THE RELATIONSHIP OF AGING ON THE RATE OF VOCAL FATIGUE BASED ON PERSONAL RATING SCALES AND FUNDAMENTAL FREQUENCY

By

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A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

Communicative Sciences and Disorders – Master of Arts

2018

ABSTRACT

THE RELATIONSHIP OF AGING ON THE RATE OF VOCAL FATIGUE BASED ON PERSONAL RATING SCALES AND FUNDAMENTAL FREQUENCY

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INTRODUCTION: The relationship between aging and the quality of voice has been researched for the last several decades. Multiple studies have found that females older than 40 consistently experience more instances of voice problems than their male counterparts.

RESEARCH QUESTION: to what degree does a vocal loading task fatigue older women? How does the rate of vocal fatigue compare to that found in younger women?

METHODS: Eleven female subjects from the age of 55-70 years old were recruited. Participants read aloud for 36 minutes at predetermined dB levels in an attempt to induce vocal fatigue. Subjective and acoustic vocal measures were taken not before and after the vocal loading task and at intervals during the task.

RESULTS: Subjective results, acoustical parameters, and comparison data from the younger population were found to not be significant.

CONCLUSION: The results of the study showed that vocal loading task did vocally fatigue the participants based on subjective ratings. Acoustically there trending evidence of fatigue from the loading task. The aging female population did not vocally fatigue at any greater rate than their younger counterparts. However, there was evidence that fatigue rate did relate to pulmonary health (estimated lung age) in the older population.

ACKNOWLEDGEMENTS

I would like to acknowledge the kind cooperation of the participants that made this work possible. I want to acknowledge my family, Edward and friends for their unlimited support and understanding for the busy and crazy schedule that being a thesis candidate allows.

Special thanks to Rachel Burtka, Stirling Witthoeft, Courtney Bodrie, and Elizabeth Tompkins for their assistance in making this protocol possible. My deepest thanks to the Ph.D candidates, Russell Banks, Mark Berardi, and David Ford for their hard work, and dedication to my study and countless hours in the lab. I want to thank Lady Catherine Cantor Cutiva for her assistance in the lab as well as for assistance with statistical analysis. I would like to extend my thanks to my thesis committee, Matthew Phillips, Dr. Peter LaPine, and Dr. Jeffrey Searl for guiding my study and asking all of the right questions.

Finally, I would like to thank Dr. Eric Hunter for his guidance, teachings, many hours, and input over the past year in making this thesis possible. Thank you for sharing your love of voice and research with me, and for giving me the inspiration to continue to pursue research. I would not be the budding clinician I was without this amazing experience of being a thesis track student under your guidance.

Research reported in this thesis document was supported by the College of Communication Arts and Sciences and the National Institute on Deafness and Other Communication Disorders of the National Institutes of Health under Award Number R01DC012315. Content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

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INTRODUCTION

Extensive research has shown that females have a higher prevalence of voice disorders compared to men. The reason behind a greater rate of voice problems, particularly in those who use their voice as an occupational tool, has often been related to physiological differences, leading to vocal fatigue (Hunter et al, 2011). For example, the decline of pulmonary function can be a primary cause for vocal complaints and vocal fatigue in the elderly population (Mueller, 1997). Likewise, there have been studies that have established various relationships between the aging population and the quality of voice (Goy et al., 2016). The planned study aims to assess the fatigue ratings of an aging population of females. First, a review of vocal fatigue is presented followed by measures related to vocal fatigue. Next, voice production changes with aging is reviewed. Finally, the research question and hypothesis are presented.

What is Fatigue?

Before vocal fatigue can be defined, a general definition of fatigue will be presented for context. For this study, fatigue will be defined using the Merriam-Webster Dictionary's definition, which describes fatigue as, "weariness or exhaustion from labor, exertion, or stress" (Merriam-Webster, 2017). Medical researchers refer to fatigue as "an overwhelming sense of tiredness, lack of energy, and feeling of exhaustion" (Cristian & Griswald, 2009, p. 1). Medical professionals categorize fatigue into two different categories based on symptoms. For example, fatigue with the key symptom as decreased maintenance of focused attention is defined as central fatigue. Fatigue that is characterized as reduced exercise tolerance is defined by medical researchers as peripheral fatigue (Cristian & Griswald, 2009). Specifically in this study, the fatigue of interest is vocal fatigue. Vocal fatigue, which includes some of the same descriptors as in general fatigue, will be defined below in terms of physiology, acoustical and aerodynamic measures. For the remainder of the thesis, use of the word fatigue refers to vocal fatigue.

What is Vocal Fatigue?

Vocal fatigue is a concept that has been used in a variety of ways in the literature, thus it is without an agreed upon means of quantifying and there are not specific nor agreed upon indicators that it is part of a genetic disposition. It has been used both as a specific symptom and a vocal diagnosis. Vocal fatigue and the potential physiology has been studied and reviewed by Welham & Maclagan (2003), who found that vocal fatigue has both physiological and biomechanical components involved. Components of physiology such as neuromuscular fatigue of the laryngeal musculature, increased vocal fold viscosity, reduced blood circulation to the vocal process and surround structures, and non-muscular tissue strain are all elements shown to be involved in progression of vocal fatigue (Welham & Maclagan, 2003).

The definition of vocal fatigue can, additionally, be described by the symptoms one presents with when experiencing vocal fatigue. Kostyk and Rochet (1988) defined symptoms of vocal fatigue including but not limited to: hoarse/husky voice quality, breathy vocal quality, loss of voice, pitch breaks, reduced pitch range, lack of vocal carrying power, the need to use greater vocal effort, unsteady voice, throat fatigue, throat/neck pain, pain on swallowing, increased need to throat clear as well as other symptoms. Additionally, vocal fatigue has been a concept that many can measure by how an individual can perceive in themselves, such as after a long phone conversation or during a long speaking task (Hunter, E.J., 2011; Titze, 2000).

Attempts to Measure Vocal Fatigue

There have been many ways to quantify vocal fatigue. These include acoustic, aerodynamic and perceptual measures. The more objective measures, being acoustic and aerodynamic measures are collected through instrumental means. Subjective measures are subject to critique and possible misinterpretation because these measures can be based off of personal and psychological ratings; however, subjective ratings can be beneficial for clinical research, where an individual's personal perception of their voice may take precedent. Below is a brief review of these measures.

Acoustic Measures - Relevant Studies

There have been a multitude of studies that have aimed to acoustically measure vocal fatigue. Acoustic measures have included fundamental frequency, sound pressure level (SPL), phonation type reflecting alpha ratio, jitter, and shimmer. A study conducted by Laukkanen, Ilomaki, Leppanen and Vilkman (2006) used acoustical measures as one component for assessment of vocal fatigue in female teachers. The study found that in the teacher's working day, there was an increase in fundamental frequency, alpha ratio, jitter and shimmer. For the experimental vocal loading task, the participants had increased jitter and mean fundamental frequency (Laukkanen, Ilomaki, Leppanen and Vilkman, 2006). Another study, used dB SPL as well as electromyography (EMG) for the acoustical analysis during a vocal fatiguing task (Boucher & Ayad, 2008). More recently, in a study of school teachers, a standard deviation of the vocal sound pressure level had relationship to fewer voice complaints of fatigue, thus potentially being a parameter of interest in quantifying vocal fatigue severity (Cantor Cutiva et al, 2017).

Aerodynamic Measures

For vocal fatigue, aerodynamic measures usually refer to Phonation Threshold Pressure (PTP), or the amount of air needed to initiate and sustain vocal fold oscillation (Chang & Karnell, 2004). PTP was measured in a vocal loading and vocal effort study conducted by Chang and Karnell (2004) who found a strong relationship between PTP and perceived phonatory effort, a subjective index for vocal fatigue (Chang & Karnell, p. 454, 2004); however, a similar study that observed female speakers before and after a vocal loading task did not find a significant relationship between Perceived Phonatory Effort (PPE) and PTP due to variability between subjects (Milbrath & Solomon, 2003). While useful, it should be noted that aerodynamic measures can have a high variability and require a specific and time-consuming protocol.

Visual Perceptual Judgment

Visual perception of vocal fatigue can be examined through videostroboscopy, involving a strobe light attached to a camera that is able to visualize the motion of the vocal folds. Studies have included visual perception in their studies to show the effects of a vocal loading tasks on the vocal process (Stemple et al., 1995; Linville, 1995). However, these studies require a pre- and post-stroboscopic exam which not all persons tolerate well. For this study, videostroboscopy was not used due to lack of proper observation determined by the Institutional Review Board.

Auditory-Perceptual Judgment

Listener ratings of vocal fatigue is a subjective measure of vocal fatigue that has been briefly researched in the voice community. Notably, Barsties et al. (2017) has conducted recent work in the areas of voice quality and auditory-perceptual judgement. In that study, the GRBAS (grade, roughness, breathiness, asthenia and strain) was used as the main rating scale. Researchers found that while there were statistically significant results when comparing specific vocal loading tasks to auditory-perceptual ratings and that there is high variability in auditory perceptual judgement, that the amount of training in the ratings can affect consistent ratings of voice quality (Barsties et al., 2017).

Self-Ratings of Vocal Fatigue

Subjective measures that aim to demonstrate the participant's feelings both emotionally and physically in regards to the voice have been carefully examined through multiple surveys created for research purposes and clinical voice patients. Research studies have used multiple methods for evaluating subjective ratings during vocal loading tasks. Hunter and Titze (2009) used three rating scales for a study that analyzed the relationship between vocal fatigue recovery after a vocal loading task. The scales included inability to produce soft voice (IPSV), current speaking level (EFFT), and laryngeal discomfort level (DISC). All scales were numbered 1-10 and were taken every 2 hours after the vocal loading exercise. Another study used the Glottal Function Index (GFI) scale as a voice symptom severity index, rated from numbers 1 (no problem) to 5 (severe problem). The GFI was used in this study over an extended period of time, and was rated by participants who were diagnosed with vocal fold paresis (Stager & Beilamowicz, 2014). More recently, Bottalico et al. (2016) illustrated how a simple self-rating of vocal fatigue (1 - no fatigue; 10 - highest fatigue) related to vocal duration and variation of dB SPL. The scale used by Bottalico et al. (2016) will be used for the present study.

Females and Vocal Fatigue

Based on previous research, it has been illustrated that voice disorders due to prolonged speaking have vocal fatigue as a precursor, and that voice disorders are found more often in women (Smith et al., 1998). Additionally, occupations that are dominantly female are often occupations that experience voice disorders more commonly such as performers, call center workers and teachers (Hunter, Tanner & Smith, 2011). In that report, Hunter and colleagues suggested that women vocally fatigue at a greater rate due in part to several structural and physiological differences. For example, post-pubescence, women have thinner/shorter vocal folds and a smaller larynx overall compared to men (Titze, 1994). These differences result in the vocal folds to oscillate more frequently; given a comparable amount of talk-time the average female vocal folds will vibrate many more times than male vocal folds. The higher rate of vibration cycles these folds experience may be one of several contributing factors for the vocal problems that occurs more often in women.

Another physiological distinction that creates differences that may be a contributing factor in the rate of vocal fatigue in women is the endocrine function. After the onset of puberty, changes in hormones affect the laryngeal function of women during menses as well as during menopause. This can be linked to hormone receptors that are located in the tissues of the vocal folds, affecting the voice both acoustically and perceptually. Previous studies have shown increased vocal complaints during periods of an increase in hormones, specifically during menstruation as reported by females (Schneider et al., 2004).

Aging and Quality of Voice Function

The relationship between aging and quality of voice has been researched with structural and functional changes in mind across multiple studies. For example, several reports (Mueller, 1997; Roy, et al., 2004; and Russell, Oates, & Greenwood, 1998) have discussed how elderly persons report greater vocal difficulties as well as a decrease in vocal function as a result of decreased lung, vocal fold and laryngeal function. Presbyphonia, or vocal difficulties with aging have been related back to physiological changes from aging, genetic factors, and diseases such as COPD or asthma. Without adequate and coordinated breath support from the pulmonary system , the vocal folds will not receive enough airflow for phonation, resulting in the tendency for a talker too overuse, overextend or push their vocal folds to fatigue, potentially leading to unneeded vocal damage.

