent
- Statistically significant ($p < .05$)

Table 13: Extemporaneous Speech Samples, Linear Mixed Model

ALL PARTICIPANTS	SPEECH SAMPLE 2			SPEECH SAMPLE 3		
	Mean (SD)	**T-stat (DF)**	**p-value**	**Mean (SD)**	**T-stat (DF)**	**p-value**
CPP FO (Hz)	198.89 (17.46)	0.24 (82)	0.81	193.57 (22.25)	-1.72 (82)	0.09
CPP FO SD	40.81 (9.45)	1.55 (82)	0.12	40.68 (9.67)	1.51 (82)	0.13
CSID	14.76 (9.59)	-0.32 (83)	0.75	16.48 (9.29)	0.76 (83)	0.45
CPP (dB)	4.65 (0.84)	-1.34 (82)	0.18	4.60 (0.84)	-2.1 (82)	***0.04***
CPP SD	3.12 (0.36)	0.56 (82)	0.57	3.07 (0.41)	-0.99 (82)	0.33
L/H Spectral Ratio	29.55 (1.65)	-2.88 (82)	0.005	29.29 (2.15)	-3.75 (82)	***0.0003***
L/H Spectral Ratio SD	10.64 (0.81)	5.26 (82)	.0000113	10.48 (0.89)	4.49 (82)	***.0000228***

Compared to Speech Sample 1 as Referent
- Statistically significant ($p < .05$)

6.4 PRIMARY OUTCOMES

6.4.1 Research Question 1

Research Question 1 examined the relationship between acoustic change and the degree/amount of self-reported trauma. First, the Shapiro-Wilk Test of Normality was used to determine whether data violated assumptions of normality. The independent variables obtained from the trauma questionnaires are listed in Table 6, Table 7, Table 8, and Table 9. As described earlier, acoustic variables serving as the dependent variables were: CPP, CPP F_0, L/H Spectral Ratio, CSID and the standard deviation of each of these measures. These were each included as difference scores, calculated as follows: = ((average SS1 + SS2) - SS3).

Where assumptions were not violated, Pearson's Product-Moment Correlation was utilized. Alpha level was Bonferroni adjusted for multiple comparisons, and significance was set at $p < .005$. These findings are listed in Table 14, though no statistically significant findings were observed. Where assumptions were violated, Spearman's Rank Order Correlation coefficient was utilized. Alpha level was Bonferroni adjusted for multiple comparisons, and significance was set at $p < .0125$. These findings are listed in Table 15. No statistically significant findings were observed.

Anecdotally, however, many trends were noted in the course of statistical analysis. This is specifically true with variables of anxiety and variables of emotional neglect. Due to the fact that our laryngoresponder group happened to be so small, and because our participants' incidence of trauma was also fairly lower than expected, this study was not powered to find statistical effects. Given the exploratory nature of this study, however, evidence exists that a more statistically robust

review of these relationships may be fruitful. Exploratory analyses were performed to probe relationships further given the aforementioned limitations and are described Section 6.4.3.

Table 14: Pearson's Product-Moment Correlation – Trauma and Acoustics

		"We were away" Change from SS1 to SS3				*Extemporaneous speech Change from SS1 to SS3*					
		CPP	**CPP SD**	**CPP F_0**	**CHANGE L/H SR**	**CPP**	**CPP SD**	**CPP F_0 SD**	**L/H SR)**	**L/H SR SD**	**CSID**
"Ideal" External Communication	Correlation Coefficient	.229	-.079	-.092	.107	.149	-.135	-.375	.107	-.420	-.031
	Sig.(2-tailed)	.231	.685	.636	.579	.440	.486	.045	.579	.023	.872
	N	29	29	29	29	29	29	29	29	29	29
Anxiety (*STAI)*	Correlation Coefficient	.121	-.125	-.017	.127	-.284	-.191	.113	.127	-.158	.412
	Sig.(2-tailed)	.531	.517	.932	.510	.135	.320	.560	.510	.413	.026
	N	29	29	29	29	29	29	29	29	29	29
Minimization (*CTQ)*	CorrelationCoefficient	.227	.044	-.027	-.083	.277	-.025	-.276	-.083	-.447	-.043
	Sig.(2-tailed)	.236	.819	.888	.668	.145	.896	.148	.668	.015	.826
	N	29	29	29	29	29	29	29	29	29	29

- Statistically significant ($p < .005$)

Table 15: Spearman's rank order correlation coefficient – Trauma and Acoustics

		"We were away" Change from SS1 to SS3			*Extemporaneous speech Change from SS1 to SS3*
		CPP FO SD	**CSID**	**L/H SR SD**	**Mean CPP FO**
"Ideal" Internal Communication	Correlation Coefficient Sig.(2-tailed) N	-.052 .791 29	.007 .973 29	-.279 .143 29	-.076 .694 29
Anxiety (*STAI)*	Correlation Coefficient Sig.(2-tailed) N	-.371 .048 29	-.187 .332 29	-.075 .700 29	-.090 .641 29
CTQ total score	Correlation Coefficient Sig.(2-tailed) N	.010 .958 29	-.119 .539 29	.400 .031 29	.055 .776 29
DES total score	Correlation Coefficient Sig.(2-tailed) N	-.031 .872 29	-.074 .701 29	.120 .536 29	-.098 .614 29
Absorption (*DES)*	Correlation Coefficient Sig.(2-tailed) N	.016 .934 29	-.046 .813 29	.045 .816 29	-.149 .439 29
*THQ t*otal score	Correlation Coefficient Sig.(2-tailed) N	.051 .793 29	-.241 .207 29	.096 .620 29	-.228 .233 29

- Statistically significant ($p < .0125$)

6.4.2 Research Question 2

Research Question 2 examined the relationship between acoustic features and vulnerable body systems. The language used in this question reflects the intent to include those who report neck, throat and/or voice concerns into one group; the "laryngoresponders". As described in Section 6.2, this group was renamed the "Neck Responders" (n=26), as it included too many of our participants for any or appropriate analyses. The qualifications for the laryngoresponders (n=6) was then narrowed to include complaints specific to throat and the voice. Though this group comprises fewer participants than is ideal for statistical analyses, it was nevertheless the most

appropriate group for analyses. It was also most appropriate and specific to our primary system of concern. As such, we explored **RQ2** by analyzing acoustic change across speech samples for our group of laryngoresponders (n=6) and our non-laryngoresponders (*n*=23).

Using SPSS, the normality of data was evaluated using the Shapiro-Wilk Normality Test. A T-test was performed on those variables that did not violate assumptions, and Mann-Whitney U-test was performed on those variables which did violate assumptions. The same acoustic variables included in **RQ1** were again used here. No statistically significant findings were observed. Thus, we performed select exploratory analyses based on anecdotal/qualitative observations of our data. Details are reported below in the section titled Exploratory Analyses.

6.4.3 Exploratory Analyses

6.4.3.1 Between Group Trauma Comparison

Given the exploratory nature of this study, as well as the limitations of small sample size and a small number of laryngoresponders, an informal inquiry was made into to how our groups (laryngoresponders vs. non-laryngoresponders) fared in relation to each other on measures of trauma. On the grounds that having experienced a greater degree of trauma or less "ideal" communication situations is *worse,* and that fewer experiences of trauma and more "ideal" communication experiences is *better* for an individual, the results of these variables were categorized in this manner. We explored our data by coding whether the laryngoresponders group had *better* or *worse* average scores on trauma variables compared to the non-laryngoresponders group. Each of the variables included, and the findings of this descriptive analysis, are listed in Table 16. Several of the scales provided by the self-report questionnaires had a build in redundancy

(e.g. the *THQ* total score is a sum of the independently reported *THQ* subscales of sexual assault, threat of physical assault and loss). To avoid falsely inflating the number of instances where one group scored *worse* than the other, only the subscales were included in this analysis, and "total" scores were excluded.

Based on this analysis, the laryngoresponders scored *worse,* than the non-laryngoresponders on 70.58% of all of the trauma subscales. The subscales on which the laryngoresponders exhibited *worse* scores were: "ideal" internal communication and "ideal" external communication (via the "Ideal" Internal and External Communication questions); emotional abuse, emotional neglect, physical neglect, and adverse childhood experiences (via *CTQ;,* sexual assault, threat of physical assault, and loss (via *THQ)*; and amnestic dissociation, absorption, and the *DES* clinical cutoff (via *DES).* Subscales where the laryngoresponders scored *better* than the non-laryngoresponders groups include measures of trait anxiety (via *STAI*); physical abuse, sexual abuse, and minimization (via *CTQ)*; and depersonalization (via *DES).*

We compared the laryngoresponders and non-laryngoresponders with personality and acoustic data in a similar fashion. However, we ultimately found it too challenging to reasonably and justifiably dichotomize variables into *better* or *worse* categories. Furthermore, with regard to the acoustic variables, differences between groups were often fractional and thus of questionable meaningfulness. The acoustic variables used in this story were chosen based on their utility in the literature for measuring dysphonia in a voice-disordered population. Since we recruited only vocally healthy individuals, we began to question the sensitivity of these measures for differentiating vocally healthy groups. We will discuss this issue further in the context of our research findings, but it is because of these considerations that we did not continue this exploratory analysis approach and will not discuss it further herein.

Table 16 Exploratory Analysis: Dichotomized better/worse subscale comparison

SUBSCALE	LARYNGO-RESPONDERS	SUBSCALE	LARYNGO-RESPONDERS
EXPLORATORY INTERNAL/EXTNERAL COMMUNICATION QUESTIONS		**TRAUMA HISTORY QUESTIONNAIRE**	
INTERNAL COMMUNICATION	X	SEXUAL ASSAULT	X
EXTERNAL COMMUNICATION	X	THREAT OF PHYSICAL ASSAULT	X
		LOSS	X
CHILDHOOD TRAUMA QUESTIONNAIRE		**DISSOCIATIVE EXPERIENCES SCALE**	
EMOTIONAL ABUSE	X	DEPERSONALIZATION	0
PHYSICAL ABUSE	0	AMNESTIC DISSOCIATION	X
SEXUAL ABUSE	0	ABSORPTION	X
EMOTIONAL NEGLECT	X	DES TOTAL SCORE	X
PHYSICAL NEGLECT	X		
MINIMIZATION	0		
ADVERSE CHILDHOOD EXPERIENCES	X		
STATE TRAIT ANXITY INVENTORY		**X = *Better score for laryngoresponder***	
		0 = *Worse score for laryngoresponders*	
ANXIETY	0		

6.4.3.2 Chi-square tests to compare laryngoresponders and non-laryngoresponders

Because we observed qualitative differences between laryngoresponders and non-laryngoresponders with regard to trauma scores (see previous section, Between group trauma comparison), we performed the Pearson chi-square test for association. Many of the trauma variables either existed as, or were easily translated into categorical variables, which is an assumption for Chi-square analysis. Chi-square tests were run for the laryngoresponder and non-laryngoresponder groups and the following trauma variables; the anxiety score (*STAI),* and the

dichotomized scores of physical abuse, sexual abuse, emotional abuse, physical neglect, and the emotional neglect as reported by the (*CTQ).*

The only significant association (p = 0.033) was found for laryngoresponders and a dichotomized variable of emotional neglect (a subscale of the *CTQ*), such that 83.30% (n = 5) of laryngoresponders scored reported higher on measures of that experience (see Figure 4).

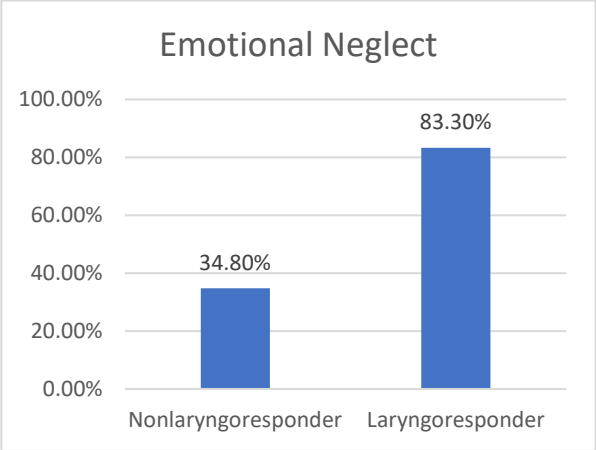


Figure 4: Emotional Neglect Association

6.4.3.3 Emotional Neglect and External Communication

Given the finding that 83.3% of laryngoresponders reported emotional neglect in childhood, further exploration of the relationship between emotional neglect and external communication was pursued. All participants (n=29) were grouped according to whether they had a self-reported history of emotional neglect as determined by the emotional neglect dichotomized score (*CTQ). 44.8%* (n=13) of participants were identified as participants with emotional neglect, and 55.17% (n=16) of participants were identified as participants without emotional neglect.

Internal and external communication scores were assigned out of a possible score of 100, with 100 being the "ideal" communication scenario. Participants with emotional neglect had a lower mean "ideal" internal communication score of 51 (*sd*=28.81) than the participants without emotional neglect (mean=75.56, *sd*=20.65). Similarly, participants with emotional neglect had a lower mean "ideal" external communication score of 44.77 (*sd*=22.97) than the participants without emotional neglect (mean= 78.3, *sd*=18.93) (see Table 17). This suggests that participants who have experienced emotional neglect also have experienced communication scenarios that are farther away from "ideal" than those participants without emotional neglect.

Table 17: Emotional Neglect and External Communication, Descriptive findings

	PARTICIPANTS WITH EMOTIONAL NEGLECT (n=13)		PARTICIPANTS WITHOUT EMOTIONAL NEGLECT (n=16)	
	Mean Score (SD)	**Range (Min-Max)**	**Mean Score (SD)**	**Range (Min-Max)**
Ideal Internal Communication	51 (28.81)	14 - 100	75.56 (20.65)	30 - 100
Ideal External Communication	44.77 (22.97)	10 – 80	78.31 (18.93)	40 – 100
	***n* (%)**		***n* (%)**	
Ideal External Communication	HIGH	5 (38.46%)	HIGH	13 (81.25%)
	MEDIUM	3 (23.08%)	MEDIUM	2 (12.5%)
	LOW	5 (38.46%)	LOW	1 (6.25%)
Ideal Internal Communication	HIGH	3 (23.07%)	HIGH	12 (75%)
	MEDIUM	6 (46.15%)	MEDIUM	4 (45%)
	LOW	4 (30.77%)	LOW	0

6.4.3.4 Anxiety and Trauma

The relationships between various trauma variables were explored. In particular, we sought to understand the relationship between trauma variables and the construct of anxiety, since

descriptively, Trait Anxiety showed a relationship with both CCP F_0 SD ("We were away a year ago"), and CSID (Extemporaneous speech), but is not a trauma measure *per se*. Using Pearson's Product-Moment correlation and Spearman's Rank Order Correlation Coefficient as described earlier. Alpha level was Bonferroni adjusted for multiple comparisons, and significance was set at $p < .016$ and $p < .0083$, respectively. A statistically significant relationship was found between minimization (*CTQ)* and "ideal" external communication" ($r = .479$, $n = 29$, $p < .016$), suggesting that a more positive experience of external communication is related to a greater degree of minimization, or denial about ones' experiences. A statistically significant relationship was seen between anxiety (*STAI)* and the *DES* total score ($r = .500$, $n = 29$, $p < .0083$), suggesting that a greater degree of anxiety is related to greater dissociation, or detachment from physical or emotional experiences. Finally, a statistically significant relationship was seen between absorption (*DES*) and the *DES* total score ($r = .872$, $n = 29$, $p < .0083$). Findings are presented in Table 18 and Table 19.

Table 18: Pearson's Product-Moment Correlation - Trauma

		"IDEAL" EXTERNAL COMMUNICATION	ANXIETY (*STAI)*	MINIMIZATION (*CTQ)*
"IDEAL" EXTERNAL COMMUNICATION	Correlation Coefficient Sig.(2-tailed) N	1	-.108 .576 29	.479 ***.009*** 29
ANXIETY (*STAI)*	Correlation Coefficient Sig.(2-tailed) N		1	-.365 .051 29
MINIMIZATION (*CTQ)*	Correlation Coefficient Sig.(2-tailed) N			1

- Statistically significant ($p < .016$)

Table 19: Spearman's rank order correlation coefficient – Trauma

		ANXIETY CUTOFF (*STAI)*	TOTAL SCORE (*DES)*	ABSORPTION (*DES*)	"IDEAL" INTERNAL COMM.	*TOTAL (*THQ)	TOTAL (*CTQ)*
ANXIETY CUTOFF (*STAI)*	Corr. Coefficient Sig.(2-tailed) N	1	.500 ***.006*** 29	.477 .009 29	-187 .332 29	.322 .089 29	.462 .012 29
TOTAL SCORE (*DES)*	Corr. Coefficient Sig.(2-tailed) N		1	.872 ***.0004*** 29	-.074 .701 29	.201 .297 29	.430 .020 29
ABSORPTION (*DES*)	Corr. Coefficient Sig.(2-tailed) N			1	-.112 .564 29	.137 .478 29	.333 .077 29
"IDEAL" INTERNAL COMM.	Corr. Coefficient Sig.(2-tailed) N				1	-.026 .892 29	-328 .082 29
*TOTAL (*THQ)	Corr. Coefficient Sig.(2-tailed) N					1	.237 .215 29
TOTAL (*CTQ)*	Corr. Coefficient Sig.(2-tailed) N						1

- Statistically significant ($p < .0083$)

7.0 DISCUSSION

The present study was developed to explore and evaluate the relationship between past traumatic experiences and (a) current vocal quality and (b) vulnerable body regions. The latter focus was inspired by clinical anecdote in the context of functional voice disorders, which is that the larynx—and thus by proxy, the voice—acts as a vulnerable body system in some individuals.