A study relating to vocal fatigue of the aging system stated, "Age related voice problems due to hormonal changes appear in females predominantly between the ages of 45 and 70 years… During menopause the lack of estrogen causes an overbalance in aldosterone production in the suprarenal gland and the average pitch of the speaking voice is lowered" (am Zehnhoff-Dinnesen, A., Angerstein, W., & Deuster, D., 2010, p. 185). Likewise, Gama et al. (2009) found that "acoustic analyses have indicated a decrease in the fundamental frequency of women, as well as increased percentage of jitter and shimmer" (Gama et al., 2009, p. 128-129). Gama et al. (2009) evaluated acoustic measures of voice for 96 women aged between 60 and 103 years and found a significant and gradual reduction in fundamental frequency for aged women (Gama et al., 2009, p. 128-129). The reasoning for why these changes may occur in the aging population could be due to thinning or changes of vocal folds, causing a change in fundamental frequency (Titze, 1994) Based on these studies, it would be a fair hypothesis to state that the current study will find an increase in vocal fatigue in the aging population.

Research Question and Hypothesis

Due to the aging population and the higher incidence of voice problems among women, this study is designed to quantify vocal fatigue from a vocal loading task among older women. The question for this study was as follows: To what degree does a vocal loading task fatigue older women? A secondary question is, how does the rate of vocal fatigue compare to that found in younger women?

To address the primary research question, pre and post-vocal loading measures around a vocal loading task were compared; specifically compared were vocal fatigue ratings and acoustical parameters. This is a descriptive aim without a hypothesis other than the expectation that pre-post differences will be found. The study is designed to expose older women to a vocal loading task, quantify the rate of perceived vocal fatigue, and compare it to previous studies which used a younger population. The hypothesis is that there will be an increase in rate of vocal fatigue in aging females compared to younger females. If the hypothesis is accepted, then using the measures taken, researchers can infer potential underlying reasons for the vocal fatigue due to aging physiology.

METHODS

Participants

Thirteen females between the ages of 55 and 70 were recruited into the study with eleven completing the protocol. The inclusion and exclusion criteria for participants as approved by the IRB is outlined in Appendix A and B. Briefly, the criteria was that participants have normal and age appropriate hearing and speech systems. For this study, the primary researcher will keep in mind the possibility that menopause, hormonal changes, as well as other structural and physiological changes that occur the pharynx of an aging female.

Participants reported the following: no smoking within the last 5 years, no previous vocal, speech, pulmonary or hearing impairment or history of vocal problems that required the services of a physician or speech-language pathologist, native speakers of English. Participants signed an IRB approved consent form and underwent a baseline and screening process that included a pulmonary function test, a voice survey, breathing screening and hearing screening with details described in the appendices. After the screening, the participants completed in a vocal loading task (prolonged speaking task) that was preceded by a short voice recording used to assess change due to the loading task. Participants were compensated for their time.

Pre-Vocal Loading Task

Prior to the vocal loading task, an audio recording of each participant reading a standard passages, including the Marvin Williams Passage, Stella Passage or the Rainbow Passage (See Appendix C for specific passages read; Figure 1 for specific loading task order) was collected while participants were seated in a sound booth. The researcher instructed participants to talk in a normal and comfortable voice with no specified decibel range. The pre-vocal loading task was recorded using a head mounted microphone (Countryman B3, 20-20kHz +-3dB) attached to a

Millennia HV-3D 8 channel microphone pre-amplifier (Millennia Media). The pre-amp delivers the signal to an RME ADI-8 DS AD/DA Converter and an RME Multiface II 36 channel digital audio interface (RME, Germany). The digital interface connects to the primary recording computer via a proprietary PCI expansion card on the motherboard. Reaper sound editing software (www.reaper.fm) was used to interface with this hardware to finalize the speech recordings (44,100Hz, 16bit) that were saved for later analysis in WAV format. The head mounted microphone recording setup was used also used for the post loading task. During this pre loading task, participants were asked to rate their vocal fatigue from 1-10, with 1 being no vocal fatigue and 10 being the greatest vocal fatigue.

Vocal Loading Task

The vocal loading task consisted of a smaller set of predetermined tasks to be completed in 6 minutes, repeated 6 times (36 minutes total). Each time the participant repeated the smaller set of tasks, they were given a radiated dB goal that alternated between 72 dB and 76 dB (ref 30 cm) every 6 minutes. Screen prompts presented the instructions with a predetermined start time keep the participant on time. Computer prompts required the participant to indicate when they were completed with the task (a small wireless clicker was provided). The set of tasks (listed below), which lasted 6 minutes, were repeated 6 times:

1. Drink water (using a small cup provided)
2. Self-rating of vocal fatigue (between 1 and 10), participant clicked to advance
3. Say “ahh” extended productions three times in a comfortable
4. Say “afa” three times in comfortable voice
5. Read aloud the Marvin Williams Passage at the indicated loudness goal of 72 or 76 dB (which stays consistent through Task 9), participant clicked to advance

6. Read aloud the Stella Passage, participant clicked to advance
7. Say "Ahh" three times, extended productions, (see Figure 1, left)
8. Read the first paragraph of the Rainbow Passage (See Figure 1, right), participant clicked to advance
9. Continue to read the remainder of the Rainbow Passage, repeating until the 6 minute interval is reached
10. Return to Step 1, Drink water

Figure 1. Examples of the screen displayed to participants during the pre-, post- and vocal-loading task. The highlighted lettering "STAY ABOVE THE LINE" indicates the portions of the vocal loading task where participants were required to speak above 72 and 76 dB. Left: Step 7 with each "AAAH" presented individually per predetermined timing. Right: Step 8 indicating the passage to be read.

The tasks above were practiced by the participant in a comfortable voice during the pre-vocal loading task to familiarize the participants with the task in order to reduce initial learning affect and related variability across all of the participants. Water drinking time was specified within the visual directions presented on the screen and water was provided in small cups so that the amount was controlled (1 ounce of water per drinking time). Reading at alternating dB levels continued until a total speaking of 36 minutes accrued. The alternating dB levels were controlled for every other cycle of the tasks during the study. For example, for one cycle the participant will read the passages at 72 dB, then for the following cycle they would read at 76 dB. The passages read by the participants include the Rainbow Passage, Stella Passage, Marvin Williams Passage (see Appendix C for full text), as well as a set of sustained set of steady vowels. Between each 2 and a half minute reading segment, the subject stated, “My vocal fatigue level is _____”, and would give their rating of vocal fatigue between 1-10 as stated previously.

To help participants maintain the target dB SPL during reading segments, a dB indicator (LingWAVES) was presented to the participant, showing a time history of the vocal level and a large green arrow pointing up which would appear when the target dB was not met.

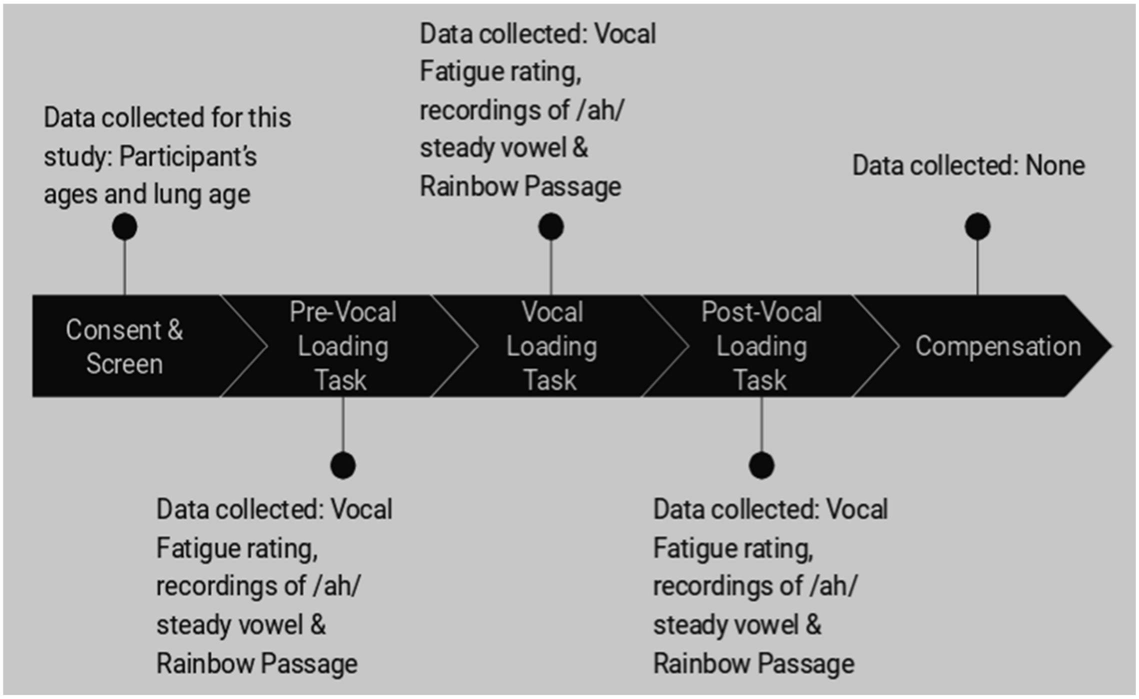
Post-Vocal Loading Task

The post-vocal loading task included the same readings from the pre-loading task with the participant reading “/a/” vowels and Part 1 of the Rainbow Passage. For the post-vocal loading task, participants were also allowed to follow through with these tasks at a comfortable voice, or pitch.

Measures of Interest

Figure 2 depicts the protocol carried out for this study and the measures gathered. As stated previously, acoustical and perceptual measures were taken from the pre- post, and during the vocal loading tasks. Part 1 of the Rainbow Passage as well as the extended /a/ steady vowel were the specific tasks taken from recordings for acoustical analysis. Participants were asked to complete the task; however, if they are unable or become too fatigued, they were allowed to leave at any time and were compensated for their time.

Figure 2. A visual of the protocol for the present study with specific data collected.



From the above described protocol, three measures were obtained to quantify the effect of the vocal loading task as experienced by the participants. As shown in Figure 3, these measures included: (1) the vocal fatigue self-ratings during the vocal loading task, (2) acoustic perturbation measures from the steady vowels (/a/) from pre-, post- and during the vocal loading task, and (3) variation of dB SPL from a read passage (Rainbow Passage) recorded before and after the loading task. Specifically, the data taken for analysis includes: the steady vowel /a/ taken from the recordings for analysis was from pre-vocal loading task, during the vocal loading task at the 6th repetition of the protocol (around approximately 18-20 minute time stamp in recordings) and at the post-vocal loading task which were completed in a comfortable voice, with the exact procedures for clipping the recordings of the steady vowel were applied when clipping the Rainbow Passage. The vocal fatigue rating would be given to the researcher verbally by the participant. This rating would range from 1 (no fatigue) to 10 (the greatest amount of fatigue experienced). Ratings will be given out verbally by the participant at 2 and a half-minute timed intervals during the screening tasks and vocal loading tasks. In summary, the participants underwent a loading task of a specific vocal amplitude (72-76 dB) and duration of 36 minutes (independent variables), where perceptual and acoustic metrics were obtained (dependent variables) to quantify the effect of vocal loading in the aging female.

Measurement and Data Analysis

Data was analyzed for multiple parameters including the subjective ratings taken by the participants, and the acoustical data. The clipped recordings were analyzed using custom MATLAB (https://www.mathworks.com/products/matlab.html) scripts which did the bulk file handling for analysis in PRAAT (http://www.fon.hum.uva.nl/praat/); these scripts are custom made and part of standard speech acoustic analysis at the Voice and Biomechanics and Acoustics Laboratory (Michigan State University). The results of these scripts were (among many others) the perturbation measures (jitter, shimmer), as descriptive statistics of the fundamental frequency (in Hz), and descriptive statistics of the estimated dB (including dB standard deviation).

To address the primary research question, student t-tests for paired homogeneous data were applied to each of the following pre- and post-vocal loading measures: participant rating of vocal fatigue, jitter, shimmer, and dB SPL standard deviation. Parameter changes were considered statistically significant when $p < .05$. Additionally, regression analysis were performed using excel and SPSS. Normal distribution of the data used was assessed by means of the Shapiro-Wilk test. Some of the tested variables were normally distributed but others were not. Therefore, ANOVA and Kruskal-Wallis was used to assess differences on acoustic parameters of voice in the middle and at the end of the vocal loading task. In addition, since the dependent variable (repetitions) was a categorical variable and each participant had three repetitions (repeated measures), we used the Generalized Estimating Equations with a Gamma distribution analysis to assess the association between the vocal loading task and the voice acoustic parameters. Subjective vocal fatigue ratings were listed and timed via Excel from researchers analyzing recordings, and then the data was used to create a t-test and p-values. To address the secondary research question comparing the rate of vocal fatigue to a younger pool of participants, the data from a similar study conducted by Burtka (2018) was compared using calculated slope values and t-tests in Excel.

RESULTS

The questions proposed previously are as follows: To what degree does a vocal loading task fatigue older women? A secondary question is, how does the rate of perceived vocal fatigue compare to that found in younger women? The following sections aim to present the results of this study with use of statistical analysis with both trending and significant data. Subjective ratings of the participant's vocal fatigue will be outlined and described; additionally, acoustical parameters and correlational analysis will also be included in the results.

Participants

As stated previously, eleven participants completed the study's protocol. Table 1 provides individual participant age as well as participant screening results for hearing, breathing and lung function. The average age was 65 years old (standard deviation. 4.6 years). The spirometry software (Carefusion) estimated "lung age" of the participants by using standard spirometry metrics and the following formula females: (0.022 × height (cm)-0.005-FEV1 (L))/0.022" (Toda et al., 2008, p. 514). Overall, the estimated lung age was higher than chronological age.

Table 1. Participant information and screening data. Average age of participants was 65 years old with a standard deviation of 4.6.

Participant	Lung Age	Actual Age	Hearing/Breathing Screening
O3	80	70	Normal/Normal
O4	80	62	Normal/Normal
O5	79	64	Normal/Normal
O6	65	67	Normal/Normal
O7	70	57	Normal/Normal
O8	70	59	Normal/Normal
O9	67	64	Normal/Normal

Table 1. (cont'd)

O10	59	61	Normal/Normal
O11	66	69	Normal/Normal
O12	70	69	Normal/Normal
O13	80	70	Normal/Normal
Average:	*71*	*65*	

Subjective Ratings by Participants

During the vocal loading task, participants were asked to rate their vocal fatigue from 1-10, with 1 being the least amount of vocal fatigue, and 10 being the greatest amount of vocal fatigue felt. After two and a half minutes, participants were asked to rate their vocal fatigue during the recorded fatiguing tasks. Results of all participant's ratings over time are shown in Figure 3 and listed in Table 2 with the calculated slopes also listed.

Figure 3. Participants' subjective ratings of their vocal fatigue over the vocal loading task over time. The lines indicate the slope.

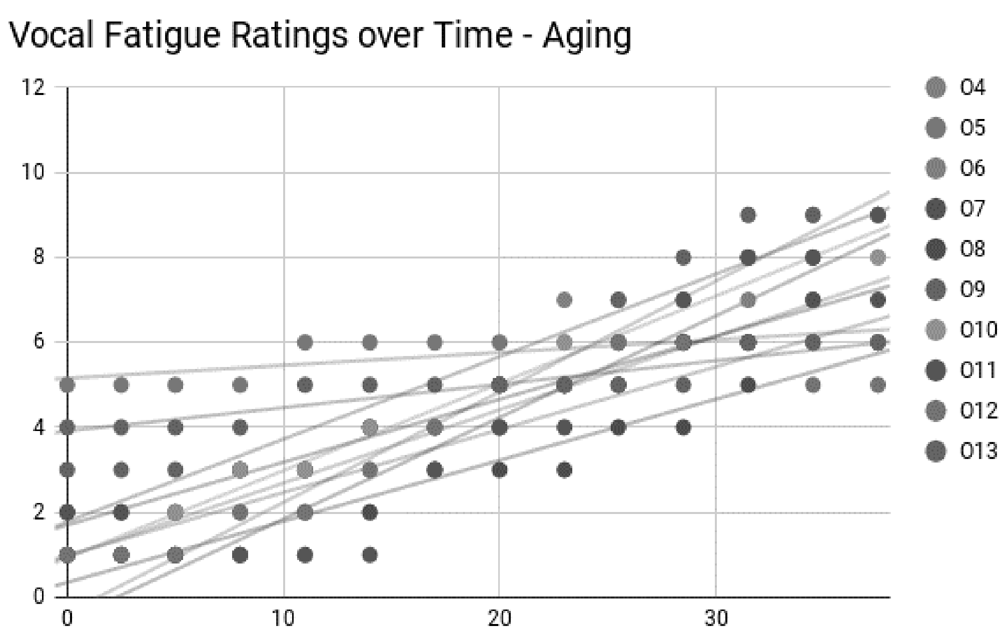


Table 2. Vocal Fatigue Ratings for each participant with calculated slope.

	Vocal Fatigue Ratings															
	-5	**0**	**2.5**	**5**	**8**	**11**	**14**	**17**	**20**	**23**	**25.5**	**28.5**	**31.5**	**34.5**	**37.5**	**Slope**
O3	4	4	4	4	4	4	5	5	5	6	6	6	7	7	7	0.087
O4	1	1	1	1	1	2	3	5	7	7	7	8	9	9	9	0.246
O5	5	5	5	5	6	6	6	6	6	6	6	6	6	6	6	0.026
O6	2	2	2	2	2	3	3	4	5	5	6	7	7	8	9	0.179
O7	2	2	2	3	3	4	4	5	5	6	6	6	7	7	7	0.140
O8	1	1	1	1	2	2	3	3	3	4	4	5	6	6	7	0.148
O9	3	3	3	3	3	4	4	5	5	7	8	9	9	9	9	0.186
O10	1	1	2	3	3	4	4	5	6	6	7	8	8	8	10	0.209
O11	1	1	1	1	1	1	3	4	4	5	7	8	8	9	9	0.233
O12	1	1	1	2	2	3	4	5	5	6	6	6	5	5	6	0.138
O13	4	4	4	4	5	5	5	5	5	5	5	6	6	6	6	0.053
Avg	*2*	*2.3*	*2.4*	*2.6*	*2.9*	*3.5*	*4*	*4.7*	*5.1*	*5.7*	*6.2*	*6.8*	*7.1*	*7.3*	*7.7*	*0.150*

Each participant's perceptual ratings indicated an increase in fatigue during the vocal fatiguing task; as would be expected, every participant had a different rate (slope) of fatigue over time. Figure 4 below displays graphs of each participant's fatigue rating over time. It should be noted that participants O5 and O13 responded with a very different rate of fatigue compared to their peers.

Figure 4. All participant's individual vocal fatigue ratings over time.

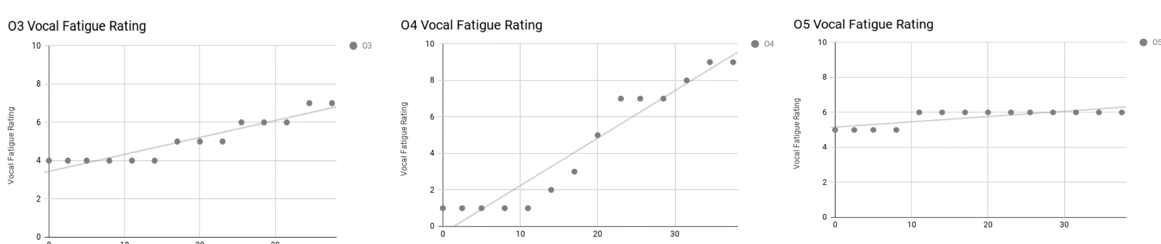
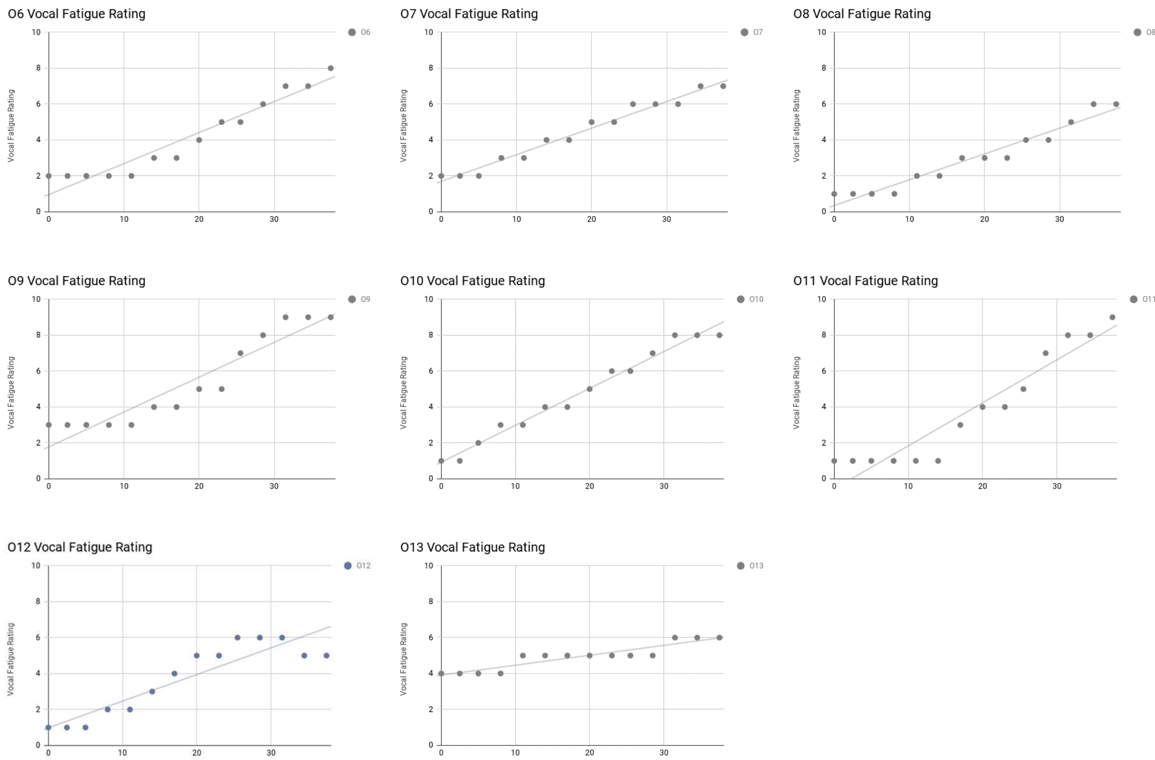


Figure 4. (cont'd)



Acoustical Parameters

<u>Steady Vowel Analysis - Perturbation - Jitter and Shimmer</u>

The perturbation measures were taken using Jitter and Shimmer analyzed from the clipped recordings during the pre, post, and during the vocal loading task 6^{th} repetition of the steady vowel (/a/). Statistical analysis of a regression analysis using a Gamma Distribution of the perturbation measures compared the pre-vocal loading task to the vocal loading task, and the vocal loading task to the post-vocal loading task during the steady vowels. Table 3 can be used as a reference for the specific data points when comparing pre- and, post-vocal loading task to the exact moment within the experimental protocol. Table 3 below lists the results of the statistical analysis of jitter and shimmer (/a/). The table also displays an additional acoustical parameter harmonic-to-noise ratio (/a/), decibel standard deviation, and fundamental frequency from the pre- and post-vocal loading tasks from running speech. The degrees of freedom were 1 for the Beta analysis.