Ultimately, this study did not reveal statistically significant relationships between tested variables. While this could be a legitimate finding, it could also be due to the fact that (1) the current group of participants reported experiencing an unusually low amount of trauma, and (2) the primary group of interest (neck responders) occupied too large a group to statistically explore, and our alternative group of interest (laryngoresponders) was too small a group to statistically explore as originally intended. It is unclear whether the inconclusiveness of results for our Research Questions 1 and 2 is due to these issues which led to an underpowered study, or reflective of true null results. Nonetheless, the following findings were deemed interesting and worth future pursuit.

7.1 RESEARCH QUESTION 1

No statistical support for the hypothesis in **RQ1**—that there is a positive correlation between acoustic changes in recorded spoken text and self-reported traumatic experiences—was shown. Since relationships and trends observed in the data did not withstand corrections for

multiple statistical comparisons, we are cautious in interpreting findings beyond acknowledging a hint that voice-trauma relationships might exist. However, tentative interpretations of our findings are as follows.

One consideration pertaining to statistical analysis is as follows. In the course of data exploration, we noted that acoustic changes occurred in both directions for many of the acoustic measures used. This observation harkens what we reported earlier (see introductory Section 2.1), that the same emotion can manifest a in seemingly conflicting manner in two different voices, yet it can still be accurately perceived and decoded by a listener (Bachorowski, 1999; Scherer, 2003). Thus, it is possible that the individual styles of expression used by various participants impacted group-level findings.

Nonetheless, that four of seven acoustic variables were found to have a significant change from speech sample 1 to speech sample 3 (see Table 12 and Table 13) might be considered even more meaningful when we take into account other methodological aspects of this study. It could be said that we sought to identify *trait* vocal differences more than *state* vocal differences; great care was taken to avoid priming for or triggering an extreme emotional response in participants while they completed their trauma surveys. For instance, to avoid triggering participants, we elected during the planning phase of this study to omit surveys that used language deemed disturbing or overly explicit. The surveys that were administered were completed immediately prior to recording the third speech sample. However, the speech sample stimuli were in no way related to trauma experience, and participants never verbalized any items of the trauma measures or content related to past trauma. If these historical experiences were to be brought to the present in a more active or evocative manner – e.g., if participants were asked to verbally recall or recount

their experiences; if questioning had been more explicit and/or occurred in an interpersonal manner rather than via computerized methods – we suspect that greater acoustic changes might have observed as result of a greater emotional response.

Participants in this study were screened for vocal complaints and excluded if they reported a voice handicap even to the extent that someone with mild clinical voice impairment would. However, the acoustic measures selected for this study were chosen for their validity in clinically voice-impaired populations. Thus, it is possible that these measures were not sufficiently sensitive to capture the fine changes occurring in this cohort of healthy voices. In their research, Awan et al. (2010) observed that L/H spectral ratio SD and CPP SD can present differently in connected speech for normal voice users as opposed to disordered voices - especially in connected speech. As the normal voice alternates between consonants and vowels, natural transitions between periodic to aperiodic speech signals account for an increased variability of dysphonia. These transitions are not similarly drastic in dysphonic voices (Awan, Roy, Jette, et al., 2010). While this limitation is worth noting and should be considered, these measures are nevertheless the best tools currently available for acoustic analysis.

7.2 RESEARCH QUESTION 2

No statistical support for our hypothesis in **RQ2**—that those participants who identify as "laryngoresponders" exhibit unique hallmarks of vocal acoustics—was found in the current study. Difficulties with fully addressing this question included overall sample size, as well as the size of the "laryngoresponder" group as determined by the "vulnerable systems hypothesis". The latter

was dealt with by narrowing the qualifications of the designation for a "laryngoresponder" as established in the research question. As nearly all participants identified the "voice and/or neck as a recurring source of concern", we instead narrowed the cohort down to only those participants whose "neck" concerns were localized to the area of the larynx, or if they specifically mentioned the voice, swallowing difficulties, or throat tightness.

As discussed previously in the discussion section pertaining to Research Question 1, the sensitivity of our acoustic measures may be insufficient to tease out subtle vocal changes in this cohort of vocally healthy participants. With regards to the acoustic hallmarks presented by laryngoresponders, it is worth considering that acoustic changes may be reduced due to the individual's suppression of their vocal response to stress (Scherer, 1986). The *Trait Theory of Voice Disorders* (Roy et al., 2000a) incorporates Constraint as one of the personality characteristics associated with a predisposition to develop a voice disorder, and 100% of laryngoresponders in this study were shown to have a moderate level of this personality trait (*MPQ-BF).* Further analyses should be done prior to drawing definitive conclusions on this matter. While our predictions were not borne out in primary analyses, some compelling trends were observed in exploratory analyses, in which we compared laryngoresponders and non-laryngoresponders with regard to past trauma.

7.3 EXPLORATORY ANALYSIS

In the interest of gaining a broader perspective about how voice and trauma might overlap, a great deal of data were collected. Exploration of these data has uncovered several intriguing

stories beyond the immediate scope of Research Questions 1 and 2. Specifically, commonalities within our group of laryngoresponders were interesting and perhaps worth future study.

On the whole, laryngoresponders exhibited higher scores of Trait Anxiety than did non-laryngoresponders. As discussed in Exploratory Analyses, the trait characteristic of anxiety (as determined by the *STAI)* was found to have a statistically significant relationship with the trauma measure of the total dissociation score (*DES*). The use of this particular measure of anxiety is somewhat limited for the present population, as it is primarily intended for assessing populations who experience a clinically relevant anxiety or dissociative disorder, however, previous reports that both anxiety and early adverse life effects might impact an individual's susceptibility to functional disorders of other body systems (Chang, 2004; Mussell et al., 2008) encourages further inquiry into anxiety as it relates to functional disorders of the voice.

While the majority of personality characteristics between our laryngoresponders and non-laryngoresponders were fairly uniform, a notable disparity between the groups was found in absorption as measured by both the *DES* and the *MPQ-BF*. Altogether, these findings represent an unexpected area of interest, particularly in light of the widely accepted *Trait Theory of Voice Disorders* (Roy et al., 2000a) and its assertion that personality can predispose a person to long-term functional patterns or disorders of the voice. Interestingly, absorption is said to be strongly linked to the personality trait of neuroticism (Spindler & Elklit, 2003) – one of the "superfactor" traits believed to be associated with impulsive behavior, an excessive degree of voice use, and increased risk of vocal fold nodules (Roy et al., 2000b).

Finally, reporting a past history of emotional neglect (*CTQ)* was the most unifying trauma variable for laryngoresponders, with 83.3% (n=5) reporting emotional neglect as a part of their childhood experience. If this finding is recapitulated in future studies containing larger samples of

laryngoresponders, it would help to corroborate a psychoclinical perspective that if a person feels they are unimportant, or their needs remain unmet or ignored, they will cease expressing their feelings and their needs (Austin, 2009). Broadly, the experience of emotional abuse has a negative impact an individual's communication. A deeper look into the relationship between emotional neglect and "ideal" communication led us to find that those participants who had experienced emotional neglect (n=13, or 44.82% of all participants) did in fact report having experienced less "ideal" internal and external communication during and after traumatic experiences than the participants who had not experienced emotional neglect. These findings are also supported by the clinical observation that it is not uncommon for a patient who presents with a functional voice disorder to admit that they are sometimes known to limit their verbal communication at a general level, to hold in their verbalization of emotional state, or even to engage in frank breath-holding behaviors.

These exploratory findings are interesting, especially as they relate to much of our source material and clinical observation. Descriptive findings for this particular variable draw another intriguing connection between key players in this story – past trauma and communication. We are reluctant to give these trends too much weight, yet the findings are sufficiently compelling to warrant future exploration, ideally after further honing the "ideal" internal and external communication questions.

7.4 SYNTHESIS OF RESEARCH QUESTIONS 1 AND 2

We initially pursued both primary research questions as though acoustics and "neck responders" were wholly distinct phenomena. Research Question 1 sought to understand the acoustic features of past trauma, whereas Research Question 2 was aimed at understanding if any credence could be given to the "vulnerable systems hypothesis" by identifying relationships between "neck responders" and acoustic characteristics. One takeaway of this study is that while our acoustic measures might not be sensitive enough to identify past trauma, the self-identified laryngoresponders *do* seem to share some commonalities with regard to past trauma.

Given that in voice, the physiologic gesture gives rise to acoustic output, it stands to reason that if we could fill a study with laryngoresponders, acoustic features of trauma might become more evident. The fact that our small sample of laryngoresponders showed quantitatively more trauma leads us to wonder if laryngoresponders are simply individuals whose vulnerable body system is the laryngeal region, or if "laryngoresponder" could perhaps be a physical metric of trauma severity. As discussed earlier in this paper (see Exploratory Analyses) laryngoresponders differed from their counterparts on 75% of our trauma measures – scoring *worse* in areas of trauma exposure and severity. A similar observation was not made with our Front Neck Responders, indicating that the "laryngoresponder" categorization is more sensitive than a "front neck responder" categorization, with respect to vocal characteristics and complaints.

This observation seems fundamental to pursuing the current line of questioning, as it supports the idea that a relationship exists between personal history and the larynx (and by proxy, the voice) as a vulnerable body system. This proposal is bolstered by our current understanding of and direct interactions with clinical patients presenting with a functional voice disorder. Despite

the inconclusiveness of the current study at large, this discovery alone serves as an affirmation that there is a story waiting to be told, and that story is one worth pursuing. The work represented on these pages is the first step towards uncovering that story, and it is intended to improve and strengthen subsequent work. We will emphasize that our interpretations are speculative, but it does seem worthwhile to further probe the relationship between laryngoresponders, voice-related physiology, and vocal features, both independently and in the context of trauma.

7.5 LIMITATIONS

This preliminary study had multiple limitations, largely pertaining to methods for obtaining speech samples, speech stimuli administration, sample size, and homogeneity of participants. First, several aspects of acoustic recording measures unintentionally violated preferred protocol (Patel et al., 2018). Procedures utilized when recording speech samples for the present study included recording only one sustained vowel for each of the 4 speech samples. It is customary, however, to record three repeated sustained vowels during each instance of collecting a speech sample. Acoustic values are obtained by selecting steady portion of each repeated vowel, the average values of which are then calculated to determine (1) mean fundamental frequency and measures of its variation, (2) mean vocal intensity and measures of its variation, (3) cepstral peak prominence and measures of its variation, and (4) low/high spectral ratio and measures of its variation. This ensures a more accurate representative of the speaker's habitual vocal use, rather than looking at only one snapshot of their vocal use during one specific instance.

Regarding the calculation and evaluation of a speaker's vocal intensity, steps were taken to ensure a certain level of continuity between subjects. This included microphone placement and distance of the microphone from the speaker's mouth, and other environmental conditions (ambient noise levels, use of a sound shield in font of speaker). Most importantly, recorder settings and gain remained consistent between and within subjects. We did not, however, calibrate for intensity which would have given full assurance that intensity levels could be compared between subjects. Use of a sound level meter would have helped to improve the accuracy of inter-subject comparisons.

Noise levels in the room used for data collection were regularly tested. This included recording moments of silence or capturing only ambient noise. Those recordings were then analyzed via Praat, to check that they remained below the recommended 50 dB SLP (Romak et al., 2017). In hindsight, it would have been preferable to have at least 5 seconds of silence captured in speech samples, which would provide an opportunity to check for background noise throughout each session.

A second, minor limitation is that the order of Speech Sample stimuli (e.g. "Cookie Theft" and "Cat Rescue") was not changed throughout the course of data collection. This was a methodological oversight. Each participant interacted with these stimuli in the same manner; "Cookie Theft" before "Cat Rescue" in Phase I, and "Cat Rescue" before "Cookie Theft" in Phase II. In further iterations of the study, arrangements will be made to ensure that stimuli are appropriately counterbalanced and changed throughout the course of this study in order to reduce any possible order effect.

A third limitation has to do with our process of analyzing spontaneous speech samples. An advantage of using ADSV and measures of CPP and CSID is the ability to complete acoustic

analysis with continuous speech samples. Unlike using a scripted and uniform speech task (such as the CAPE-V sentences), inter-subject comparison is limited when analyzing spontaneous speech. More importantly, in paying attention only to the acoustic signal of speech, a wealth of information is being overlooked. Our paradigm would likely be enriched by looking more closely at other aspects of the speech signal (rate of speech, prosody, word choice, etc.), which would improve ecological validity and information depth in our research, though of course we would need to dramatically scale up our sample sizes. Similarly, the use of acoustic variables which focus on dysphonia is somewhat limiting when evaluating only vocally-healthy participants. It is possible that these measures of dysphonia are simply not sensitive enough to observe changes in these participants, adding further justification that it would be beneficial to consult additional aspects of the speech sample.

Finally, the participants represented in this study represented a fairly homogeneous population. Efforts were made to recruit participants from various areas and communities throughout the city of Pittsburgh, but our participants had an overwhelming homogeneity with respect to age and race. Their association with the University of Pittsburgh (many of the participants were students of the School of Health and Rehab Science) suggests similarities in interest, education level, and insight about the process of conducting research. We cannot draw any conclusions about whether these features of homogeneity had an impact on the overwhelmingly low degree of trauma disclosed by these participants, but this is also viewed as a limitation of the current study. Since trauma scores and the presence of neck responders→ laryngoresponders were central to this study's design, having a limited spread of trauma data and too large (neck responders) or small (laryngoresponders) a group of interest is a shortcoming of

the study. However, we are now well-positioned to pursue this line of inquiry with recruitment and inclusion/exclusion methods that strengthen our research paradigm.

8.0 FUTURE DIRECTIONS AND CONCLUSIONS

Throughout the course of the present study, several areas of improvement and further exploration have been identified. Future studies should make every effort to include more sufficiently powered cohorts of laryngoresponders and non-laryngoresponders in order to make appropriate comparisons between groups. Future studies would also benefit from participants with a greater degree of, and greater variation of traumatic experiences. Direct recruitment of such specific populations, however, is limited if certain biases are to be avoided. One easily accessible starting point would to place a greater focus on recruiting participants from varied backgrounds, communities and age groups.

Further development and validation of custom materials ("Ideal" Internal and External Communication questions and the Physical Report Form) should be pursued. "Ideal" Communication questions should be simplified for ease of participant understanding, and visual prompts and references for the defined "ideal" scenario should be provided for each participant. Feedback from participants and observations of the author agree that in their current form, the two internal communication questions and the two external communication questions are too similar, which leads to confusion about what each set of questions is asking. We propose that questions 2 and 4 should either be eliminated, or more clearly differentiated from questions 1 and 3.

The Physical Report Form elicited no negative participant feedback, but more strictly defined requirements regarding what qualifies an individual as a front neck responder or a laryngoresponder would be useful for ease of categorization. With additional clarity on this issue,

administrators could easily review each participant's form and immediately ask for further clarification in the case of any ambiguity.

Finally, it might be useful to attempt to tease out a bigger spread of vocal responses from participants. One possibility would be to have them more fully engage with their memories of past traumatic experiences. For instance, participants might verbally describe their past experiences, and that description might serve as the speech sample. Naturally, any such task would have to be managed with extreme care as this poses a greater than minimal risk to participants.

This exploratory study sought to identify relationships between vocal acoustics and past trauma, and to determine if acoustic features of so-called laryngoresponders could be identified. Although we did not identify statistically significant effects, we did collect a rich body of data to explore, and upon which we can base future research. Preliminary findings from this study suggest that the often-cited voice-trauma link may be legitimate, and with the right tools, measurable.

APPENDIX A– Supplemental Documents

Please See Next Page

A.1 INITIAL SCREENING FORM

University of Pittsburgh

Demographic Information

First Name

Last Name

Gender Identity

- ○ Cisgender Male
- ○ Cisgender Female
- ○ Not cisgender (i.e., transgender, non-binary, etc)

Phone Number

Email Address

Are you between the ages of 18 and 65?

- ○ Yes

- ○ No

Eligibility Questions

Are you pregnant?

- ○ Yes
- ○ No

Do you have difficulty hearing or understanding conversational speech without the use of hearing aids?