Table 3. Pre and Post measures analyzed with regression analysis using a Gamma Distribution with Beta values from post-loading task.

	Pre-Vocal Loading		**Post-Vocal Loading**		**Analysis**	
Acoustic Parameter	avg	SD	avg	SD	Beta	SE
Jitter (/a/)	0.004	0	0.003	0.001	-0.14	0.1
Shimmer (/a/)	0.03	0.01	0.023	0.009	-0.12	0.1
H2Noise (/a/)	20.32	4.82	21.66	3.34	0.06	0.1
dB stdev (Rainbow Passage)	66.88	5.8	65.9	5.05	-0.05	0.1
Fo (Rainbow Passage)	220.5	37.8	218.5	47.53	-0.05	0.1

Figure 5. Perturbation measures, Jitter and Shimmer average measures taken at pre-vocal, vocal loading and post-vocal loading task with slope lines provided. Note the insignificant change from pre- to post-vocal loading task with an overall decreasing trend line for both jitter and shimmer.

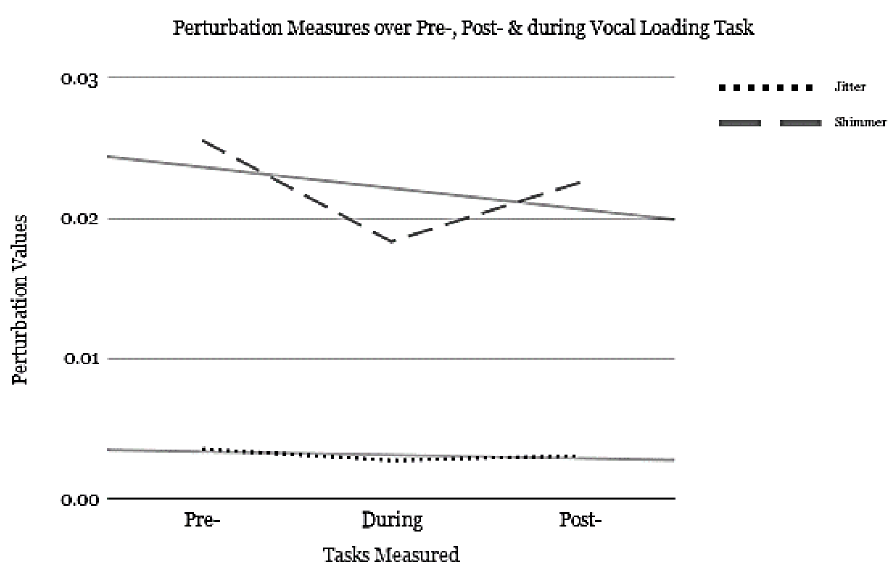


Table 3, and Figure 5 display the perturbation measures, taken and analyzed with steady vowels during the pre-, post- and vocal loading tasks. When regression analysis using a Gamma Distribution was completed comparing the pre-vocal loading task and vocal loading task, both jitter and shimmer measurements were found to not significantly change (Beta=0.01; p>0.05). Figure 5 displays the Jitter and Shimmer throughout the pre, post- and during the vocal loading task. While the data was not significant, there is a trending decrease for Jitter throughout the vocal loading task.

Running Speech –Rainbow Passage –Fundamental Frequency - Variation of dB

The next acoustical measure for comparison is the pre- and post-vocal loading variation of dB SPL (Sound Pressure Level) from a read passage just before and after the loading task (Refer to Figure 2). The data was analyzed using the same methods as the perturbation measures explained above, but using recordings from the Rainbow Passage (see Table 3). While the change in dB stdev did not significantly decrease, a second analysis was done to check if there was a greater difference in another measure of dB variation, that of the inter-quartile range. A paired student t-test analysis of the dB stdev and the dB IQR resulted in p values of 0.106 and 0.048 respectively. This indicates that there was a general trend to decrease variation in dB from pre to post though only the dB IQR resulted in a significant decrease.

Rate of Perceived Vocal Fatigue and Lung Age in Aging Population

While not part of the research question, estimated lung age (per spirometry) and participant chronological ages were compared to the vocal fatigue ratings via a correlation matrix. Table 4 lists a compilation of lung age, chronological age, and the vocal fatigue ratings from the 11 participants. Using Excel's built in correlation analysis, Table 5 was generated from the data in Table 4. The comparison revealed a notable trend of a high percentage of the measures including, baseline slope of vocal fatigue ratings, fatigue change and lung age.

Table 4. Comparison data of aging population for correlational analysis.

Vocal Fatigue Rating Baseline	Slope of Fatigue Rating	Post-Loading Fatigue	Fatigue Change (post-pre)	Lung Age	Chronological Age
4	0.087	7	3	80	70
1	0.246	9	8	80	62
5	0.026	6	1	79	64
2	0.179	9	7	65	67
2	0.14	7	5	70	57
1	0.148	7	6	70	59
3	0.186	9	6	67	64
1	0.209	10	9	59	61
1	0.233	9	8	66	69
1	0.138	6	5	70	69
4	0.053	6	2	80	70

As seen in the Table 5, there is a high correlation between the baseline fatigue ratings to the slope of the fatigue ratings. Additionally, there is a modest negative correlation between the slope of fatigue rating and chronological age (-.245) indicating some potential relation between perceived rate of vocal fatigue and aging. When comparing estimated lung age from the pulmonary task and the rate of vocal fatigue, the correlation is even stronger (-.576).

Table 5. Correlational data table of the data from the tables above. A majority of the data that was analyzed was found to have a correlation greater than 50%.

	Vocal Fatigue Rating Baseline	Slope of Fatigue Rating	Post-Loading Fatigue	Fatigue Change (post-pre)	Lung Age	Chrono Age
Vocal Fatigue Rating Baseline	1					
Slope of Fatigue Rating	-0.828	1				
Post-Loading Fatigue	-0.504	0.850	1			

Table 5. (cont'd)

Fatigue Change (post-pre)	-0.867	0.968	0.867	1		
Lung Age	0.597	-0.576	-0.625	-0.704	1	
Chronological Age	0.318	-0.245	-0.201	-0.299	0.258	1

Comparison Data- Between Aging and College-Age Females

The data used to compare the present study to a younger population was from Rachel Burtka's (2018) study titled, "The Impact of Expiratory Muscle Strength Training on Vocal Fatigue". The participant's data was taken from college-age females under the height of 5'2" who had undergone an identical fatiguing task as the aging females in the present study. The data compared was the fundamental frequencies and the subjective ratings given by the young females. This data was then compared over time to the aging population. The Figure 6 below illustrates the subjective ratings over time, while Table 8 lists the comparison of the Vocal Fatigue Ratings between the two different populations. The comparison in Table 8 also has the slope and average slope.

Figure 6. Comparison between the aging population and college-age population, vocal fatigue ratings over time.

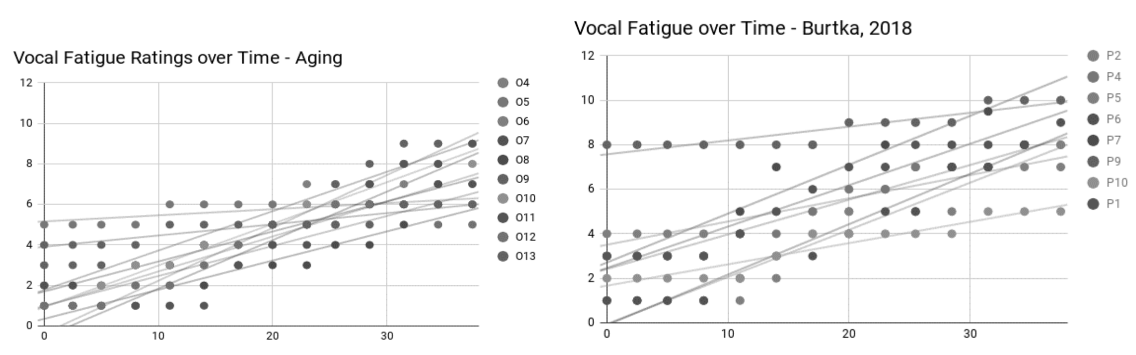


Table 6. Slope values compared between age groups.

College-Age Participants	Slope	Aging Participants	Slope
P1	0.182	O3	0.087
P2	0.096	O4	0.246
P4	0.156	O5	0.026
P5	0.204	O6	0.179
P6	0.222	O7	0.140
P7	0.202	O8	0.148
P9	0.060	O9	0.186
P10	0.098	O10	0.209
		O11	0.233
		O12	0.138
		O13	0.053
Average	*0.152*	*Average*	*0.150*

Table 6 distinguishes between the slopes of the data from each participant as well as a comparison between the two age groups. On average, the younger population started and ended on a higher vocal fatigue rating than their older counterparts. The average slopes between the two populations were almost identical and the results of the t-test performed on this data was not significant.

DISCUSSION

The purpose of this study was to observe vocal fatigue in the aging female and to compare if there is a significant difference in rate of vocal fatigue in the aging females versus college- age females. To accomplish this purpose, fatigue ratings and acoustic measures were obtained prior to vocal loading, during 36 minutes of vocal loading, and immediately after vocal loading in a group of older females. Data from the older females were also compared to the younger college-age female data obtained in a prior study that used the same protocol. The main findings for the primary research question and the secondary question are presented below. Additionally, future research in regards to the aging female and vocal fatigue will be discussed. And finally, clinical applications of these results for the speech-language pathologist, and possibly the voice instructor will be discussed.

Subjective Ratings

Participants in this study showed an increase in the perception of vocal fatigue over time. Eight of the eleven participants had a rate of vocal fatigue that was much higher overall during the vocal loading task with a majority of the eight participants increasing their fatigue rating by at least 5 points by the conclusion of the vocal loading task. This indicated that the vocal loading task did indeed impact the participant's perception of their voice. While most of the participants' rate of fatigue was similar, two participants only reported mild increases in their vocal fatigue levels during the vocal loading task (See Table 2). Possible reasoning behind the differences in each participant could be due to a multitude of factors including age, lung age, and previous voice use during the day, time of day, whether or not the participant had encountered menopause or not, or even the participant's level of hydration.

In terms of age, some participants may have fatigued at a faster rate due to their age being higher in the allowable range (i.e., 66-70 years old). Additionally, time of day and varied amounts of voice usage during the day could have impacted the participant's specific vocal fatigue. A majority of these participants had participated in the evening, when, more than likely, their voices had been used more than if they had participated in the study in the morning when voice usage was likely to be minimal. Furthermore, correlations between vocal fatigue ratings and lung age shown below had a stronger impact on results of the study than any of the other parameters measured.

Acoustical Parameters

When comparing the pre- and post-vocal loading tasks, there were no significant results found from statistical analysis; however, there was a trending relationship from the jitter and shimmer from the pre- to post-vocal loading data, indicating that there was a slight change in the perturbation measures during the vocal loading task.

The fundamental frequency of the Rainbow Passage was not presented as a metric of interest in the research question, but analysis revealed trending numbers from pre- to the post-vocal loading task. Using a one-tailed t-test, the fundamental frequency mean was statistically significant when comparing the pre- and post-vocal loading tasks. The fundamental frequency also increased over time during the vocal loading task but was not found to be significant. Conclusively, the acoustical data analyzed yielded non-significant results from the specific research question; likewise, the data also indicated trending values and significant values between the pre- to during the vocal loading task as well as the vocal loading task to the post-vocal loading task. There are multiple indications for why the data had presented this way, including the data found for the comparison of lung age verses the slope values of the vocal fatigue ratings. Exact reasoning for the trending and non-significant data would be need to be investigated further to find the cause for the non-significant findings in acoustical parameters seen in this data pool.