- ○ Yes
- ○ No

Do you have a history of problems with your voice or larynx, or have you ever been diagnosed with a voice or laryngeal disorder?

- ○ Yes
- ○ No
- ○ I don't know

Do you have a history of breathing or respiratory disorders? This includes obstructive lung diseases such as asthma or chronic obstructive pulmonary disease, and restrictive lung disease.

- ○ Yes
- ○ No
- ○ I don't know

Do you have a history of autonomic dysfunction or dysautonomia? This includes postural orthostatic tachycardia syndrome, inappropriate sinus tachycardia, vasovagal syncope, neurocardiogenic syncope, and orthostatic hypertension and hypotension.

- ○ Yes
- ○ No
- ○ I don't know

Do you have asthma?

- ○ Yes
- ○ No
- ○ I don't know
- ○ Probably not

Please enter your height in inches. (4' = 48"; 5' = 60"; 6' = 72")

How much do you weigh in pounds?

Powered by Qualtrics

A.2 PHASE I CONSENT FORM

University of Pittsburgh

School of Health and Rehabilitation Sciences
Department of Communication Science and Disorders

4033 Forbes Tower
Pittsburgh, Pennsylvania 15260
412-383-6540
Fax: 412-383-6555

CONSENT TO ACT AS A PARTICIPANT IN A RESEARCH STUDY

TITLE: Vocal Psychophysiology

PRINCIPAL INVESTIGATOR: Leah B. Helou, PhD. CCC-SLP
Department of Communication Science & Disorders
University of Pittsburgh
6080 Forbes Tower, Pittsburgh PA 15260
Telephone: 412-383-6541
Email: lbh7@pitt.edu

This study is supported by departmental funds associated with the Department of Communication Science and Disorders at the University of Pittsburgh.

Why is this research being done?

We are interested in identifying how your body responds during various speech and non-speech tasks, and as a function of your personality and/or past experiences.

Who is being asked to take part in this research study?

People invited to participate in this study must be healthy adults between 18-65 years of age. Participants will be ineligible if they have a known current pregnancy, or if they suspect they may currently be pregnant. Participants may not have any of the following: history of voice disorders; history of neck or throat surgery (e.g., thyroidectomy, parathyroidectomy, anterior cervical disc fusion, tracheostomy, or other structurally invasive procedures); history of clinically diagnosed severe manifestations of psychological disorders including depression, eating disorders, or anxiety and panic disorders; history of asthma or respiratory disorders (e.g., obstructive lung diseases such as asthma or chronic obstructive pulmonary disease, restrictive lung disease); history of blood clotting or coagulating disorders such as hemophilia; current upper respiratory illness or seasonal allergies that affect the respiratory system. Obese individuals (i.e., body mass index > 30) may not participate in this study. Also, participants may not have a history of autonomic dysfunction, or dysautonomia. Autonomic dysfunction usually affects different parts of the body and is not the same in everyone. People with autonomic dysfunction may have excessive thirst, excessive fatigue or tiredness, very fast or slow heart rate, feelings of panic or anxiety, or a number of other symptoms. Examples of autonomic disorders include postural orthostatic tachycardia syndrome (a condition associated with a large increase in heart rate when you stand up), inappropriate sinus tachycardia (fast heart rate), vasovagal syncope (repeated episodes of fainting in response to certain triggers), neurocardiogenic syncope (episodes of lightheadedness, fuzzy thinking, hot flashes, and other symptoms, which may result in fainting), and orthostatic hypertension or hypotension (increased or decreased blood pressure when you transition from sitting to standing). Up to 50 individuals will participate in this study.

What procedures will be performed for research purposes?

If you are eligible and decide to take part in this research study, you will undergo the following procedures. All procedures will take place at the University of Pittsburgh in Forbes Tower. These procedures may take up to two hours to complete. You are permitted to stop the research procedures at any time and withdraw from the study.

Completion of Questionnaires: You will be asked to fill out questionnaires that ask questions about how you physically and mentally feel when you are under stress and/or aspects of your personality. These typically take ~30 minutes to complete.

Experimental Procedures, in order of occurrence:

1. While you are sitting in an exam chair, we will place a blood pressure cuff on your arm, and non-invasive surface electrodes (sticky patches) on your shoulder, chest, torso, and leg that will measure electrical and movement activity of your body. We might also fit you with a stretchy band around your torso; ring-like devices on one hand; and/or a lightweight head-mounted microphone.
2. Using the equipment with which you are fitted, we will record the activity of your body for several minutes.
3. We might ask you to breathe at four different rates (i.e., a specific number of breaths per minute), for about two minutes per rate. You will get a short break between each condition, and the whole task will take about 15 minutes.
4. We might ask you to watch a video designed to help you relax. While you are resting, we will record from the electrodes. You will not have to do anything during this period of time, which will last just a few minutes.
5. Next, we will ask you to engage in a speech task for several minutes.
6. Finally, you will rest for up to five minutes while we continue recording from the equipment.
7. At various stages in this experiment, we might also ask you to provide speech samples, self-rate your stress and anxiety at that moment, and/or use a form to tell us what part(s) of your body are giving you discomfort now or in the past. We might also perform a diaphragm ultrasound, which will require that we put gel near your lower ribs and press a probe against your skin. Diaphragm ultrasound is entirely painless and non-invasive. The investigator will tell you specifically if diaphragm ultrasound will be performed during your time in this study.

What are the possible risks, side effects, and discomforts of this research study?

The possible risks of this research study are minimal. You might find the experimental procedures to be boring, or you might experience very mild discomfort from the equipment which will be fitted to various parts of your body. Some people with sensitive skin will experience redness where electrodes were attached, lasting from minutes to days.

What are possible benefits from taking part in this study?

You will receive no direct benefit from taking part in this research study. This study will contribute to the body of knowledge about how the body responds to simple speech and non-speech tasks.

Will my insurance provider or I be charged for the costs of any procedures performed as part of this research study?

Neither you, nor your insurance provider, will be charged for the costs of any of the procedures performed for the purpose of this research study. We will not request any information regarding your health insurance.

Will I be paid if I take part in this research study?

You will be paid $10 for completing this study. If your participation takes longer than the expected two hours, you will be compensated an additional $10 for each subsequent hour that you participated in this study.

Who will know about my participation in this research study?

Any information about you obtained from this research will be kept as confidential (private) as possible. All records related to your involvement in this research study will be stored in a locked file cabinet. Your identity on these records will be indicated by a case number rather than by your name, and the information linking these case numbers with your identity will be kept separate from the research records. You will not be identified by name in any publication of the research results.

Will this research study involve the use or disclosure of my identifiable medical information?

No. Apart from the medical history questions that have already been asked as part of the screening procedures for this study, we do not collect identifiable medical information from you or from your medical records as part of this research study.

Who will have access to identifiable information related to my participation in this research study?

In addition to the investigator listed on the first page of this authorization (consent) form and their research staff, the following individuals will or may have access to identifiable information (which may include your identifiable medical information) related to your participation in this research study:

> Authorized representatives of the University of Pittsburgh Research Conduct and Compliance Office may review your identifiable research information (which may include your identifiable medical information) for the purpose of monitoring the appropriate conduct of this research study.
>
> In unusual cases, the investigators may be required to release identifiable information (which may include your identifiable medical information) related to your participation in this research study in response to an order from a court of law. If the investigators learn that you or someone with whom you are involved is in serious danger or potential harm, they will need to inform, as required by Pennsylvania law, the appropriate agencies.

For how long will the investigators be permitted to use and disclose identifiable information related to my participation in this research study?

The investigators may continue to use and disclose, for the purposes described above, identifiable information (which may include your identifiable medical information) related to your participation in this research study for a minimum of seven years after final reporting or publication of a project.

Is my participation in this research study voluntary?

Your participation in this research study is completely voluntary. Whether or not you provide your consent for participation in this research study will have no effect on your current or future relationship with the University of Pittsburgh.

May I withdraw, at a future date, my consent for participation in this research study?

You may withdraw, at any time and for any reason, your consent for participation in this research study, to include the use and disclosure of your identifiable information for the purposes described above. Any identifiable research or medical information recorded for, or resulting from, your participation in this research study prior to the time that you formally withdrew your consent may continue to be used and disclosed by the investigators for the purposes described above.

To formally withdraw your consent for participation in this research study you should provide a written and dated notice of

this decision to the principal investigator of this research study at the address listed on the first page of this form.

Your decision to withdraw your consent for participation in this research study will have no effect on your current or future relationship with the University of Pittsburgh.

If I agree to take part in this research study, can I be removed from the study without my consent?

It is possible that you may be removed from the research study by the researchers if you appear to be having a stronger-than-expected negative response to any of the procedures. If you are withdrawn from participation in this research study prior to completion of the experimental tasks, you will be compensated $10.

****

VOLUNTARY CONSENT

The above information has been explained to me and all of my current questions have been answered. I understand that I am encouraged to ask questions about any aspect of this research study during the course of this study, and that such future questions will be answered by a qualified individual or by the investigator(s) listed on the first page of this consent document at the telephone number(s) given. I understand that I may always request that my questions, concerns or complaints be addressed by a listed investigator.

I understand that I may contact the Human Subjects Protection Advocate of the IRB Office, University of Pittsburgh (1-866-212-2668) to discuss problems, concerns, and questions; obtain information; offer input; or discuss situations that have occurred during my participation.

By signing this form, I agree to participate in this research study. A copy of this consent form will be given to me.

_____	_____	_____
Participant's Signature	Printed Name of Participant	Date

CERTIFICATION of INFORMED CONSENT

I certify that I have explained the nature and purpose of this research study to the above-named individual(s), and I have discussed the potential benefits and possible risks of study participation. Any questions the individual(s) have about this study have been answered, and we will always be available to address future questions as they arise. I further certify that no research component of this protocol was begun until after this consent form was signed.

_____	_____
Printed Name of Person Obtaining Consent	Role in Research Study
_____	_____
Signature of Person Obtaining Consent	Date

A.3 PHASE I CONSENT FORM SCRIPT

"Thank you for coming in today. Before we get started, I need to make sure that you understand what I will be asking you to do today, and please ask questions you may have.

This study looks at how our bodies and voices work together. Tasks include filling out some surveys on the computer or on paper, and recording a few short speech samples.

Throughout this session we're also going to collect some physiological data, which means that we'll collect information about your heart rate, pulse, respiration, and muscle activity. To do this we'll connect some sticky electrode pads on your face, neck and chest, wrap a respiration monitor around your chest. All equipment will sit outside the body and will be painless. Once we set that up you'll be able to ignore it - you will not be asked to complete any physical or movement tasks.

You've been given some time to look over this consent form since we sent it to you at home, but I'd like to point out a few things before we proceed. I'm going to ask you to take a look and sign this shortly, and I'd like you to go through it on your own, but there are a few things that I would like to point out.

- Signing this consent form shows us that you are willingly participating in this study today, and it also says that you agree to let us save and use any information that you provide during your participation.

- You will receive no direct benefit from taking part in this research study, but your participation will contribute to the body of knowledge about how the body responds to simple speech and non-speech tasks.

- Through your participation, risks to you are minimal. They include slight discomfort due to the equipment that you will be fitted with, and fatigue or boredom with questionnaires that you will be asked to complete.

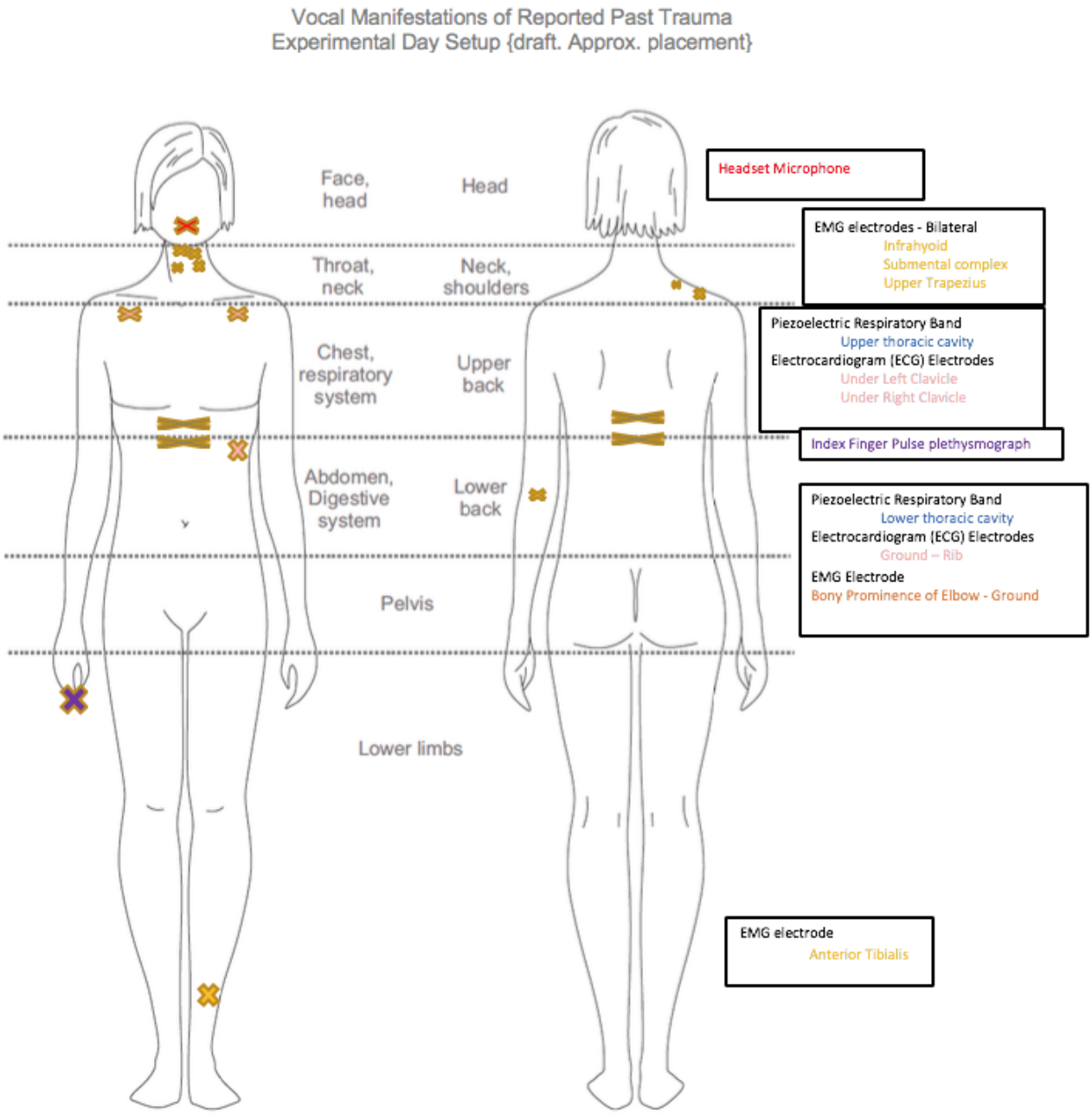
- At any point during our time together you can choose to end this experiment. This can be for any reason from you getting bored to just not liking the smell of this room or the way I dressed today! You have the final say in everything we do today. And regardless of how long you stay, you will receive the $10 per hour that you were promised in exchange for your participation.

- At the conclusion of these tasks I am going to give you the option of continuing with another set of *very* similar tasks. Simply stated, we'd be repeating the same study with slightly different questions, so I'll ask you then whether you would like to continue on or conclude our time together at that point. Again, there's no need for you to think about that now, I just wanted to give you a little heads up that this option will be open to you. All and all, I still don't expect us to be here long than 2 hours.

Finally, I'd also like to reassure you that everything that we discuss or record today will remain confidential. Nobody will be able to connect your name to your answers, your data, or anything we discuss together.

Take a few moments to review this consent form. It outlines some of our procedures and ask you whether or not you would like to continue. If you choose to participate, once you sign, we can get started. *What questions do you have for me?*

A.4 EXPERIMENTAL DAY SETUP & SCRIPT



Any additional physiologic equipment placement and calibration (via maximum voluntary contraction tasks) will be performed and verified according to procedures described in the larger study.

Placement of Electrodes and Respiratory Band

"To get us started, we are going to place several electrodes on your skin that will measure your heart rate and your muscle activity. They will be on your face, neck, shoulder, ribs, chest, and leg. To make sure they stick, we will prep your skin with an alcohol wipe. We might put a little gel on the electrode to help make the signal strong; it will wipe off easily when we are finished with the study. Also, we will put an elastic band around your torso, which will give us some information about your breathing. Please just try to lie here and relax while we get these items in place."

Place equipment.

"Thank you, everything is in place. Because there are so many wires here, we are going to ask you to stay still—but as relaxed as possible, not stiff or rigid—for most of the experiment. If you need to make any big adjustments to how you are positioned, please let one of us know as we might need to help you do it without pulling on the equipment."

Baseline Values

"Are you comfortable?" *Allow participant to make physical adjustments if needed.* "For the next few minutes, we want you to just lie here and try to remain still and relaxed." *Draw participant's attention to laptop computer with video of neutral emotional stimuli.* "Try to just watch this video and allow your attention to be on it for the next few minutes. Please refrain from talking, coughing, clearing your throat, and otherwise using your voice." *Begin recording when participant is settled and still.*

A.5 SPEECH SAMPLE STIMULI & SCRIPT

CAPE-V Sentences & Spontaneous Speech Sample Script

"On these two sheets of paper are a list of sentences and a cartoon. Please read each sentence in your natural speaking voice, and then take approximately 30 seconds to describe the cartoon. I would like for you to speak for as much of the 30 seconds as possible, so if I haven't told you that your time is up, please try to find something to say about the picture in front of you."

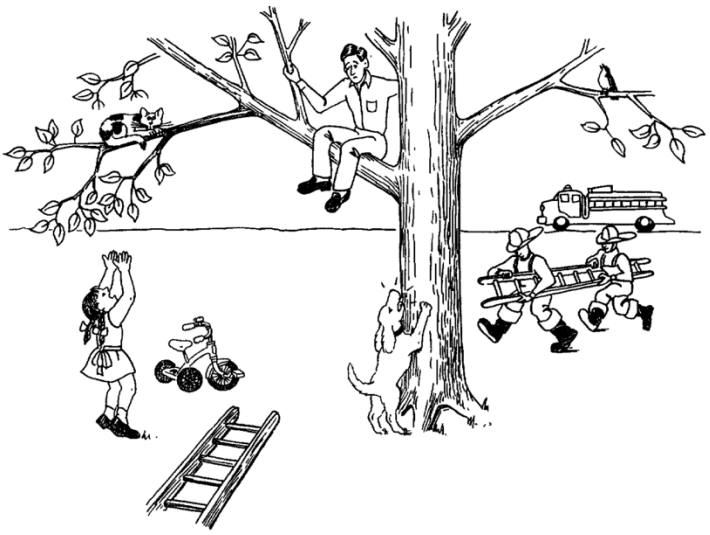
Prompt if needed: "Can you tell me anymore?"

CAPE-V Sentences

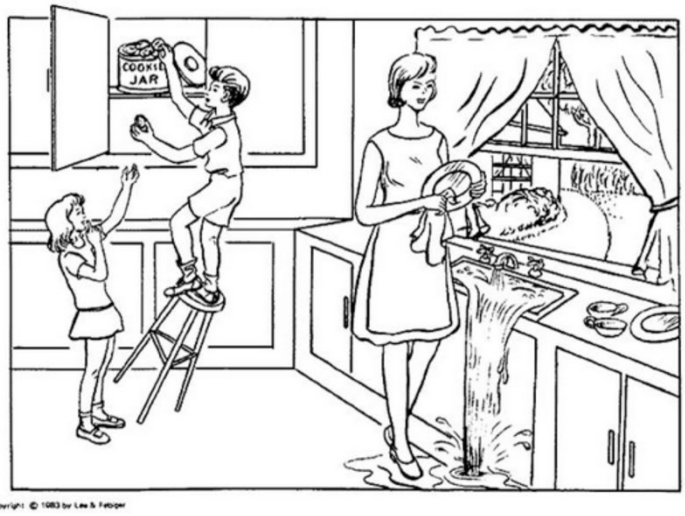
1. The blue spot is on the key again.	4. We eat eggs every Easter.
2. How hard did he hit him?	5. My mama makes lemon muffins.
3. We were away a year ago	6. Peter will keep at the peak

Spontaneous Speech Sample Stimuli

"Cat Rescue" (Nicholas & Brookshire, 1993)



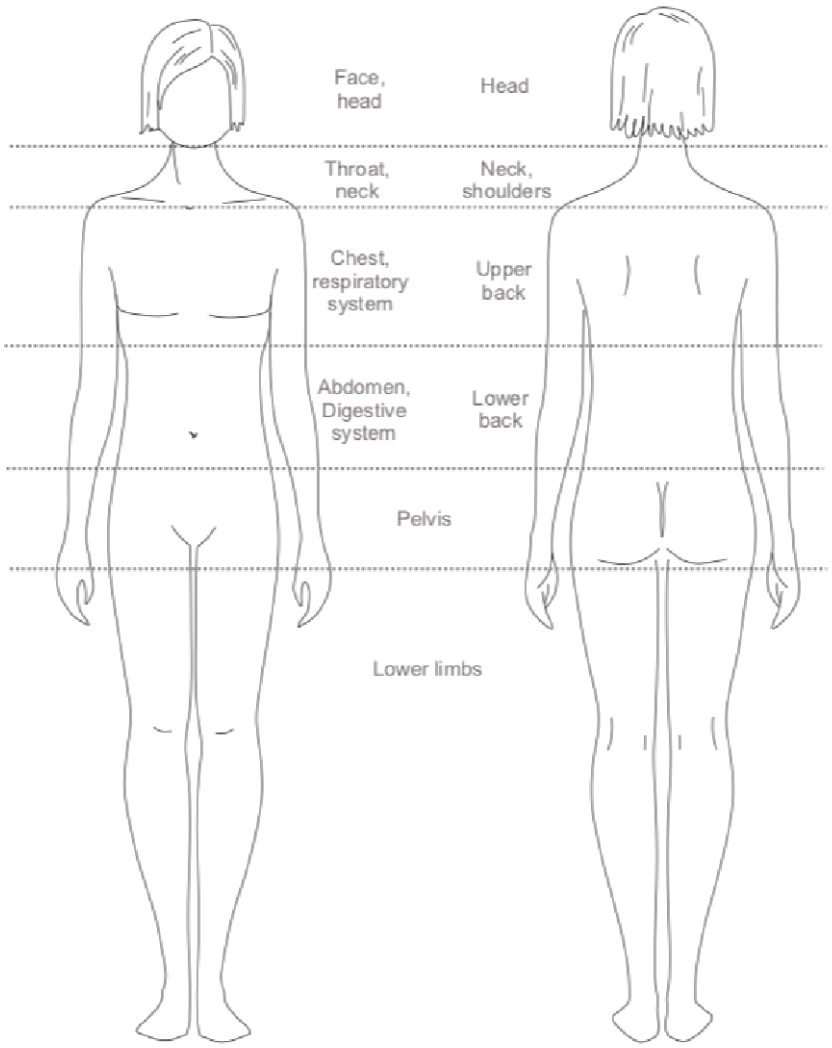
“Cookie Theft” (Kaplan, Goodglass, & Weintraub)



A.6 PHYSICAL REPORT FORM

Participant:_____

Date: _____



Please describe

Suspected Conditions:

Diagnosed Conditions:

Phase I Physical Report Form Administration Script

"I would like for you to spend a little time considering this next form. *We are very interested in how different people physically experience, or feel stress or other heightened emotion.* Everybody has a different physical reaction to feeling stress or heightened emotion, and sometimes they can identify a specific part of their body that feels more vulnerable than other parts. Some people have irritable bowel syndrome, other people get headaches, some people have chronic low back pain or eczema, and so on. Some people have more problem areas than others. Some people get diagnosed with specific disorders, and others experience the discomfort but don't get a diagnosis. On this form, I'd like for you to identify the parts of your body that tend to be problem areas for you, in your past and right now. You don't need to indicate if you broke your arm once and it then healed perfectly, because I'm really looking the areas that show a *pattern or history of vulnerability* for you.

Using the blue colored pencil provided to you, please mark the parts of this figurine that correspond to your problem areas. Take a few minutes to scan this figure from head to toe and see if anything comes to mind. If you're not sure whether a specific item should be included, just write it down. There are no wrong answers and the more info the better. I'll give you about 3-5 minutes to fill this out. I'll keep time, so no need for you to worry about that. Do you have any questions?"

Phase II Physical Report Form Administration Script

"It's been a few minutes since you've seen this form, but I wanted you to take another look at it and think about whether there is any information that you'd like to add to it. Maybe there is something that didn't occur to you before. I'd like you to use this green pencil for that. Or maybe there is something new that you're feeling right now or that comes up for you in the next few minutes. Please use the orange pencil for that.

I am interested in all any information that you have to share, so if you're not sure if something should be included, just write it down.

I'll give you about 1-2 minutes to think about this now, but you can hold onto it until the end of our time together. You can add or update it whenever you'd like. Do you have any questions? Then you can begin whenever you're ready."

A.7 PHASE II CONSENT SCRIPT

"Thank you for your participation in this study so far. At this point, we are approximately halfway finished with the total duration of experimental time that we asked you to set aside today. There's a bit of a surprise element now, and you will have a decision to make.

We are interested in knowing a bit about your history of trauma throughout your life, from early childhood until now. If you decide to continue in the second half of this experiment – and it is entirely your decision -- we have 2 items that we will ask you to complete. They are self-reported questionnaires of trauma. They might elicit little or no response from you, and they might be highly triggering to you; of course, I can't know what your response might be. In addition to these tasks, we will ask you to provide another speech sample and complete the figurine again, and generally keep this testing environment the same.

So at this point, you have the opportunity to consider if you want to continue this experiment and provide us with some information about your past experiences, knowing that they might change your mood and emotional state, or you can choose to end this experiment earlier than you had anticipated. Either way, you will receive the $10 that you were promised.

Take your time to think about this, and ask me any questions you might have. If you agree to participate in the next portion of this study, sign here, and if you decline to participate, sign here."

A.8 PHASE II CONSENT FORM

University of Pittsburgh

School of Health and Rehabilitation Sciences
Department of Communication Science and Disorders

4033 Forbes Tower
Pittsburgh, Pennsylvania 15260
412-383-6540
Fax: 412-383-6555

CONSENT TO ACT AS A PARTICIPANT IN A RESEARCH STUDY – ADDENDUM

TITLE: Vocal Psychophysiology

PRINCIPAL INVESTIGATOR: Leah B. Helou, PhD. CCC-SLP
Department of Communication Science & Disorders
University of Pittsburgh
6080 Forbes Tower, Pittsburgh PA 15260
Telephone: 412-383-6541
Email: lbh7@pitt.edu

Why am I being asked to sign a new consent form?

We have completed the first goal of today's visit, which was to examine how your body responds during various speech and non-speech tasks, and as a function of your personality. At this stage, we have new information to offer you about this study. Specifically, we recruited participants who might be willing to share information about their past experiences. However, it is important that we tell you our interest is in understanding how people's bodies respond as a function of their past experiences. We would like to invite you to complete Part II of this study, which involves completing questionnaire(s) related to your past experience of trauma.

Why didn't you tell me about this earlier?
Because traumatic experiences are, by definition, traumatic, many people might feel distressing emotions if they are expecting to complete trauma questionnaires. Because stress and anxiety are associated with body responses, the anticipation of trauma questionnaires might have influenced the data we collected up to this point.

What are my options at this stage?

You have three options at this point:

(1) You are not obligated to complete any of these questionnaires. You may stop the research procedures now and end your time in the study. If you decide to do that, the data that we collected up to this point will still be useful for our research.

(2) You can agree to complete a series of questionnaires, some of which will ask you about experiences you might feel were traumatic. These questionnaires would be delivered to you on one of our devices (e.g., tablet or laptop) while you remain seated as you have done up to this point. We will continue collecting data about your body's activity, as we have been doing already today. If you begin completing the questionnaires and decide that you don't want to continue, just let us know and we will end the study immediately. The questionnaires take about fifteen minutes to complete in their entirety, and we will want to record your body activity for a few more minutes after that. Thus, your time left in this experiment will be approximately twenty-five minutes if you choose to complete these questionnaires.

(3) If you wish to continue in the study but do not want to complete the questionnaires, you might have the option instead to engage in one more task involving speech and non-speech performance. This task might feel more demanding than the ones you have already engaged in today. As with the previous options, you may discontinue your participation in this task at any time.

What are the possible risks, side effects, and discomforts of this research study?

Some people might feel distressing emotions when they complete the questionnaires, since recalling past events can trigger difficult emotions and memories. Depending on your own response to these questionnaires, you might experience stress, anxiety, emotional pain, distress, and physical responses associated with recalling your past history. This could happen here during the research study, or later once you have left. If you find that your participation in this study has triggered you in a way that feels harmful, you can end participation in this study at any time, take extra time in this room at the end of the study before leaving, and/or ask to be given contact information for local therapists. Finally, since this study involves collecting and storing private health information, there is a risk of breach of confidentiality.

What are possible benefits from taking part in this study?

You will receive no direct benefit from taking part in this research study. This study will contribute to the body of knowledge about how the body responds to simple speech and non-speech tasks as a function of past experiences.

Will I be paid if I take part in this research study?

You will be paid $10 for completing this study. Your payment will be given via a reloadable debit card. Since you are being compensated for your participation in this study, your name, address, and social security number will be released to the Accounting Office. If the total reimbursement for your participation in research is greater than $600 in a year, this will be reported to the Internal Revenue Service (IRS) as income.

Who will know about my participation in this research study?

Any information about you obtained from this research will be kept confidential (private). All records related to your involvement in this research study will be stored in a locked file cabinet. Your identity on these records will be indicated by a case number rather than by your name, and the information linking these case numbers with your identity will be kept separate from the research records. You will not be identified by name in any publication of the research results.

Will this research study involve the use or disclosure of my identifiable medical information?

No. Apart from the medical history questions that have already been asked as part of the screening procedures for this study, we do not collect identifiable medical information from you or from your medical records as part of this research study.

Who will have access to identifiable information related to my participation in this research study?

In addition to the investigator listed on the first page of this authorization (consent) form and their research staff, the following individuals will or may have access to identifiable information (which may include your identifiable medical information) related to your participation in this research study:

Authorized representatives of the University of Pittsburgh Research Conduct and Compliance Office may review your identifiable research information (which may include your identifiable medical information) for the purpose of monitoring the appropriate conduct of this research study.

In unusual cases, the investigators may be required to release identifiable information (which may include your identifiable medical information) related to your participation in this research study in response to an order from a court of law. If the investigators learn that you or someone with whom you are involved is in serious danger or potential harm, they will need to inform, as required by Pennsylvania law, the appropriate agencies.

For how long will the investigators be permitted to use and disclose identifiable information related to my participation in this research study?

The investigators may continue to use and disclose, for the purposes described above, identifiable information (which may include your identifiable medical information) related to your participation in this research study for a minimum of seven years after final reporting or publication of a project.

Is my participation in this research study voluntary?

Your participation in this research study is completely voluntary. Whether or not you provide your consent for participation in this research study will have no effect on your current or future relationship with the University of Pittsburgh.

May I withdraw, at a future date, my consent for participation in this research study?

You may withdraw, at any time and for any reason, your consent for participation in this research study, to include the use and disclosure of your identifiable information for the purposes described above. Any identifiable research or medical information recorded for, or resulting from, your participation in this research study prior to the time that you formally withdrew your consent may continue to be used and disclosed by the investigators for the purposes described above.

To formally withdraw your consent for participation in this research study you should provide a written and dated notice of this decision to the principal investigator of this research study at the address listed on the first page of this form.

Your decision to withdraw your consent for participation in this research study will have no effect on your current or future relationship with the University of Pittsburgh.

If I agree to take part in this research study, can I be removed from the study without my consent?

It is possible that you may be removed from the research study by the researchers if you appear to be having a stronger-than-expected negative response to any of the procedures. If you are withdrawn from participation in this research study prior to completion of the experimental tasks, you will be compensated $10.

****

VOLUNTARY CONSENT

The above information has been explained to me and all of my current questions have been answered. I understand that I am encouraged to ask questions about any aspect of this research study during the course of this study, and that such future questions will be answered by a qualified individual or by the investigator(s) listed on the first page of this consent document at the telephone number(s) given. I understand that I may always request that my questions, concerns or complaints be addressed by a listed investigator.

I understand that I may contact the Human Subjects Protection Advocate of the IRB Office, University of Pittsburgh (1-866-212-2668) to discuss problems, concerns, and questions; obtain information; offer input; or discuss situations that have occurred during my participation.

By signing this form, I agree to participate in this research study. A copy of this consent form will be given to me.

Participant's Signature	Printed Name of Participant	Date

CERTIFICATION of INFORMED CONSENT

I certify that I have explained the nature and purpose of this research study to the above-named individual(s), and I have discussed the potential benefits and possible risks of study participation. Any questions the individual(s) have about this study have been answered, and we will always be available to address future questions as they arise. I further certify that no research component of this protocol was begun until after this consent form was signed.

Printed Name of Person Obtaining Consent	Role in Research Study
Signature of Person Obtaining Consent	Date

A.9 "IDEAL" INTERNAL AND EXTERNAL COMMUNICATION

Administration script and question were read aloud. Answers recorded via Qualtrics.