Laukkanen (2006) had similar findings between pre- and post-vocal loading task that were also not overall significant statistically. This led researchers to compare the pre-vocal loading data to the vocal loading data, and the vocal loading data to the post-loading data. Consequently, the data was statistically significant or trending when comparing the before and after tasks to the middle of the vocal loading tasks, indicating that there may have been a notable difference during the middle of fatiguing tasks, but not as much before and after. Laukkanen's similar results, has led researchers of this study to wonder if the significance of the vocal loading tasks may be found during the loading task itself, instead of a before and after comparison.

The concept of measuring vocal fatigue during the middle of a vocal loading task may be a proposal for future research due to this study's and multiple experiments inconclusive results from the pre- and post-vocal fatiguing tasks. There appears to be a significant change between the pre-vocal loading task and the vocal loading task, but this change appears to become non-significant by the end of the vocal loading task.

Rate of Perceived Vocal Fatigue and Lung Age in Aging Population

While there can be many assumptions for why the participant's fatigued at varied rates, much can be said about the correlational data compared between the slopes of the lung age, chronological age and the participant's vocal fatigue rating data. If reference is given to the table above comparing the lung age, actual age and vocal fatigue ratings, there are indications that the lung age of the participants was highly correlated as an indicator for rate and severity of vocal fatigue that the participants experienced.

A high percentage correlation greater than 50% were found between the participant's lung and vocal fatigue rating, indicating that there was an association between an individual's lung age and the rate of vocal fatigue for this study and pool of participants. The participant's chronological age could also foretell the rate at which these participant's fatigued over time during the vocal loading task due to the high correlational percentage as seen in Table 6.

The results of the correlational analysis completed for this data tells the researchers that the chronological age may only be on factor for determining the severity of vocal fatigue that the participants experienced. Additionally, the correlational analyzation reveals to the lung age of the participants as a notable indicator for the rate at which these participant's fatigued. The data points the researchers to explore the possibility that aging may not be just the individual's chronological age, but the aging of the biological systems and the relationships with the rest of the body, as is captured in the estimate of the lung age. Perhaps some of the females fatigued at a greater rate due to their higher lung age, compared to their peers who did not fatigue at a great rate because they had a lower lung age. The points made and found in this research may indicate that more research is still needed to be done in the area of aging and vocal fatigue.

Comparison Data (Old vs. Young)

One of the questions for this study must be answered through comparison of the data from both the aging population and the college-age population data. The comparison data of the two different participant pools was found to be insignificant, and in fact, rather close in comparison to the slope values of the averaged vocal fatigue ratings. The following data is both a cross comparison of the vocal fatigue ratings over time, during the study.

Limitations

As with all studies, there are limitations. Such limitations may have impacted the significance and overall impact of the results of the data presented. For example, the low number of recruited subjects for this study is a limitation, with only 11 subjects recruited and fully participated in the study; additional subjects would have allowed for a more generalizable discussion of the results. Additionally, another better selection control of study participants, including stricter inclusion/exclusion criteria for participants, as well as better protocol control would could reduce potential outcome variation. Controlling the subject's start time specifically for the morning may also have reduced the variability of the participant's rates of fatigue due to varied voice use of each person's everyday life. And finally, the literature does not discuss the variability from repeated vocal loading tasks. Therefore, it is possible that a participant's data were not an average representation of the participant.

Future Research

Future studies could address these limitations as well as add additional metrics to the analysis as the protocol was complex with opportunity to measure many more voice metrics. For example, focusing on fundamental frequency, or noise-to-harmonic ratio during statistical analysis, may reveal aspects of vocal fatigue not discussed in recent literature. Additionally, phonation aerodynamic measures have previously been shown to be sensitive to vocal loading and could be added in the future. Finally, a more in-depth look at the estimated lung age and vocal loading would be in order.

Furthermore, the results of this study may point to future research in the areas related to vocal fatigue and the aging female. Presently, most data and knowledge that exists involving the aging voice is based on physiological or anatomical information or changes that occur within the body as human's age. A discussed proposal for future research involves comparing more statistical data of the acoustic measures from during the vocal loading task with using the pre-vocal loading task as a reference point and the post-vocal loading task as the comparison. Additionally, controlling the participants for time of day during vocal fatiguing task, smaller age range, and an increase in amount of participants would improve the understanding of what may be happening to participants on a self-perceptual level. Understanding the acoustical changes, and the subjective opinions about this specific population should be observed more closely in future research to fully understand vocal fatigue.

Clinical Applications

The data from this thesis study will give information to clinicians on what may be leading to an increase in vocal fatigue in the aging female population. The results of this thesis may also indicate that when performing acoustic measures on patients with voice disorders, some participants may have differences in their fundamental frequency over time as they perform vocal warm-up exercises, or vocal fatigue.

CONCLUSION

The results of this study indicate that the aging female will vocally fatigue over time during a vocal loading task; however, the specific rate of this fatigue will vary across individuals and may be impacted by other factors not controlled for in this study (height, body type, previous medical histories, menopause, etc.). Secondly, the results of this study indicate that females in the aging population of this study fatigued at a rate that was no different than when compared to their younger college-age counterparts, specifically by ratings of vocal fatigue and perturbation measures over time. And lastly, a significant trend was found when comparing the participants' vocal fatigue ratings to the lung age calculated via spirometry leading researchers to believe that the participant's vocal fatigue could be directly linked to the lung age rather than the participant's chronological age overall.

APPENDICES

APPENDIX A

Protocol Measures not statistically analyzed for this study

APPENDIX A

Protocol Measures not statistically analyzed for this study

1a. Survey

The survey for this study will be used for later studies and is located online via Qualitrics. The survey is a combination of the Vocal Handicap Index (VHI), the Vocal Fatigue Index and Voice-Related Quality of Life (VR-QOL).

1b. Pulmonary Function Test

The pulmonary function test is used to compare and analyze pulmonary function pre-vocal loading task. A spirometer was used to measure pulmonary function on a computer. The participant will be instructed to blow into the spirometer and are required to pass three consistent breathes as measured by software and indicated as a “pass” on the screen. Once they have three successful trials on the spirometer, the participant will have their results printed, and a copy will be printed for the researcher’s records.

1c. Hearing Screening

The hearing screening will be administered in a soundproof booth, via an audiometer. The participant’s hearing will be tested at 25 dB, and at the frequencies of 500, 1000, 2000, and 4000 Hz. If the participant must pass hearing screening to continue with study.

1d. Breathing Screening

The breathing screening will use the chart in the protocol below. The participant’s breathing will be assessed by where in their body it takes place. If the patient has inadequate breathing patterns for the vocal loading task, they will be finished with the study and asked to leave.

APPENDIX B

Protocol Instructions

APPENDIX B

Protocol Instructions

PROTOCOL INSTRUCTIONS

SUBJECT NUMBER: _________________
DATE: ____________________________
TIME: ____________________________

"Hello and welcome to our study! --- Do you have any questions before we begin?"

SCREENINGS:
□ Seat the subject
"Please read and sign this consent form. Let me know if you have any questions."
Hand subject consent form & provide a take-home copy as well
□ Non-fatiguing tasks
"Before we begin, between each screening and survey task, you will be asked to rate your current vocal fatigue. I want you to read the following script "My vocal fatigue level is _____", with your current vocal fatigue on a scale of 1 being no level of fatigue and 10 being the greatest amount of fatigue. You cannot rate 0 or greater than 10. Other than that during the next tasks I would like you to talk as little as possible, until I redirect you to rate your vocal fatigue level. Please use post it notes or hand gestures to communicate other than that."
Provide accessible post it notes and script reading "My current vocal fatigue level is ____"- when participants rate themselves write the rating on the provided line.
□ Ask subject to complete surveys via Qualtrics questionnaire- (which includes: VHI, VFI, BFI-10, V-RQOL)
"Use this time to completely fill out the questionnaires on this online survey."
Direct subject to online surveys:

PROMPT VOCAL FATIGUE RATING- _____

□ Hearing screening: Make sure earphones are present, turn on audiometer.
Mark results on following screening form using 25dB

Left Ear	Right Ear
• 500 Hz	• 500 Hz
1000 Hz 2000 Hz 4000 Hz	• 1000 Hz • 2000 Hz • 4000 Hz

□ Pulmonary Function Test:

- Pre-check: turn on computer, having testing tubes nearby, be sure spirometer is plugged into computer and turned on.
- Enter participant's number into the software and begin exam:
  - "First I will provide you with instructions to follow the test. I will then model the procedure for you, if you have any questions at this point please ask. I will then place a nose plug on your nose, and you will inhale as much and deeply as you can. Then, exhale as fast as you can pushing all the air out of your lungs. Do not pause in between the inhalation and the exhalation. Feel free to use the rest of your body in order to move as much air as possible."
  - Offer the participant a copy of the PFT results.

OFFER A SIP OF WATER

PROMPT VOCAL FATIGUE RATING- _____

□ Breathing Screening: identifies types of breathing.
Mark results on respiration screening form

Type of breathing			
		Present	Absent
Diaphragmatic	The belly pushes out with an inhale		
Thoracic	During inhale the chest expands to accommodate the air that has been sucked into the lungs		
Clavicular	During inhale the clavicle goes up to accommodate the air that has been sucked into the upper part of the lungs		
Paradoxical	The chest compresses on the inhale rather than expands and vice versa		

Type of respiration cycle in non-speech:

Oral-Oral	
Nasal-Nasal	
Oral-Nasal	
Adequate	

Coordination of respiration-voice:

Not adequate	

OFFER A SIP OF WATER

PROMPT VOCAL FATIGUE RATING- _____

VOCAL LOADING TASKS

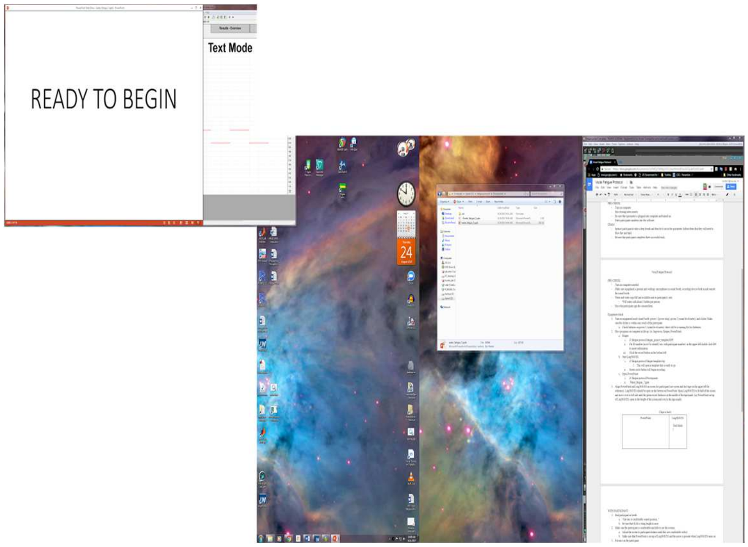
□ Pre-check:

- Are computers on and logged in?
- Is equipment present and working- microphones in sound booth, recording devices both in and outside the sound booth?
- Are water and water cups full and available next to participant's seat?
    - o Fill water with about 2 bottles per person.
- Did participant sign the consent form and understand they can leave at any point?

□ Equipment check:

1. Turn on equipment inside sound booth- power 1 (power strip), power 2 (sound level meter), and clicker. Make sure the clicker is within easy reach of the participant.
    1. Check batteries on power 2 (sound level meter)- there will be a warning for low batteries.
2. Have programs on computer in lab up- (lingWAVES, PowerPoint, Reaper).
    1. Reaper
        1. Z:\fatigue protocol\fatigue_project_template.RPP
        2. Put ID number (m or f to identify sex, with participant number)- in the upper left double click ID# to insert information.
        3. Note the record button on the bottom left.
    1. Start lingWAVES
        1. Z:\fatigue protocol\fatigue template.lwp
            1. This will open a template that is ready to go.
        2. Note green circle button at the top is the record button.
    1. Open PowerPoint
        1. Z:\fatigue protocol\Powerpoints
        2. Water_fatigue_7.pptx
2. Align PowerPoint and LingWAVES on screen for participant (use screen and duct tape on far upper left for reference). LingWAVES should be open on the bottom on PowerPoint. Open LingWAVES to fit half of the screen and move over to left side until the green record button is in the middle of the tape mark. Lay PowerPoint on top of LingWAVES, open to the height of the screen and over to the tape mark).
    1. Screen should look as follows:

(tape is here)



□ Participant instructions: go through the following ensuring no questions along the way.

1. Make sure participant is seated in an upright posture in booth.
    1. "Get into a comfortable seated position. Try to stay in an upright posture and limit movements during tasks to avoid the microphone moving".
    2. Adjust sound-level meter (SLM) to be string length nose distance away from participant.
2. Adjust screen to preferred distance from participant.
    1. "Let me know which distance you are comfortable with the screen. You should be able to clearly read the screen with no difficulty."
    2. Make sure PowerPoint is on top of LingWAVES and the arrow is present when LingWAVES turns on.
2. Put microphone around participant's ears.
3. Show the participant how to get a cup of water.
    1. "One big push will fill the cup, watch as I do it. Each time you are prompted to drink on the screen you are to fill the water cup and drink it. I would recommend filling the cup right after you finish it to make it easier next time you are prompted to drink."
2. Show the participant the click and which button to push.
    1. "You click this button to move forward in the PowerPoint to your desired pace. The PowerPoint will indicate whether or not to click when done with a slide".
2. Begin the PowerPoint and go through the practice tasks (DO NOT RECORD YET):
    1. Inform them that there will be an arrow on the right side that they want to disappear
        1. "You want to speak loudly enough that the big arrow disappears".
    1. The PowerPoint will then go through the following examples:
        1. Vocal fatigue level
            1. "As previously done in between tasks, I want you to rate your current vocal fatigue level. With 1 being 1 being no level of fatigue and 10 being the greatest amount of fatigue."
        2. Steady vowel phonation and vowel-consonant-vowel

            1. "The next two tasks are going to be producing 'ah' and 'afa'. First you will produce 'ah' for about 3-5 seconds in a comfortable extended tone for as long as the 'ah' is present on the screen. After that you will see 'afa' on the screen, you will produce 'afa' in a shorter comfortable tone without changing pitch. For example: 'ahhhhh' 'afa'- *provide examples"
        3. 2 readings
            1. "Read through the next readings in a comfortable pitch."
            2. "Note that on the last slide it says not to click to advance. When you get to this slide repeat the passage until the slide automatically changes. You may or may not have to repeat this slide, it is completely dependent on your pace".
2. Exit sound booth to begin Reaper recording.
    1. Have participant give 3 loud "Hey's" to test for acoustics.
        1. "Pretend you are saying hey to someone in the outdoor lab area, loudly and clearly."
        2. INSERT PARTICIPANT NUMBER IN REAPER.
2. Re-enter sound booth, shut the outer door to begin vocal measures.
    1. State date, time and participant number (DO NOT mention actual name)
2. Begin PowerPoint pre-tasks:
    1. "When you are ready you are going to complete some initial tasks. The PowerPoint will indicate what you should do, it will be similar to the practice tasks."
    2. Tasks:
        1. Count to five drawing out the "I" in five
        2. Extended "ah"
        3. "Afa"
        4. Rainbow passage
2. Ready to begin.
    1. "Do you have any questions? I will do the rest of my communicating with you through the intercom. Give me a thumbs up to let me know when you are ready and I will tell you to begin by clicking the clicker which will start the PowerPoint."
2. When the participant gets to the first slide and is drinking water, begin LingWAVES and click back to the PowerPoint so it is layered on top.
    1. NOTE: failure to click back on the PowerPoint will result in the clicker not working when participant clicks it!

□ Data collection- participant tasks, **equipment: PowerPoint, LingWAVES and Reaper**

- Task 1:
    - Drink water
- Task 2:
    - Self-rating of vocal fatigue
- Task 3 & 4:
    - "Aaaah" extended productions x3 in a comfortable voice and "afa" x3 in a comfortable voice
- Task 5:

- Marvin Williams Passage- loudness guided by arrows to indicate desired loudness (which will stay consistent through task 9)
- Task 6:
    - Stella Passage
- Task 7:
    - “Aaaah” extended productions
- Task 8:
    - Rainbow Passage
- Task 9:
    - Rainbow Passage Part 2

*Participants will go through a cycle of these 9 tasks until time limit is complete.

- Researchers during this time will remain outside the sound booth, only entering if signaled by participant. Ensure all recordings are working functionally throughout collection.

□ Post data-collection:

1. When PowerPoint is complete, LingWAVES will automatically shut off.
2. Participant will be guided through the following post vocal loading tasks:
    1. Count to five drawing out the “I” in five
    2. Extended “ah”
    3. “Afa”
    4. Rainbow passage
2. When they have finished the rainbow passage, instruct them via intercom that you will be re-entering the room.
3. Turn off Reaper and go in sound booth.
4. Thank participant and bring them outside booth for instructions on at home use of respiratory training device.
    1. “Thank you for coming today. We are finished with the tasks for today. If you do not have any further questions, I will compensate you for your time, and you may leave”

APPENDIX C

Passages used for Vocal Loading Task

APPENDIX C

Passages used for Vocal Loading Task

The Rainbow Passage Part 1:

When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look, but no one ever finds it. When a man looks for something beyond his reach his friends say he is looking for the pot of gold at the end of the rainbow."

First paragraph of the Rainbow Passage (Fairbanks, 1960).

Rainbow Passage Part 2

Throughout the centuries people have explained the rainbow in various ways. Some have accepted it as a miracle without physical explanation. To the Hebrews it was a token that there would be no more universal floods. The Greeks used to imagine that it was a sign from the gods to foretell war or heavy rain. The Norsemen considered the rainbow as a bridge over which the gods passed from earth to their home in the sky. Others have tried to explain the phenomenon physically. Aristotle thought that the rainbow was caused by reflection of the sun's rays by the rain. Since then physicists have found that it is not reflection, but refraction by the raindrops which causes the rainbows.

Marvin Williams Passage

Marvin Williams is only nine. Marvin lives with his mother on Monroe Avenue in Vernon Valley. Marvin loves all movies, even eerie ones with evil villains in them. Whenever a new movie is in the area, Marvin is usually an early arrival. Nearly every evening Marvin is in row one, along the aisle.

Stella Passage

Please call Stella. Ask her to bring these things with her from the store: Six spoons of fresh snow peas, five thick slabs of blue cheese, and maybe a snack for her brother Bob. We also need a small plastic snake and a big toy frog for the kids. She can scoop these things into three red bags, and we will go meet her Wednesday at the train station.

APPENDIX D

Tables used in previous presentation but not imperative to this study

APPENDIX D

Tables used in previous presentation but not imperative to this study

Table 7. Participant's lung age and actual age.

Participant ID	Lung Age OSF13	Actual Age
OSF03	80	70
OSF04	80	62
OSF05	79	64
OSF06	65	67
OSF07	70	57
OSF08	70	59
OSF09	67	64
OSF10	59	61
OSF11	66	69
OSF12	70	69
	80	70
Average	71	65

Table 8. Participant's Vocal Fatigue Ratings (over time in minutes).

Time	-5	0	2.5	5	8	11	14	17	20	23	25.5	28.5	31.5	34.5	37.5
OS03	4	4	4	4	4	4	5	5	5	6	6	6	7	7	7
OS04	1	1	1	1	1	2	3	5	7	7	7	8	9	9	9
OS05	5	5	5	5	6	6	6	6	6	6	6	6	6	6	6
OS06	2	2	2	2	2	3	3	4	5	5	6	7	7	8	9
OS07	2	2	2	3	3	4	4	5	5	6	6	6	7	7	7
OS08	1	1	1	1	2	2	3	3	3	4	4	5	6	6	7
OS09	3	3	3	3	3	4	4	5	5	7	8	9	9	9	9
OS10	1	1	2	3	3	4	4	5	6	6	7	8	8	8	10
OS11	1	1	1	1	1	1	3	4	4	5	7	8	8	9	9
OS12	1	1	1	2	2	3	4	5	5	6	6	6	5	5	6
OS13	4	4	4	4	5	5	5	5	5	5	5	6	6	6	6
Avg	2.3	2.3	2.4	2.6	2.9	3.5	4	4.7	5.1	5.7	6.2	6.8	7.1	7.3	7.7
Std Dev	1.4	1.4	1.4	1.3	1.5	1.4	0.9	0.8	0.9	0.8	1.0	1.2	1.2	1.4	1.4

APPENDIX E

IRB Approval Form

MICHIGAN STATE
UNIVERSITY

Revision Application Approval

May 23, 2017

To: Eric Hunter
1026 Red Cedar Road
Room 113, Oyer Speech & Hearing Building
East Lansing, MI 48824

Re: **IRB# 16-689** Category: EXPEDITED 4, 7
Revision Approval Date: May 22, 2017
Project Expiration Date: May 9, 2018

Title: Gender, Age, and Vocal Effort (CGA# 136350)

The Institutional Review Board has completed their review of your project. I am pleased to advise you that **the revision has been approved**.

This revision included changes to the title "Gender, Age, and Vocal Effort", recruitment/advertisement, consent form, research instruments, protocol design, and the removal of Simone Graetzer and the addition of Olivia Sowa, Rachel Burtka to the study, and change in the study coordinator from Callan Gavigan to Olivia Sowa.

The review by the committee has found that your revision is consistent with the continued protection of the rights and welfare of human subjects, and meets the requirements of MSU's Federal Wide Assurance and the Federal Guidelines (45 CFR 46 and 21 CFR Part 50). The protection of human subjects in research is a partnership between the IRB and the investigators. We look forward to working with you as we both fulfill our responsibilities.

Renewals: IRB approval is valid until the expiration date listed above. If you are continuing your project, you must submit an ***Application for Renewal*** application at least one month before expiration. If the project is completed, please submit an ***Application for Permanent Closure***.

Revisions: The IRB must review any changes in the project, prior to initiation of the change. Please submit an ***Application for Revision*** to have your changes reviewed. If changes are made at the time of renewal, please include an ***Application for Revision*** with the renewal application.

Problems: If issues should arise during the conduct of the research, such as unanticipated problems, adverse events, or any problem that may increase the risk to the human subjects, notify the IRB office promptly. Forms are available to report these issues.

Please use the IRB number listed above on any forms submitted which relate to this project, or on any correspondence with the IRB office.

If we can be of further assistance, please contact us at 517-355-2180 or via email at IRB@msu.edu. Thank you for your cooperation.

c: Callan Gavigan, Pasquale Bottalico, Rachel Burtka, James Pivarnik, Russell Banks, Peter LAPINE, Mark Berardi, Lady Catherine Cantor Cutiva

MICHIGAN STATE UNIVERSITY Founded 1855

Office of Regulatory Affairs
Human Research Protection Programs

Biomedical & Health Institutional Review Board (BIRB)

Community Research Institutional Review Board (CRIRB)

Social Science Behavioral/Education Institutional Review Board (SIRB)

Olds Hall
408 West Circle Drive, #207
East Lansing, MI 48824
(517) 355-2180
Fax: (517) 432-4503
Email: irb@msu.edu
www.hrpp.msu.edu

APPENDIX F

IRB Approved Recruitment Flyer

~Participants Needed~

Vocal Effort in Women Ages 55-70

Purpose of the Study In this study, we are trying to understand the rate of vocal effort in females between 55-70 years of age. Participants will be asked to undergo a short screening per research criteria, read passages out loud for about 40 minutes.

Inclusion/Exclusion

- We are looking for people between 55-70 years of age.
- You must have hearing within normal limits for your age (pass a short hearing screen).
- No history of prior or current voice or speech problems requiring medical intervention (including voice or speech therapy).
- Native English speaker

Potential Benefits You will not directly benefit from your participation in the study. However, your participation in this study will contribute to the understanding vocal effort during of prolonged voice use.