Administration Script: *Everyone experiences difficult, painful, and even traumatic things at some point in life. There is reason to believe that the ability to communicate your feelings and the details of your experience might play a role in how you process that experience. We asked psychologists, counselors, and therapists to describe the ideal communication scenario during difficult experiences. I'm going to read you their consensus. Keeping in mind that this is about how we communicate with others and ourselves about difficult and potentially scary experiences, and not about rewriting what happened, I'll ask you to rate each scenario in terms of what proportion of your experiences were like that scenario. For those experiences that have stuck with you in a bad way, how true was each scenario for you. So, here are the two scenarios:*

(1) <u>Ideal communication – EXTERNAL</u>

During and/or after the difficult experience the person…

- Was physically able to verbally express
- Had access to some kind of safe space or safe person, wherein you could be heard by someone. Not only were they heard, but that person also empathized with them, and welcomed and supported their communication.

Please answer the following via sliding scale listed below.

What proportion of your experiences were like this situation?

_____

None of them Some of them All of them

Considering the experiences that have stuck with you the most, how true was this scenario for you?

_____

Not at all true Somewhat true Very true

(2) <u>Ideal communication – INTERNAL</u>

During and/or after the difficult/scary/traumatic (not sure we need all three descriptors) experience, the person…

- Had the verbal ability to process the situation
- Was aware that some part of your situation was not good
- Recognized their feelings were valid and were important, and they would be to others, as well.

Please answer the following via sliding scale listed below.

What proportion of your experiences were like this situation?

_____

None of them Some of them All of them

Considering the experiences that have stuck with you the most, how true was this scenario for you?

_____

Not at all true Somewhat true Very true

A.10 PHASE I AND II COMPLETION SCRIPT

To be used if the participants declines participation in Phase II.

"Thank you very much for your participation in our research study. If you have any further questions at this point or in the future, please do not hesitate to contact myself or Dr. Leah Helou. You can always reach out to us through the lab email at pittvoicelab@gmail.com."

To be used if the participants completes participation in Phase II.

"Thank you very much for your participation in our research study.

I understand that some of the questions you were asked today might have brought up some unpleasant feelings or memories. I am happy to help connect you to a local therapist should you have any interest in discussing these feelings further.

If you have any additional questions at this point or in the future, please do not hesitate to contact myself or Dr. Leah Helou. You can always reach out to us through the lab email at pittvoicelab@gmail.com."

A.11 RECRUITMENT MATERIALS

Subjects Needed for Voice Research

If you are a healthy, native English speaker between the ages of 18 – 65 yrs, you may be eligible for a research study to examine how the body responds when reviewing your personality traits and past experiences.

The study will take place in Forbes Tower at the University of Pittsburgh (enter Forbes Tower on Atwood St. between Forbes Ave. and Sennott St.) and will take approximately two hours. This study will involve the completion of some questionnaires related to your personality and past experiences. In addition, you will engage in brief speech and non-speech tasks while activity in various parts of your body is measured. All measurements are non-invasive and painless.

You will be compensated $10 per hour for completing the study.

If interested, please email Helou.Laboratory@gmail.com with "interested in ExpB" in the subject line. You will then be sent a link to a web-based survey to determine if you are eligible to participate in this research study.

Principal Investigator: Leah B. Helou, Ph.D., Communication Sciences and Disorders, School of Health and Rehabilitation Sciences, University of Pittsburgh, 6080 Forbes Tower, Pittsburgh, PA 15260, (412) 383-6541, lbh7@pitt.edu.

type " interested in ExpB" in subject line helou.laboratory@gmail.com

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type " interested in ExpB" in subject line helou.laboratory@gmail.com
type " interested in ExpB" in subject line helou.laboratory@gmail.com

A.12 RECRUITMENT SCRIPTS

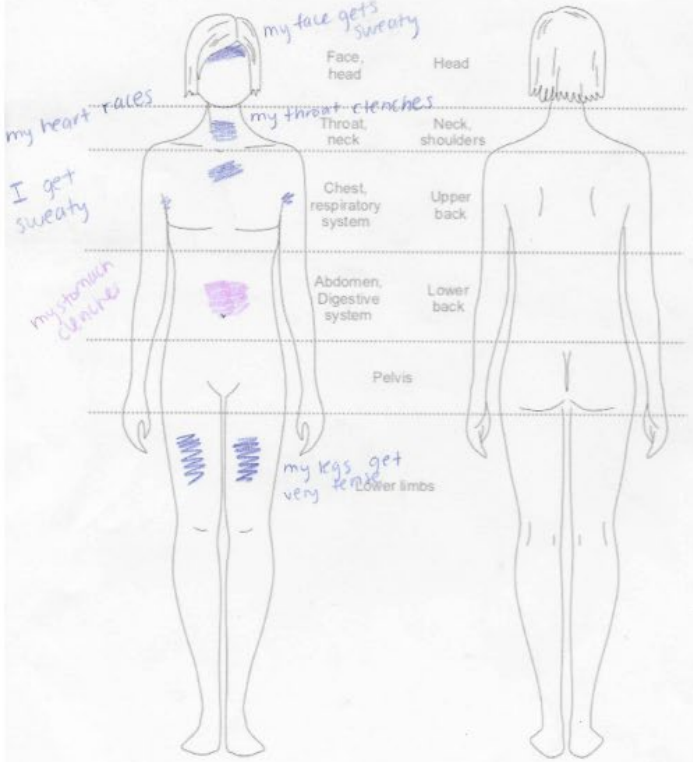
Hello! We are recruiting for a research study that examines how various parts of your body respond to simple speech and non-speech tasks. Participants will come to Forbes Tower on the University of Pittsburgh campus, and will be fitted with various pieces of equipment that will measure physiological activity during the experiment. All of the equipment sits on the outside of the body and is painless. The experiment can last as little as one hour and up to two hours, and participants will be reimbursed $10 for participation. If you are interested in participating, please email pittvoicelab@gmail.com with the word "Interested in ExpB" in the subject line. Or, I am circulating a sheet where you can write your contact information if you prefer that we contact you. We will send you a link to a web-based survey that will help us determine your eligibility. If you are eligible, we will go ahead and send you consent forms to review and some questionnaires to complete about your personality. We will also schedule your experimental date at that time.

APPENDIX B

B.1 PHYSICAL REPORT FORMS

Please see next page

Participant: V T001

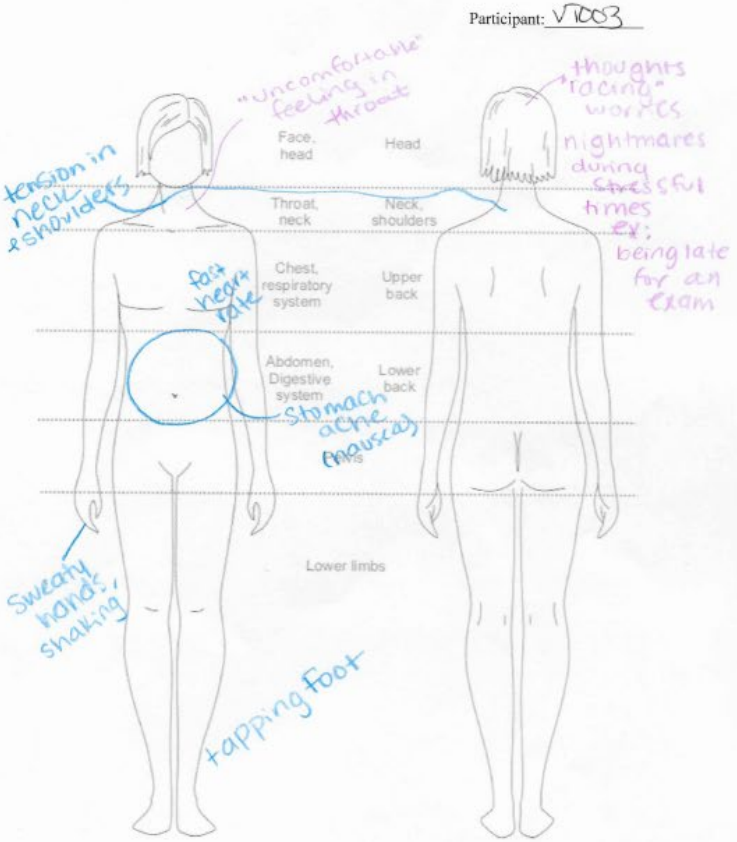


Please describe

Suspected Conditions:

Diagnosed Conditions:

Participant: V T003

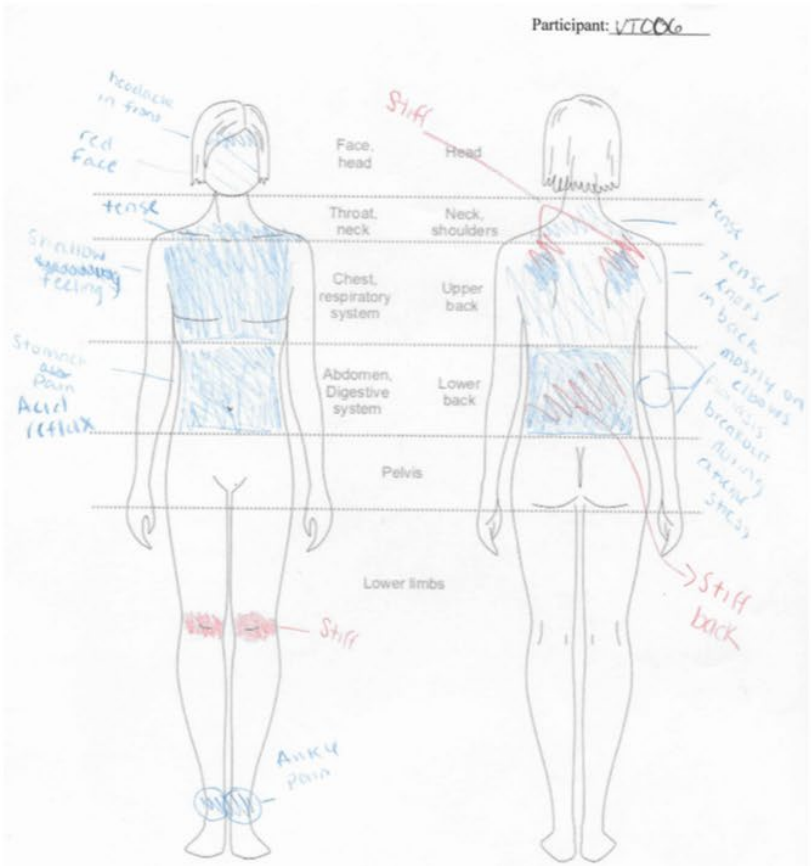


Please describe

Suspected Conditions:

Diagnosed Conditions:

Participant: VT006

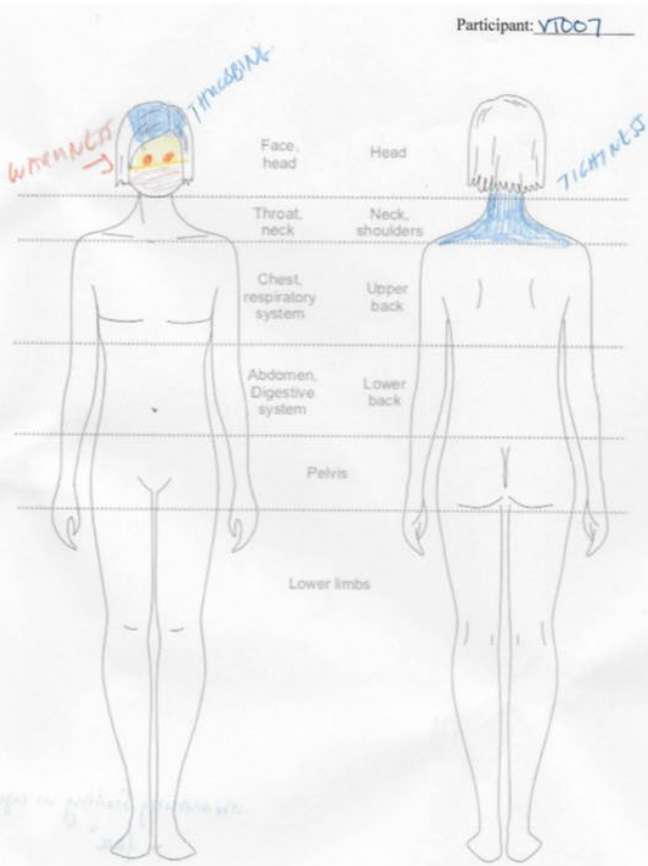


Please describe

Suspected Conditions:

Diagnosed Conditions:

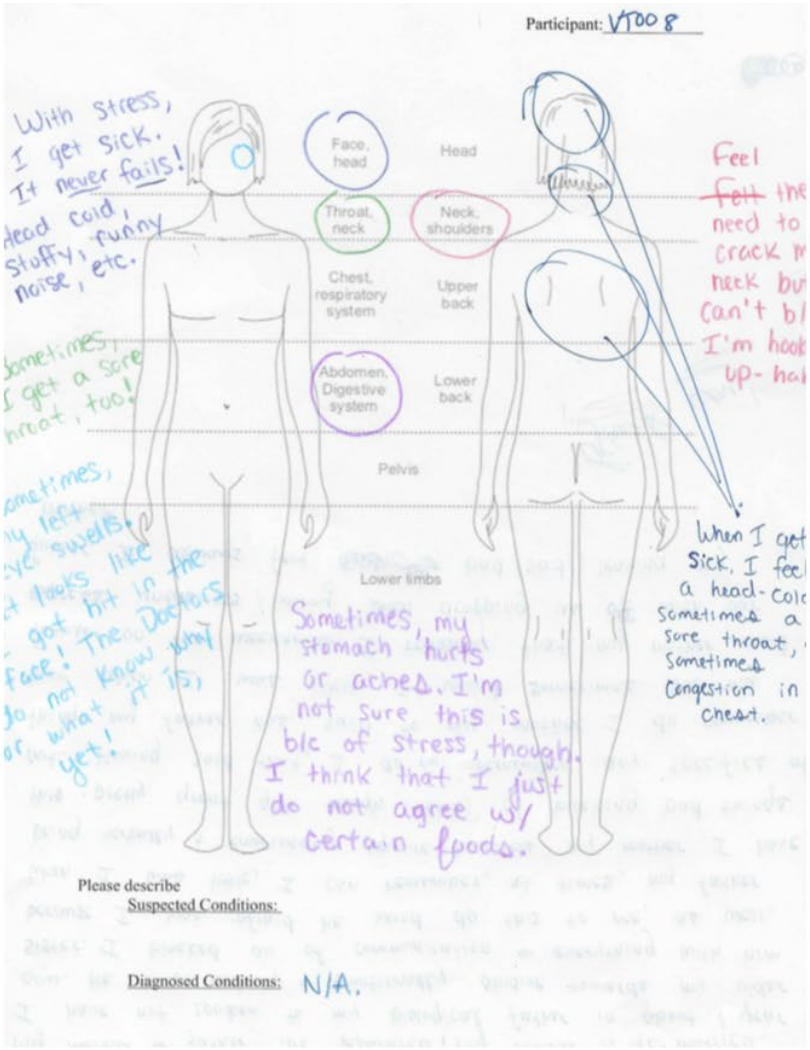
Participant: VT007

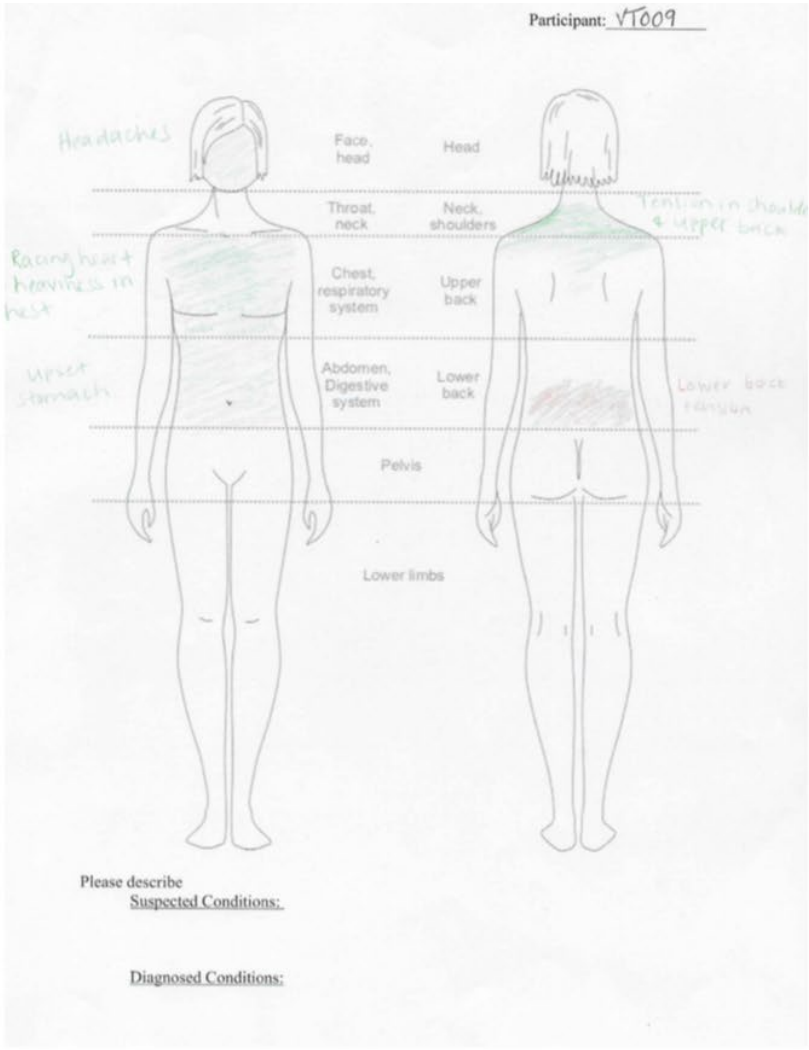


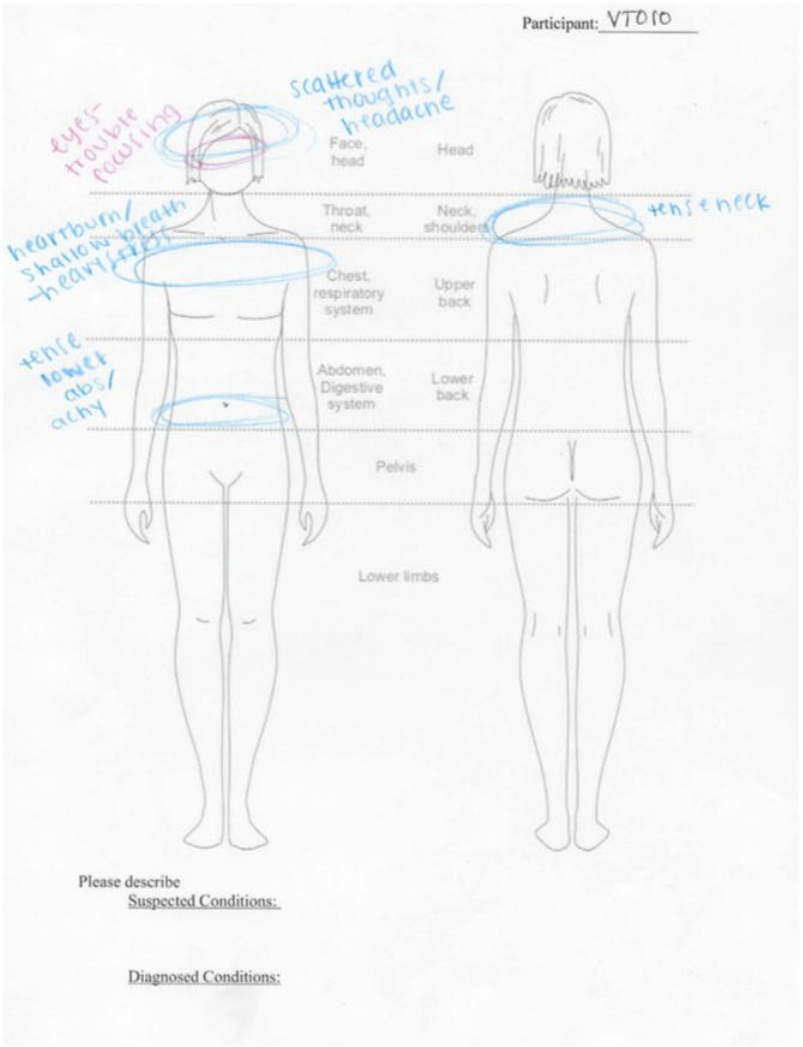
Please describe

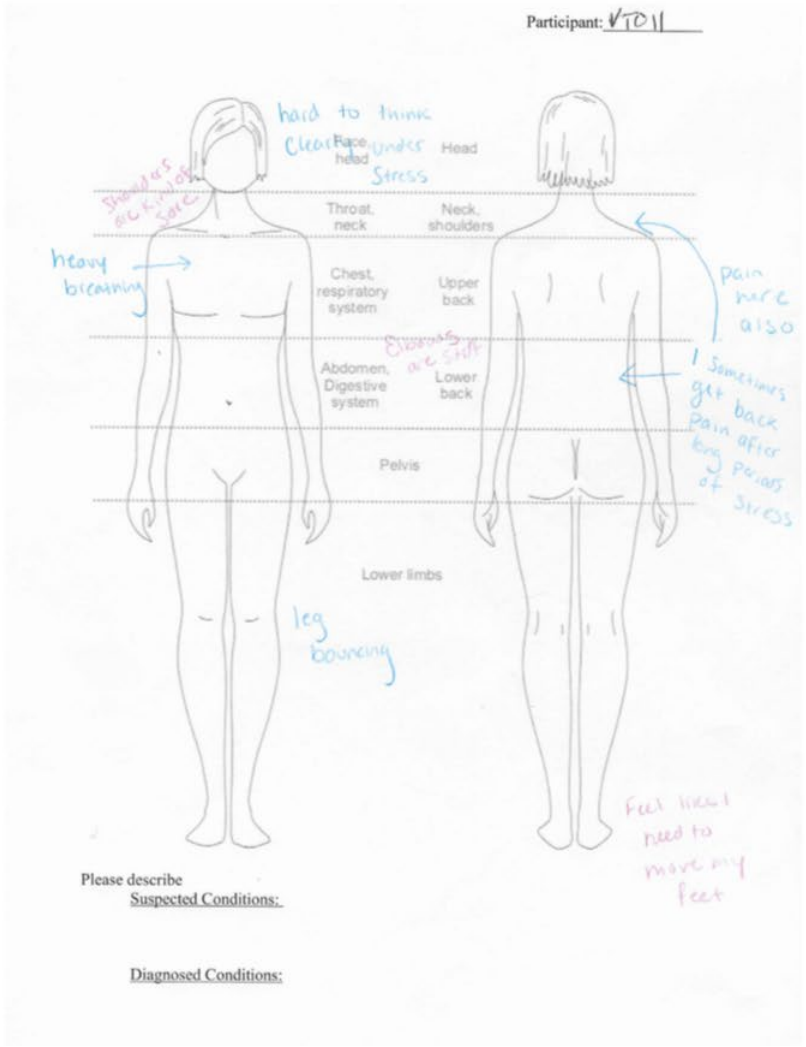
Suspected Conditions:

Diagnosed Conditions:

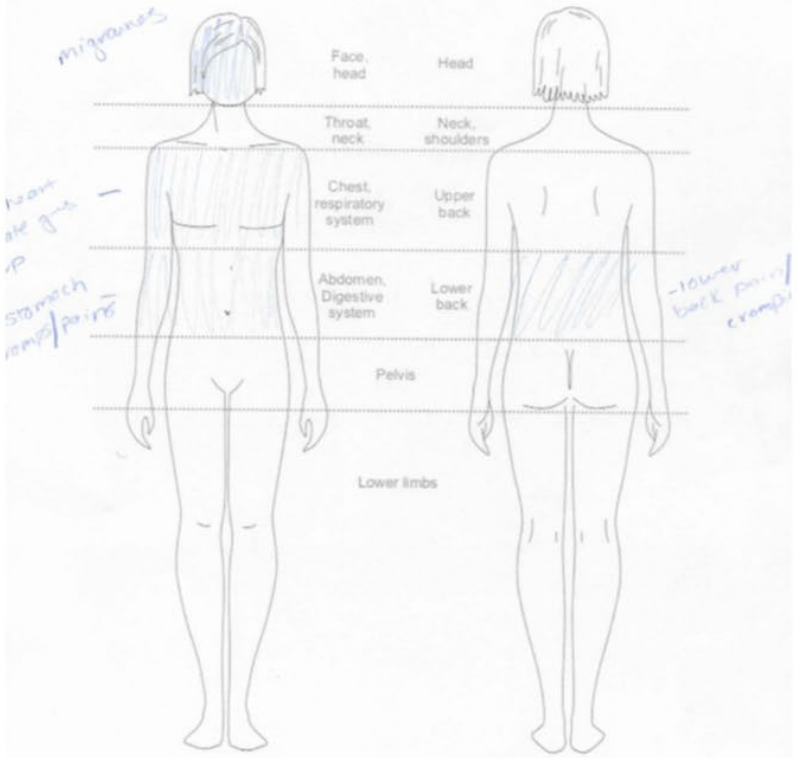

Participant: VT008
With stress, I get sick. It never fails! Head cold, stuffy, runny noise, etc.
Sometimes, I get a sore throat, too!
Sometimes, my left eye swells. It looks like I got hit in the face! The Doctors do not know what it is, or what it is yet!
Face, head
Head
Throat, neck
Neck, shoulders
Chest, respiratory system
Upper back
Abdomen, Digestive system
Lower back
Pelvis
Lower limbs
Sometimes, my stomach hurts or aches. I'm not sure this is b/c of stress, though. I think that I just do not agree w/ certain foods.
Feel
Felt the need to crack my neck but can't b/c I'm hook up- hai
When I get Sick, I feel a head- cold Sometimes a sore throat, Sometimes Congestion in chest.
Please describe
Suspected Conditions:
Diagnosed Conditions: N/A.


Participant: VT009
Headaches
Face, head
Head
Throat, neck
Neck, shoulders
Tension in shoulder & upper back
Racing heart heaviness in chest
Chest, respiratory system
Upper back
Upset stomach
Abdomen, Digestive system
Lower back
Lower back tension
Pelvis
Lower limbs
Please describe
Suspected Conditions:
Diagnosed Conditions:


Participant: VTO10
eyes- trouble focusing
scattered thoughts/ headache
Face, head
Head
Throat, neck
Neck, shoulders
tense neck
heartburn/ shallow breath heavy feet
Chest, respiratory system
Upper back
tense lower abs/ achy
Abdomen, Digestive system
Lower back
Pelvis
Lower limbs
Please describe
Suspected Conditions:
Diagnosed Conditions:


Participant: VTO11
hard to think clearly under Stress
Face, head
Head
Throat, neck
Neck, shoulders
heavy breathing
Chest, respiratory system
Upper back
pain more also
Abdomen, Digestive system
Lower back
Pelvis
Lower limbs
leg bouncing
Please describe
Suspected Conditions:
Diagnosed Conditions:

Participant: VT012

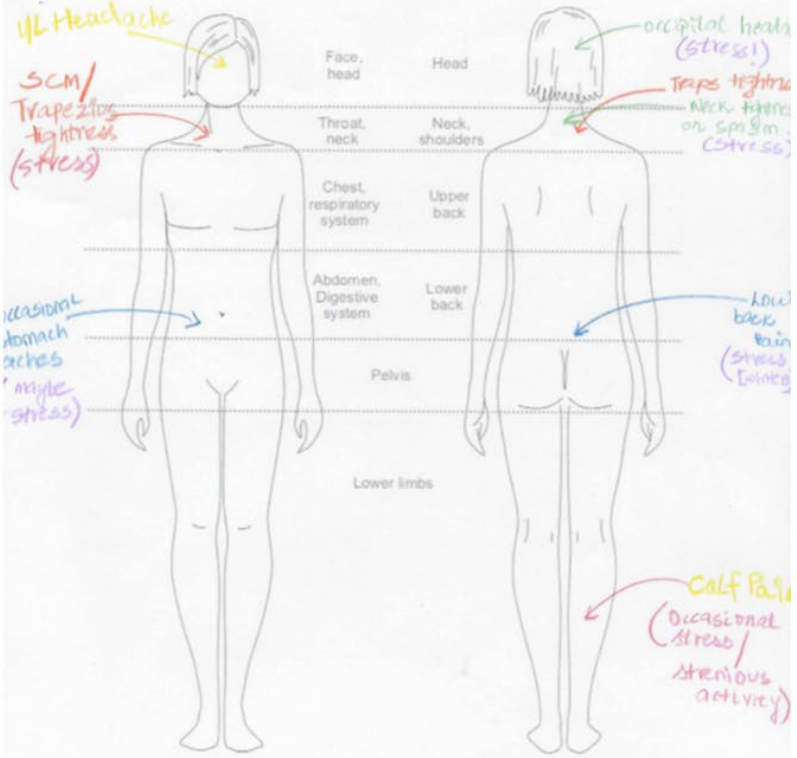


Please describe

Suspected Conditions:

Diagnosed Conditions:

Participant: VT013

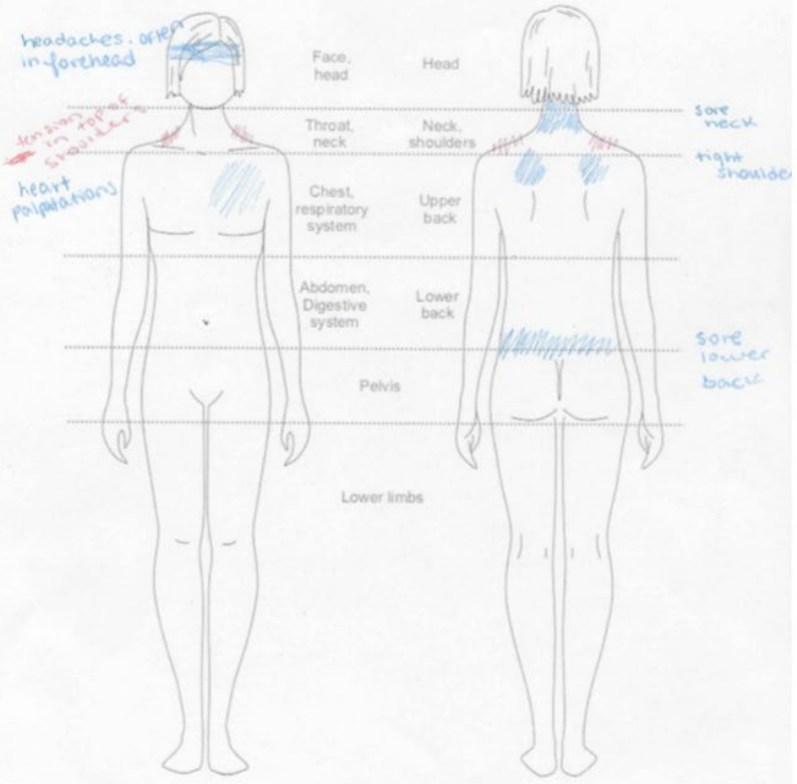


Please describe

Suspected Conditions:

Diagnosed Conditions:

Participant: VT014

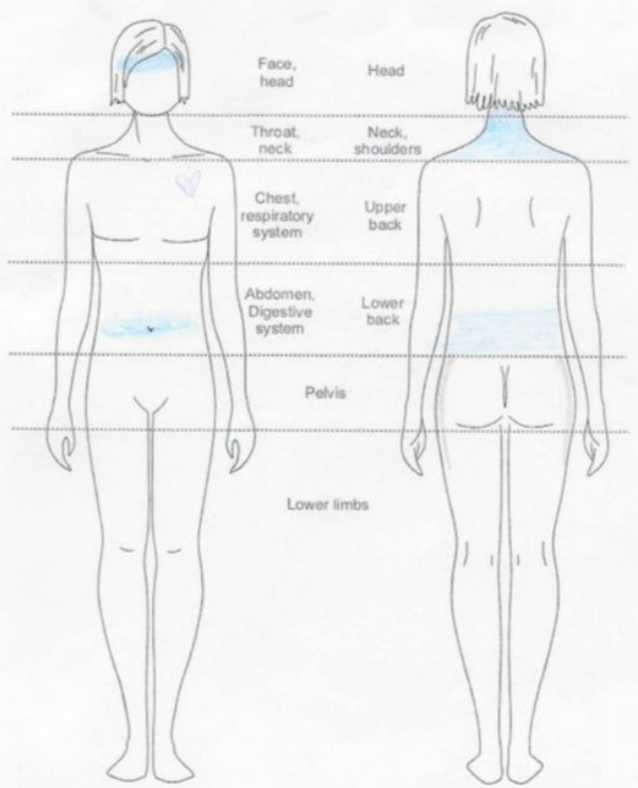


Please describe

Suspected Conditions: none

Diagnosed Conditions: none

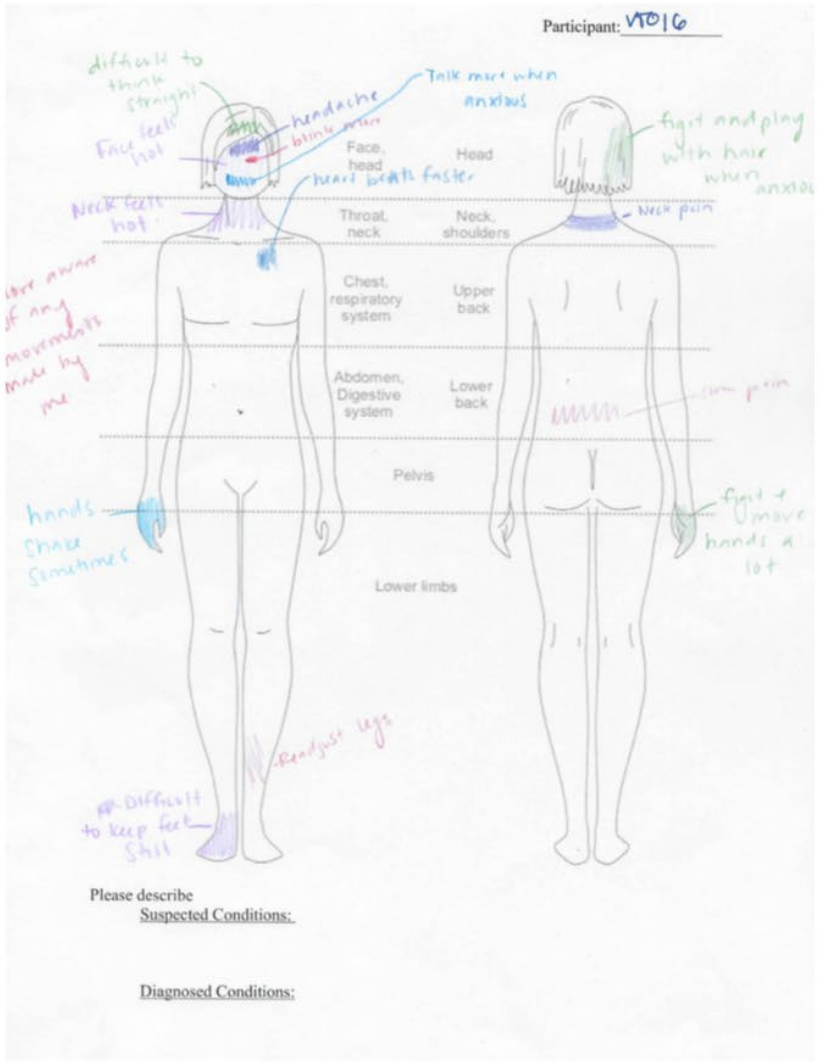
Participant: VT015

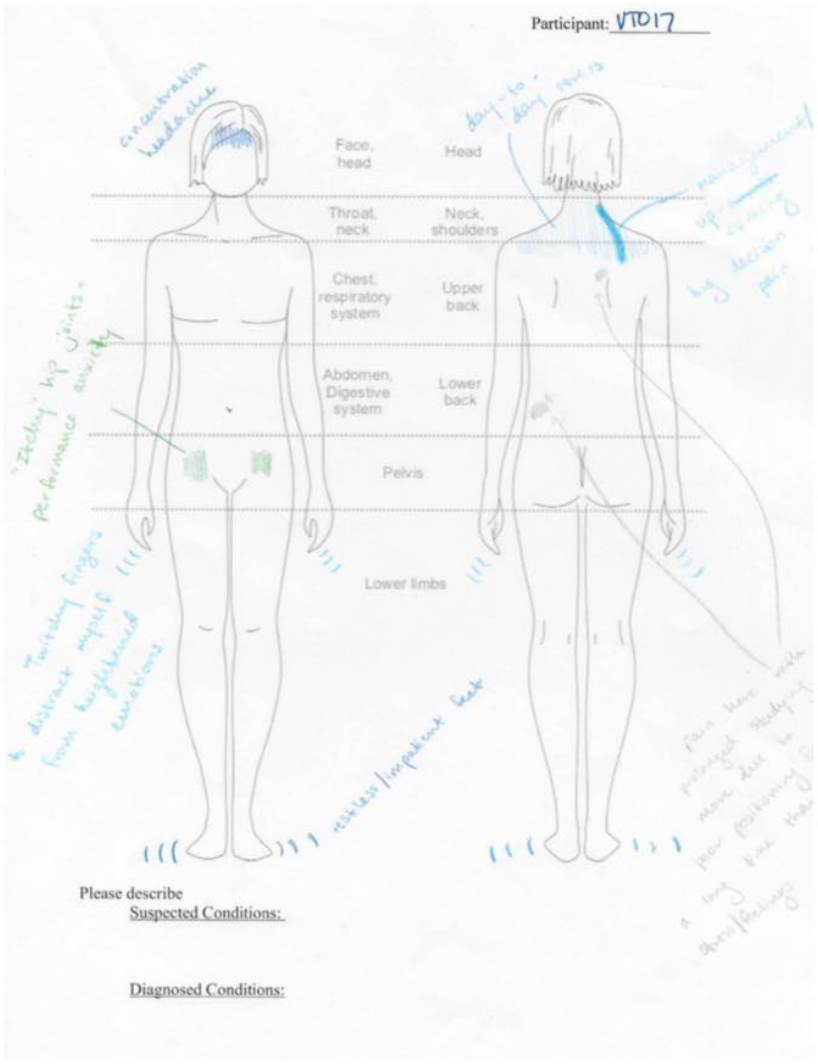


Please describe

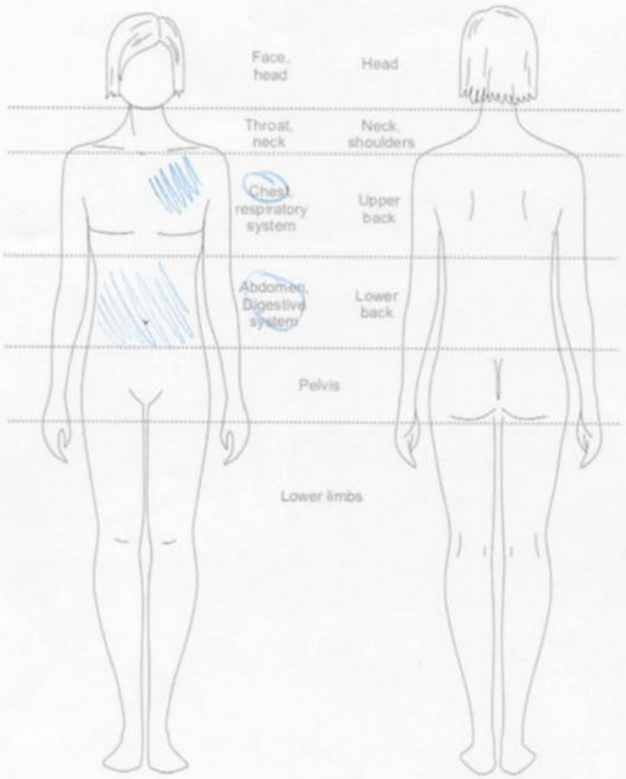
Suspected Conditions:

Diagnosed Conditions:


Participant: VTO16
difficult to think straight
Face feels hot
headache
blink more
Talk more when anxious
Face, head
Head
heart beats faster
fidget and play with hair when anxious
Neck feels hot
Throat, neck
Neck, shoulders
neck pain
Chest, respiratory system
Upper back
Abdomen, Digestive system
Lower back
pain
Pelvis
hands shake sometimes
fidget + move hands a lot
Lower limbs
Readjust legs
Difficult to keep feet still
Please describe
Suspected Conditions:
Diagnosed Conditions:


Participant: VTO17
concentration
Face, head
Head
Throat, neck
Neck, shoulders
Chest, respiratory system
Upper back
Abdomen, Digestive system
Lower back
Pelvis
Lower limbs
Please describe
Suspected Conditions:
Diagnosed Conditions:

Participant: VT019

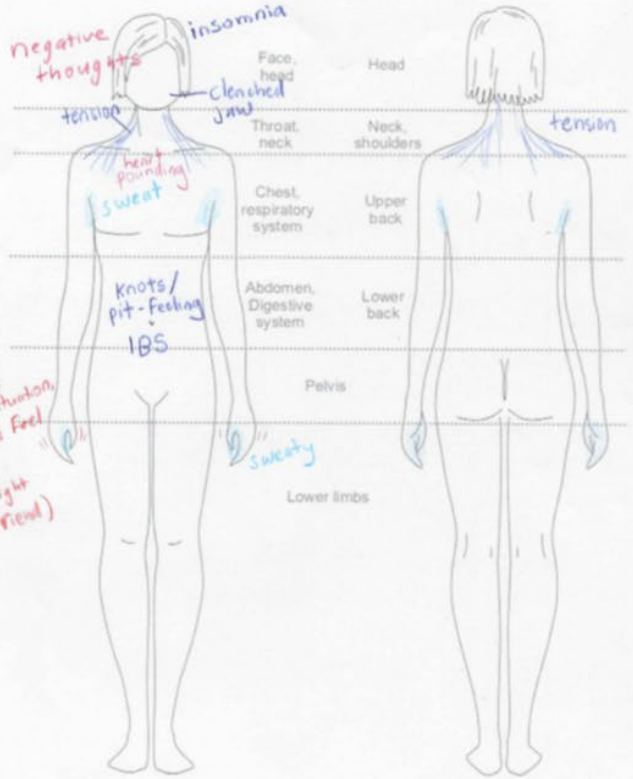


Please describe

Suspected Conditions:

Diagnosed Conditions:

Participant: VT020

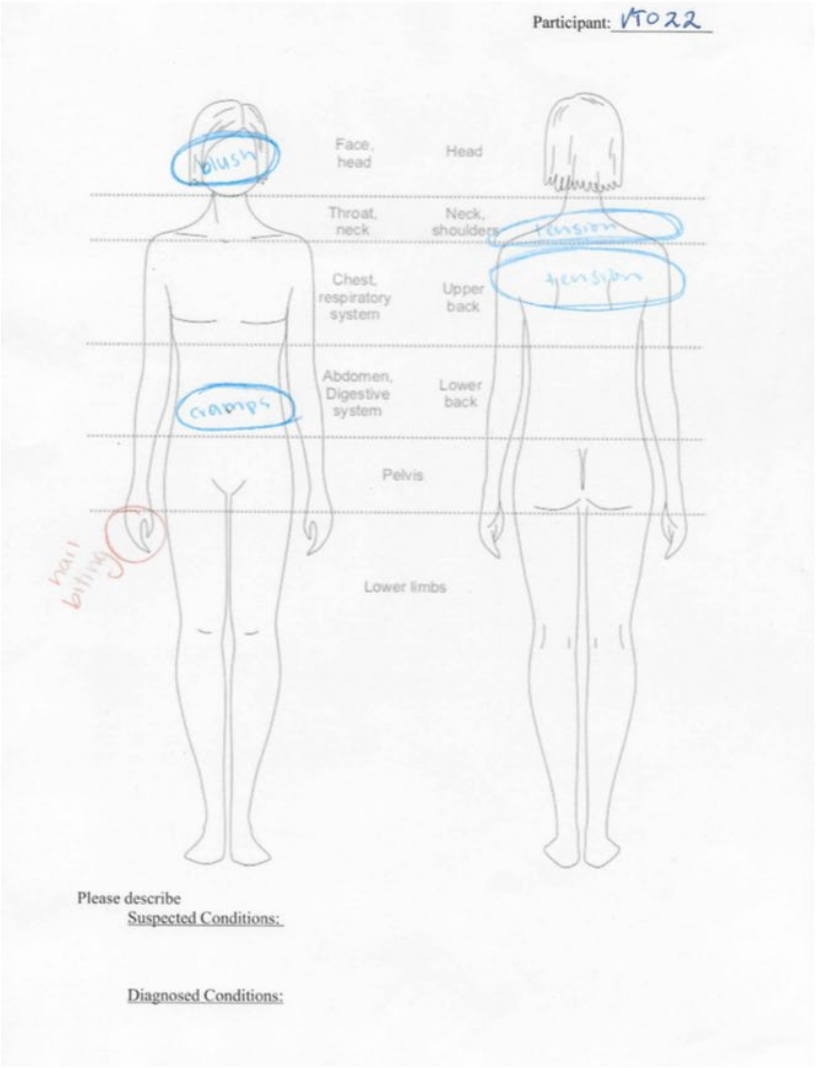


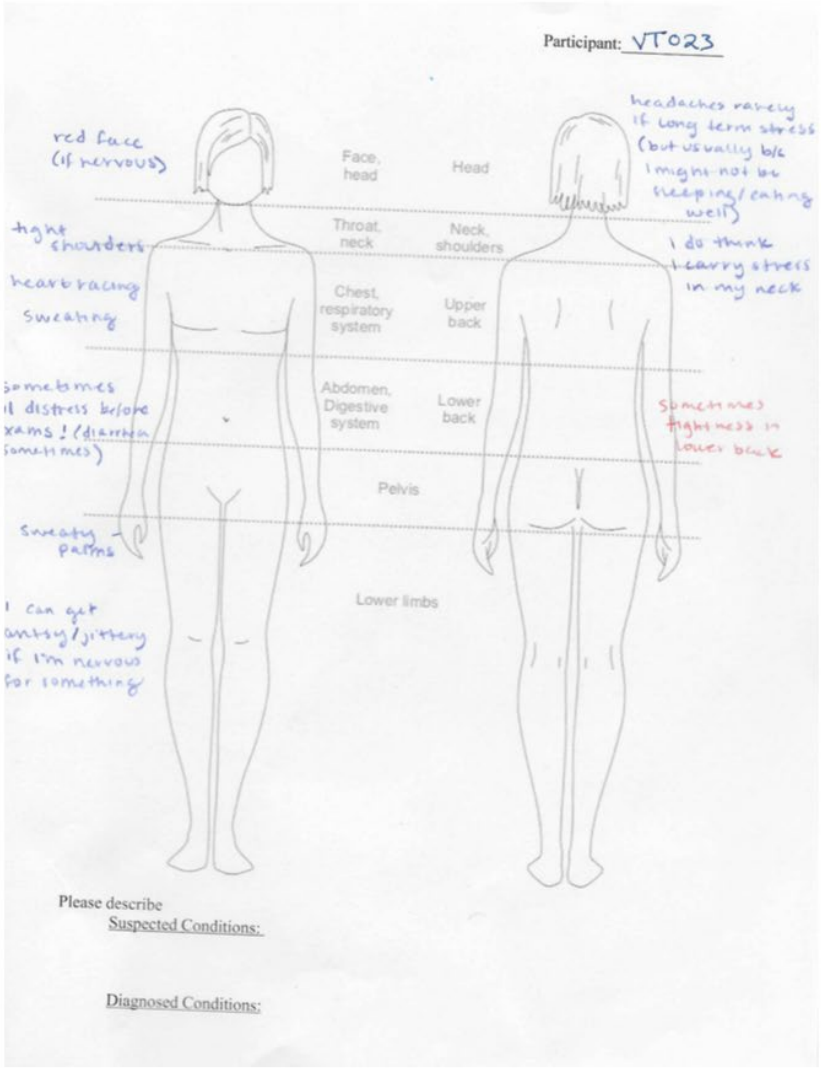
If in an emotionally stressful situation, my hands feel shaky (like a fight with a friend)

Please describe

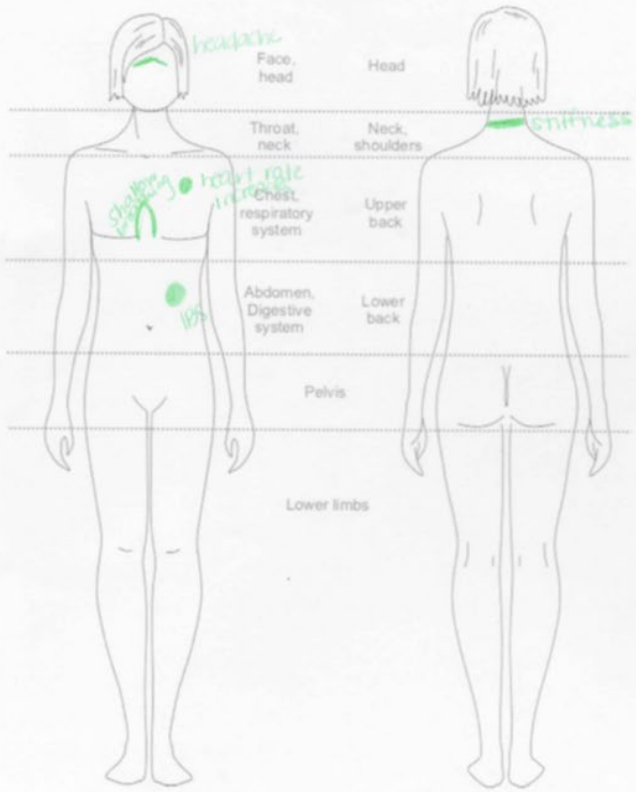
Suspected Conditions:

Diagnosed Conditions:


Participant: VT022
blush
Face, head
Head
Throat, neck
Neck, shoulders
tension
tension
Chest, respiratory system
Upper back
cramps
Abdomen, Digestive system
Lower back
Pelvis
hair falling
Lower limbs
Please describe
Suspected Conditions:
Diagnosed Conditions:


Participant: VT023
red face (if nervous)
Face, head
Head
headaches rarely if long term stress (but usually b/c I might not be sleeping/eating well)
tight shoulders
Throat, neck
Neck, shoulders
I do think I carry stress in my neck
heart racing
sweating
Chest, respiratory system
Upper back
sometimes il distress b/fore exams ! (diarrhea sometimes)
Abdomen, Digestive system
Lower back
sometimes tightness in lower back
Pelvis
sweaty palms
Lower limbs
I can get antsy/jittery if I'm nervous for something
Please describe
Suspected Conditions:
Diagnosed Conditions:

Participant: VTO24

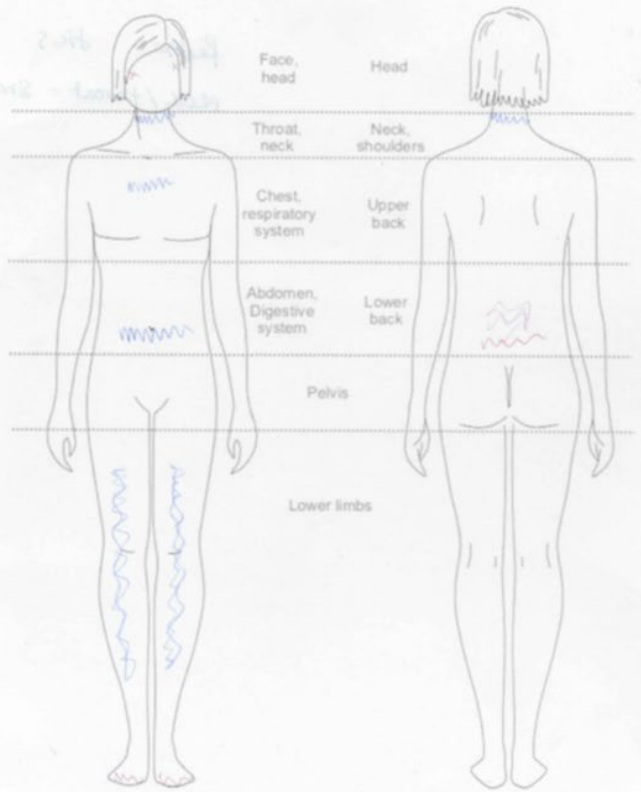


Please describe

Suspected Conditions:

Diagnosed Conditions:

Participant: VTO27

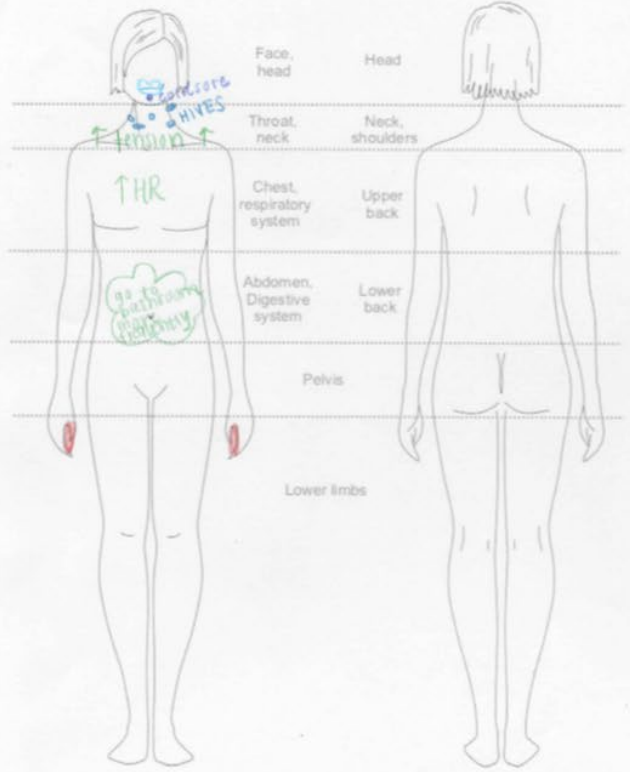


Please describe

Suspected Conditions:

Diagnosed Conditions:

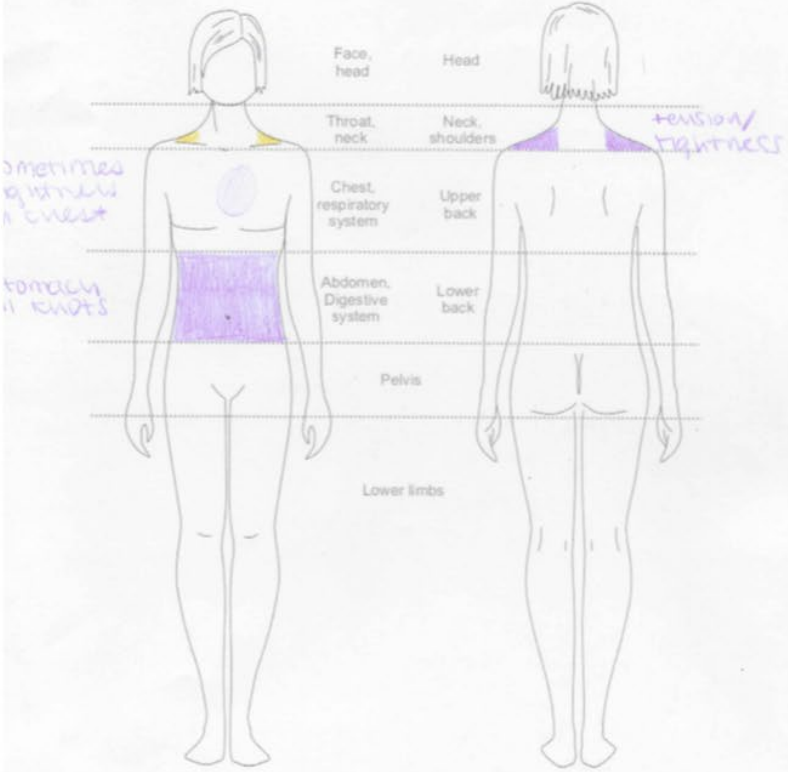
Participant: VT028



Please describe
Suspected Conditions:

Diagnosed Conditions: chronic hives (food related)
herpes virus / cold sores

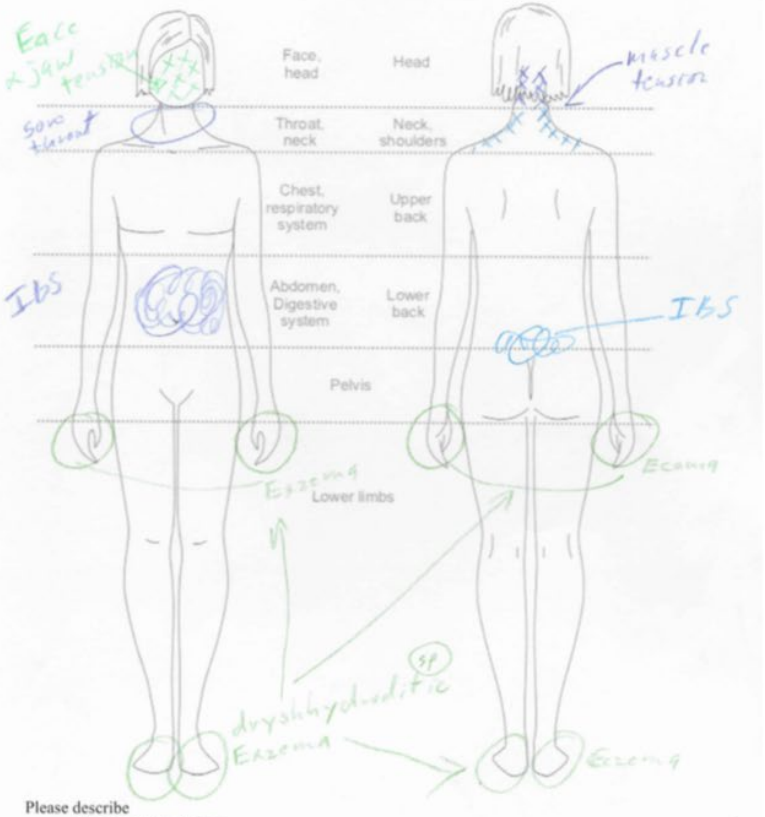
Participant: VT029



Please describe
Suspected Conditions:

Diagnosed Conditions:

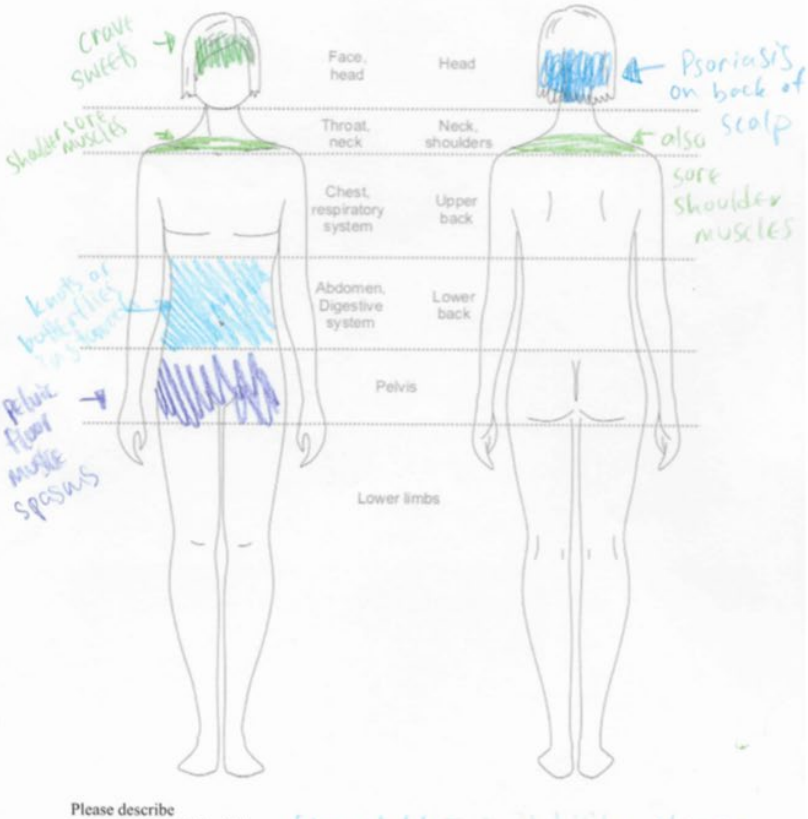
Participant: VT032



Please describe
Suspected Conditions:

Diagnosed Conditions:

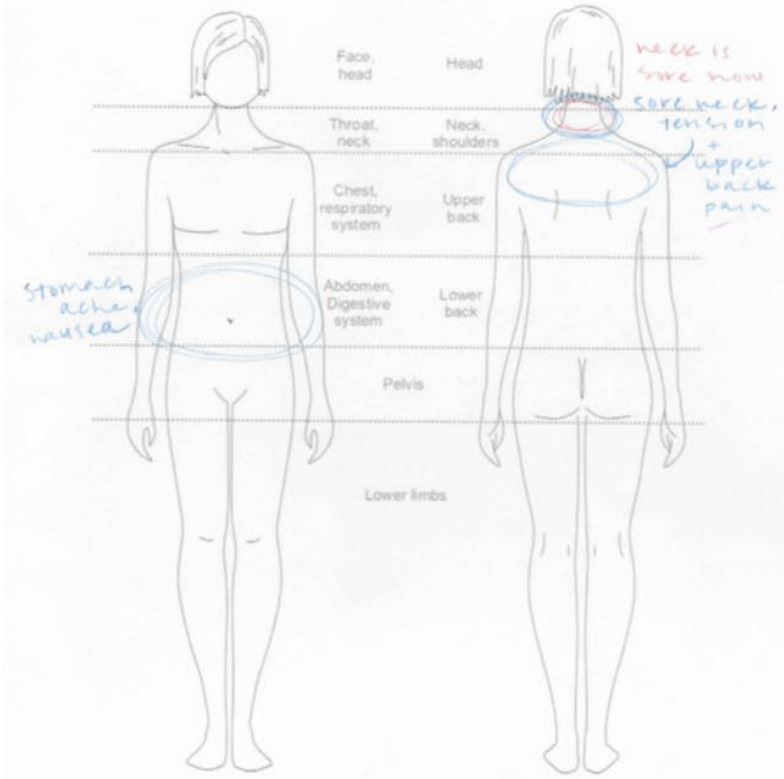
Participant: VT034



Please describe
Suspected Conditions: Stomach/GI irritability, change in appetite, crave sweet things to ingest incr
Tightness/soreness in shoulder muscles

Diagnosed Conditions: Psoriasis, pelvic floor muscle spas

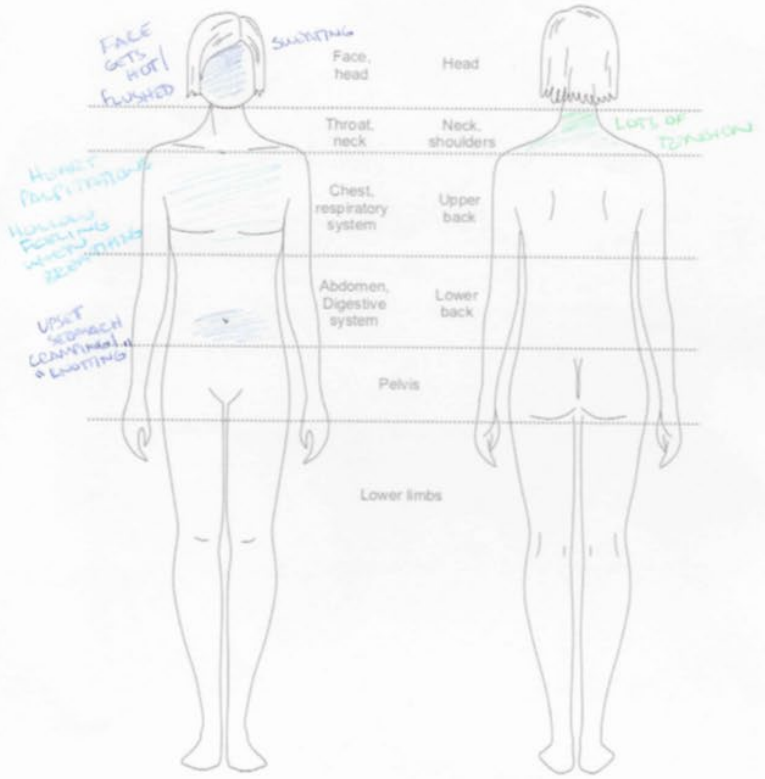
Participant: VT035



Please describe
Suspected Conditions:

Diagnosed Conditions:

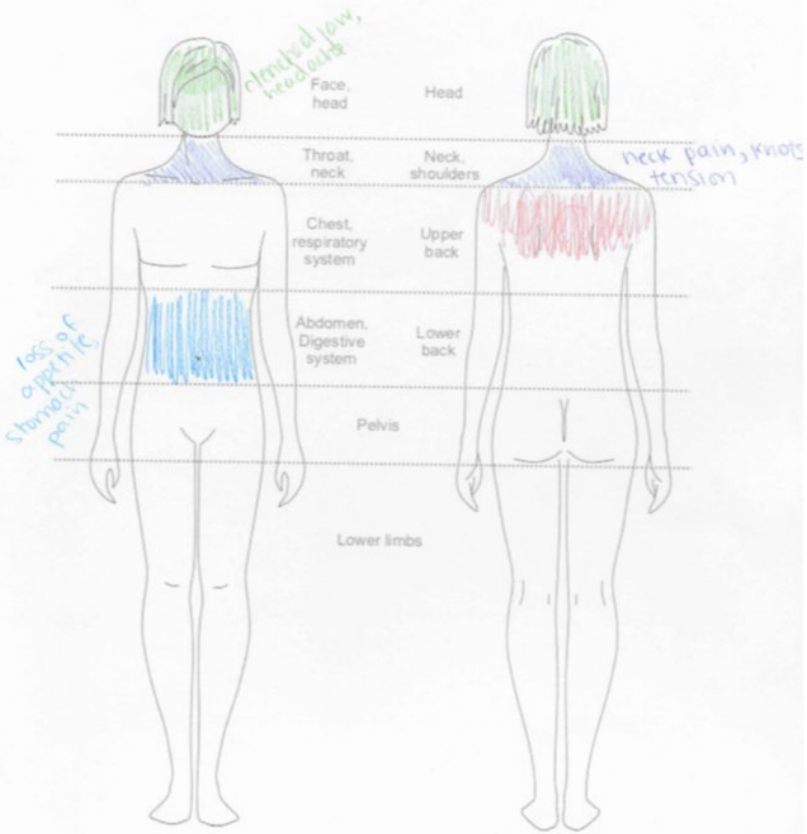
Participant: VT038



Please describe
Suspected Conditions:

Diagnosed Conditions:

Participant: VT039



Please describe

Suspected Conditions:

Diagnosed Conditions:

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