Potential Risks There are minimal risks associated with participation in this study - the risk is no greater than interacting in your normal environment or having a long phone conversation. You may feel some discomfort in the area of your throat where you speak which is normal for any average individual. The study consists of a screening task, drinking water, talking, reading text, and responding to questions about your voice.

Length of the Study: Most participants will be asked to complete a single session of about an hour and a half. Study Location: CAS Basement (rooms 6 and 7). Compensation: Participants will receive cash payment of $20/hr for up to 2 hours.

For more information or to sign-up for the study, contact: Olivia Sowa, sowaoliv@msu.edu, 231-563-3317

APPENDIX G

IRB Approved Consent Form

Research Participant Information and Consent Form

You are being asked to participate in a research study. Researchers are required to provide a consent form to inform you about the research study, to convey that participation is voluntary, to explain risks and benefits of participation, and to empower you to make an informed decision. You should feel free to ask the researchers any questions you may have concerning this project.

Study Title: *Gender, Age and Vocal Effort*

Researcher and Title: Dr. Eric Hunter, Associate Professor

Department and Institution: Department of Communicative Sciences and Disorders at Michigan State University

Address and Contact Information: 113 Oyer, East Lansing 48823, 517.353.8641

Sponsor: Michigan State University

1. PURPOSE OF RESEARCH

You are being asked to participate in this study to help researchers gain a better understanding of how fast the voice gets tired due to a long reading task. This study is voluntary.

2. ELIGIBILITY CRITERIA

It is expected that you have no significant vocal complaints and are in good physical and mental health.

- You must be between 18-70 years of age.
- You must be a native English speaker.
- You will be asked about items which might affect your speech production (e.g. hearing, heartburn)

3. ALTERNATIVE OPTIONS

There are no alternative procedures, but you have the option not to participate in this research study.

4. WHAT YOU WILL DO

We expect that full participation in the study will take between 60-90 minutes. After a brief introduction to the study, you will be asked to participate in a screening process (15-25 minutes) followed by a prolonged speaking task (no more than 45 minutes). Since it is common for your mouth to dry out while speaking for a long time, during the prolonged speaking task, you will be given the opportunity to take regular small drinks of water. However, so that all participants drink the same amount of water, we will use small measured cups and have you drink at a regular intervals. The total amount of water to drink is about the same amount as in a can of soda (less than 20 oz). During the screening process, you may be asked to do some or all of the following:

- Complete questionnaires about your voice and voice use.
- Answer questions about your vocal habits and history of vocal fatigue.
- Asked about current medications which may affect voice use (e.g. asthma, allergies, heartburn).
- Complete a short hearing screen to ensure that your hearing is within the normal age appropriate ranges.
- Complete a pulmonary function test using a device (spirometer) to measure your lung function; this may be repeated up to three times. For this test, you will be asked to breath in deeply and blow into a device to collect measurements about your lung ability. Also, your breathing while speaking will be observed (no devices used) to indicate how you breath while speaking.

After the screening process, you will do a prolonged speech reading task in a soundproof room used for recordings. You will wear a microphone that goes loosely around your neck and a microphone that goes on your head (similar to headphones). Before and after the long speaking task, you will be asked to perform some simple vocal tasks, such as a sustained "ah" vowel, pitch glides, and reading a passage. During the prolonged speaking task, you will be asked to read out loud for less than 40 minutes as prompted by a computer screen. Sometimes you will be prompted to speak louder, sometimes softer. Every few minutes you will be reminded to drink a small cup (less than 30 mL) of water.

This consent form was approved by a Michigan State University Institutional Review Board. Approved 5/22/17 – valid through 5/9/18. This version supersedes all previous versions. IRB # 16-689.

5. POTENTIAL BENEFITS
While the program in which you are being asked to participate may have no immediate benefit for you, it may benefit others by increasing our knowledge of factors affecting measures of speech and vocal function.

6. POTENTIAL RISKS
There is minimal risk involved in this research program and the procedures should cause you no undue discomfort. Likely your voice will experience some fatigue but this should resolve with some nominal vocal rest. Except for the spirometer, other devices to be used are similar to those found in singing studios, linguistic laboratories, and speech production laboratories. They include such items as microphones and surface microphones that go on the neck (to detect speech use in noise). An ear microphone and recorder may be used to record the sound you are surrounded by. While the pulmonary function test is unlikely to cause injury, breathing hard may cause some discomfort.

If there is anything in the screening that does not make you a good subject for our study, you will be remunerated for your time (see below) and no further participation is needed. If you are not healthy enough to participate (for example, if you have a cold or are hoarse from cheering at a sports activity), or if one of the screening procedures indicates that you might not match the level of communication function we are looking for (for example, your hearing is limited), you may be asked to not participate further.
The testing performed in this project is not intended to find abnormalities, the protocol does not diagnose illness and we do not refer to health care providers. Data collected do not comprise a diagnostic or clinical study. Undetected vocal abnormalities are rare but it is possible that the investigators may perceive a vocal abnormality during the initial screening. If this occurs, you will be advised to consult with a licensed physician to determine whether a health examination would be prudent.

7. PRIVACY AND CONFIDENTIALITY
The data recorded for this study will be collected confidentially. Neither the researchers nor anyone else will be able to link data to you. The data for this project will be kept confidential. Data from this study will be stored in a locked cabinet in a locked room or a password protected computer in the locked laboratory. All information will be kept for at least three years after the close of the study. Only trained researchers under the jurisdiction of this project and Human Research Protection Program will have access to the data collected in the study. Information about you will be kept confidential to the maximum extent allowable by law. Although we will make every effort to keep your data confidential there are certain times, such as a court order, where we may have to disclose your data. Identifying information will not be attached to any of your individual responses or recordings when reporting results from the surveys. You will not be asked to give your name or any other information during the recording that will allow you or your place of employment to be identified. All results will be kept in a secure location accessible only to those involved in the study. The results of this study may be published or presented at professional meetings, but the identities of all research participants will remain anonymous. By participating, you agree to allow audio recordings of your speech.

8. YOUR RIGHTS TO PARTICIPATE, SAY NO, OR WITHDRAW
Participation is voluntary. Refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled. You may discontinue participation at any time without penalty or loss of benefits to which you are otherwise entitled. You have the right to say no. You may change your mind at any time and withdraw. You may choose not to answer specific questions or to stop participating at any time. Whether you choose to participate or not will have no effect on your grade or evaluation.

9. COSTS AND COMPENSATION FOR BEING IN THE STUDY
As an incentive to participate, subjects/students who participate in this research will be offered $10 per hour of participation (up to 2 hours or $20) or, if applicable, you can choose to earn extra credit through the MSU

SONA software system. If participants are enrolled in a course that allows them to participate in a research study for credit, and the course accepts SONA credit, participants will have the option to receive MSU SONA credit instead of the cash remuneration.

For those enrolled in such courses, students can also find alternative assignments to earn extra credit if they choose not to participate in this research study but wish to earn extra credit. The SONA system awards 1 credit per 1 hour of research participation (up to 2 credits). Within the SONA system, neither researchers nor individual instructors will know what studies participants are involved in. If your participation is over an hour, which it will likely be, we will compensate you in half hour increments (rounding up) for up to two hours total.

10. THE RIGHT TO GET HELP IF INJURED

In the unlikely event that you are injured as a result of your participation in this project, Michigan State University will assist you in obtaining emergency care, if necessary, for your research related injuries. If you have insurance for medical care, your insurance carrier will be billed in the ordinary manner. As with any medical insurance, any costs that are not covered or in excess of what are paid by your insurance, including deductibles, will be your responsibility. The University's policy is not to provide financial compensation for lost wages, disability, pain or discomfort, unless required by law to do so. This does not mean that you are giving up any legal rights you may have. You may contact Dr. Eric Hunter at 517-353-8641 with any questions or to report an injury.

11. CONTACT INFORMATION

If you have concerns or questions about this study, such as scientific issues, how to do any part of it, or to report an injury, please contact the researcher(s):

- Dr. Eric Hunter, Michigan State Univ, 113 Oyer, East Lansing, MI 48823, 517-353-8641, ejhunter@msu.edu
- Olivia Sowa, Michigan State Univ., 231-563-3317, sowaoliv@msu.edu
- Dr. Lady Catherine Cantor Cutiva, Michigan State Univ., 10 Oyer, East Lansing, MI 48824, cantorcu@msu.edu

If you have questions or concerns about your role and rights as a research participant, would like to obtain information or offer input, or would like to register a complaint about this study, you may contact, anonymously if you wish, the Michigan State University's Human Research Protection Program at 517-355-2180, Fax 517-432-4503, or e-mail irb@msu.edu or regular mail at 4000 Collins Rd, Suite 136, Lansing, MI 48910.

12. DOCUMENTATION OF INFORMED CONSENT

Your signature below means that you voluntarily agree to participate in this research study.

______________________________ ______________________

Signature Date

You will be given a copy of this form to keep.

At times, it is useful to use recordings in teaching or presenting research. Therefore, we would like to ask for special permission to use your recordings in those contexts. Your name would not be associated with the recording. If you do not give permission, it will not affect your ability to participate in the research. If you agree to allow your voice recordings (audio or video) to be part of scientific reports and presentations, please indicate:

Yes No Initials____________

This consent form was approved by a Michigan State University Institutional Review Board. Approved 5/22/17 – valid through 5/9/18. This version supersedes all previous versions. IRB # 16-689.

A signature is a required element of consent – if not included, a waiver of documentation must be applied for.

This consent form was approved by a Michigan State University Institutional Review Board. Approved 5/22/17 – valid through 5/9/18. This version supersedes all previous versions. IRB # 16-689.

APPENDIX H

Information and Biographical Sheet

Participant Information Sheet

Study: ____________ Subject #: ____________

Date: ____________ Associate: ____________

Gender: M F Age: ______

a. Compared to a normal day, today I feel:

a) Much less stress
b) Less stress
c) The same stress
d) More stress
e) Much more stress

b. Compared to a normal day, today I feel:

a) Much less fatigue
b) Less fatigue
c) The same fatigue
d) More fatigue
e) Much more fatigue

c. I would describe my PRIMARY workplace / learning environment as:

a) Very Quiet
b) Quiet
c) Neutral
d) Noisy
e) Very Noisy

d. I would describe my SECONDARY workplace / learning environment as:

a) Very Quiet
b) Quiet
c) Neutral
d) Noisy
e) Very Noisy

e. Do I commonly experience symptoms of reflux (or heartburn)? yes no

Am I experiencing reflux symptoms today? yes no

f. Do I commonly experience symptoms of seasonal allergies? yes no

Am I experiencing allergy symptoms today? yes no

g. In the last two weeks, have you taken any herbal, over the counter or prescribed medication for symptoms of asthma, allergies, upper respiratory infections, heartburn/reflux, or anything which might affect your hearing, airway, or sinuses? yes no

h. In the past year, I have smoked: never occasionally daily

i. On average, I consume ___ caffeinated beverages per day. 0 1 2 3 4+

j. Are you a native speaker of American English? Yes / No

If not, what is your first language or dialect of English? ____________________

k. Do you talk like other people who live here, or do you have an accent?

If you have an accent, please describe. Where did you grow up?

l. Do you have any history of voice training, hearing disorders, or speech / language therapy? yes no

It is important that the ethnic and racial makeup of our research participant pool reflects that of the local community. Please indicate which of the following ethnic and racial categories you identify:

Ethnic Category	
Hispanic or Latino	
Not Hispanic or Latino	
Prefer not to identify	

Racial Categories	
American Indian/Alaska Native	
Asian	
Native Hawaiian or other Pacific Islander	
Black or African American	
White	
Prefer not to identify	

APPENDIX I

Respiration Form

V-BAL

Respiration and perceptual voice assessments

Study: ____________________ **Subject #:** ________________

Date: ____________________ **Associate:** ________________

Name: ____

1. Respiration assessment

Type of breathing		Score	
		Present	Absent
Diaphragmatic	The belly pushes out with an inhale		
Thoracic	During inhale the chest expands to accommodate the air that has been sucked into the lungs		
Clavicular	During inhale the clavicle goes up to accommodate the air that has been sucked into the upper part of the lungs		
Paradoxical	The chest compresses on the inhale rather than expands and vice versa		

Type of respiration cycle in no-speech

Oral-Oral	
Nasal-Nasal	
Oral-Nasal	

Coordination respiration-voice

Adequate	
No adequate	

2. Perceptual analysis of voice

GRBAS Scale			Score			
			0	1	2	3
G	Grade	Overall impression of voice deviance – hoarseness				
R	Roughness	Impression of irregular glottal pulses				
B	Breathiness	Audible turbulent noise generated at the glottal level by air leakage				
A	Asthenicity	Auditive impression of weakness in spontaneous phonation				
S	Strain	Excessive effort of tension associated with spontaneous phonation				

Vocal fry		Score	
		Present	Absent
Factor 1	Reduction/distinctly lowered pitch		
Factor 2	Rough gravel like quality		

Page 1

Compiled and design by Lady Catherine Cantor Cutiva

APPENDIX J

Survey Questions

Voice Biomechanics and Acoustics Laboratory
Department of Communicative Sciences and Disorders
College of Communication Arts & Sciences
Michigan State University

Subject Number: ______________ Date: ____________

Voice Handicap Index-10

Instructions: These are statements that many people have used to describe their voices and effects of their voices on their lives. Circle the response that indicates how frequently you have the same experience.

0 = never 1 = almost never 2 = sometimes 3 = almost always 4 = always

1. My voice makes it difficult for people to hear me.	0	1	2	3	4
2. I run out of air when I talk.	0	1	2	3	4
3. People have difficulty understanding me in a noisy room.	0	1	2	3	4
4. The sound of my voice varies throughout the day.	0	1	2	3	4
5. My family has difficulty hearing me when I call them throughout the house.	0	1	2	3	4
6. I use the phone less often than I would like to.	0	1	2	3	4
7. I'm tense when talking to others because of my voice.	0	1	2	3	4
8. I tend to avoid groups of people because of my voice.	0	1	2	3	4
9. People seem irritated with my voice.	0	1	2	3	4
10. People ask, "What's wrong with your voice?"	0	1	2	3	4

Rosen, C. A., Lee, A. S., Osborne, J., Zullo, T.& Murry, T. (2004). Development and validation of the voice handicap index-10. *The Laryngoscope, 114*(9), 1549–1556.

Voice Biomechanics and Acoustics Laboratory
Department of Communicative Sciences and Disorders
College of Communication Arts & Sciences
Michigan State University

Subject Number: ______________ Date: ___________

Big Five Inventory-10 (BFI-10)

Instructions: How well do the following statements describe your personality?

1= disagree strongly 2= disagree a little 3=neither agree nor disagree
4= agree a little 5= agree strongly

I see myself as someone who...

1. Is reserved	1	2	3	4	5
2. Is generally trusting	1	2	3	4	5
3. Tends to be lazy	1	2	3	4	5
4. Is relaxed, handles stress well	1	2	3	4	5
5. Has few artistic interests	1	2	3	4	5
6. Is outgoing, sociable	1	2	3	4	5
7. Tends to find fault with others	1	2	3	4	5
8. Does a thorough job	1	2	3	4	5
9. Get nervous easily	1	2	3	4	5
10. Has an active imagination	1	2	3	4	5

Rammstedt, B. & John, O. P. (2007). Measuring personality in one minute or less: A 10-item short version of the Big Five Inventory in English and German. *Journal of Research in Personality, 41*, 203-212.

Voice Biomechanics and Acoustics Laboratory
Department of Communicative Sciences and Disorders
College of Communication Arts & Sciences
Michigan State University

Subject Number: ______________ Date: ____________

Vocal Fatigue Index

These are some symptoms usually associated with voice problems. Circle the response that indicates how frequently you experience the same symptoms

0- never, 1- almost never, 2- sometimes, 3- almost always, 4- always

Part 1

1. I don't feel like talking after a period of voice use	0	1	2	3	4
2. My voice feels tired when I talk more	0	1	2	3	4
3. I experience increased sense of effort with talking	0	1	2	3	4
4. My voice gets hoarse with voice use	0	1	2	3	4
5. It feels like work to use my voice	0	1	2	3	4
6. I tend to generally limit my talking after a period of voice use	0	1	2	3	4
7. I avoid social situations when I know I have to talk more	0	1	2	3	4
8. I feel I cannot talk to my family after a work day	0	1	2	3	4
9. It is effortful to produce my voice after a period of voice use	0	1	2	3	4
10. I find it difficult to project my voice with voice use	0	1	2	3	4
11. My voice feels weak after a period of voice use	0	1	2	3	4

Part 2

12. I experience pain in the neck at the end of the day with voice use	0	1	2	3	4
13. I experience throat pain at the end of the day with voice use	0	1	2	3	4
14. My voice feels sore when I talk more	0	1	2	3	4
15. My throat aches with voice use	0	1	2	3	4
16. I experience discomfort in my neck with voice use	0	1	2	3	4

Part 3

17. My voice feels better after I have rested	0	1	2	3	4
18. The effort to produce my voice decreases with rest	0	1	2	3	4
19. The hoarseness of my voice gets better with rest	0	1	2	3	4

Nanjundeswaran, C., Verdolini A., Jacobson, B.H., Gartner-Smith, J., Rosem, C. Vocal fatigue index (VFI): development and validation.

Voice Biomechanics and Acoustics Laboratory
Department of Communicative Sciences and Disorders
College of Communication Arts & Sciences
Michigan State University

Subject Number: ______________ Date: ____________

Voice – Related Quality of Life (V-RQOL) Measure

Instructions: We are trying to learn more about how a voice problem can interfere with your day to day activities. On this paper, you will find a list of possible voice-related problems. Please answer all questions based upon what **your** voice has been like over the past **two weeks**.

Considering both how severe the problem is when you get it, and how frequently it happens, please rate each item below on how "bad" it is (that is, the **amount** of each problem that you have). Use the following scale for rating the amount of the problem:

1 = None, not a problem 2 = A small amount 3 = A moderate (medium) amount
4 = A lot 5 = Problem is as "bad as it can be"

Because of my voice,

1. I have trouble speaking loudly or being heard in noisy situations.	1 2 3 4 5
2. I run out of air and need to take frequent breaths when talking.	1 2 3 4 5
3. I sometimes do not know what will come out when I begin speaking.	1 2 3 4 5
4. I am sometimes anxious or frustrated (because of my voice).	1 2 3 4 5
5. I sometimes get depressed (because of my voice).	1 2 3 4 5
6. I have trouble using the telephone (because of my voice).	1 2 3 4 5
7. I have trouble doing my job or practicing my profession (because of my voice).	1 2 3 4 5
8. I avoid going out socially (because of my voice).	1 2 3 4 5
9. I have to repeat myself to be understood.	1 2 3 4 5
10. I have become less outgoing (because of my voice).	1 2 3 4 5

APPENDIX K

Specific information used in Methods Section

APPENDIX K

Specific information used in Methods Section

METHODS

Inclusion & Exclusion Criteria

In order to control for criteria in the test population, researchers had refine how the aging population was defined. The aging female population in this study was defined as women who were within the age range of 55 to 70 years of age. This age range has been created based on the average starting age range of menopause, with the average starting age being 51 years old (NIA, menopause.org, & ehealthmedicine). Menopause was chosen as an indicator of aging due to the known change in hormone levels of females.

Based on the average age range of menopause in women, the menopausal/post-menopausal population included females between the ages of 55-70 years with no smoking history within the last 5 years, and no previous vocal, speech, pulmonary or hearing impairment or history of vocal problems that required the services of a physician or speech-language pathologist. Participants that were vocally or athletically trained within this age range were excluded (i.e., professional singer, voice user or professional athlete). Additionally, non-native speakers of English and any person older than 70 or younger than 55 were excluded from this study.

Inclusion and exclusion criteria was assessed during the consent process and the initial screenings of the participants. The screenings conducted included a hearing screening, a breathing and pulmonary screening, and an endoscopic exam of the larynx and vocal processes. Included in the screening were questions about past medical history which includes a history of allergies, medications and any other medical conditions that could impact the results of the study. Patients must not have a history of gastroesophageal reflux disease (GERD), vocal nodules, upper respiratory infection or benign lesions in or on the vocal processes to be included in the study. Further, a participant who can only hear at an intensity greater than 25 dB at the frequencies 500, 1000, 2000 & 4000 Hz will be excluded from the study because this characteristic is linked to hearing loss (WHO, 2017). During the screening, if a participant was found to be within the exclusion criteria, they were compensated and dismissed from the study. Recruiting for this study will continue until 8-10 participants have been selected.

Procedures

Consent Form

Subjects were first consented to participate in the study. A consent form was signed by each participant before they can continue in the study. This form included any risks and the information about the study. Subjects were also not be informed of the hypothesis of the study during any time in order to avoid skewing the data on any subjective measures.

Vocal Fatigue Rating

The participant were then asked to rate their current vocal fatigue between the numbers of 1 and 10, with 1 being the lowest amount of vocal fatigue and 10 being the highest amount of vocal fatigue. The participants could not rate any lower than 1 and any higher than 10. The participant were to verbally rate their vocal fatigue to the researcher, either during the non-vocal loading tasks or during the vocal loading tasks.

Screenings (Non-Vocal Loading Tasks)

The screenings included a survey, a pulmonary function test, a hearing screening, and a breathing screening. Completion of the survey, an adequate pulmonary function test as well as a passed hearing and breathing screening in order to continue with participation in the study.

Survey

A survey including questions from the Vocal Fatigue Index (VFI), vocal handicap index (VHI), Big Five Inventory (BFI-10) and the Voice-Related Quality of Life (V-RQOL) will be administered to the participants before the study begins as a baseline measure, in addition to the self-rating scale after each non-fatiguing and fatiguing task. The surveys were combined and administered using the survey portal, Qualtrics, and the results of the participant's responses could be analyzed after the study has been conducted. The goal of these surveys are meant to assess the impact of vocal problems in the quality of life, assess patient ratings of vocal function, identify individuals with vocal fatigue based on symptoms of voice problems. Survey questions will be listed in the appendix below.

Pulmonary Function Test

Spirometry intends assess the pulmonary function and capacity of each participant. Spirometry will be completed using CareFusion, a computer-based program dedicated to pulmonary assessment. Prior to testing, the participant's age, height, smoking history, gender and race will be recorded in the CareFusion system. The norms for pulmonary measures will be taken from the measures used by the previous study to determine a normal percentage of pulmonary functions.

To test pulmonary function, the participant will in an upright position. A demonstration will be performed by the researcher and the following explanation will be given to ensure that the procedure is executed correctly: "Inhale as deeply and quickly as you can. Then, without pausing, exhale as hard as you can, pushing all the air out of your lungs. You may start whenever you feel ready." The participant will be required to have three successful attempts that are within 5% accuracy of each other as measured by CareFusion. If the participant cannot produce three consistent trials during the screening process, they will be dismissed from the study and compensated for their time.

The measures collected will be forced vital capacity (FVC), forced expiratory volume in the first second (FEV1), peak expiratory flow (PEF), and the ratio of forced expiratory volume in the first second of forced vital capacity (FEV1/FVC). After the data has been collected and the pulmonary function tests have been completed, each participant was allowed to view her spirometry results. The data from this screening was recorded into the database and possibly used for data analysis comparison in future studies.

Hearing Screening

A hearing screening was conducted to rule out if the participant's hearing is within normal limits to continue with the study. The participant's hearing will be screened at the frequencies: 500, 1000, 2000 and 4000 Hz; the amplitude of 25 decibels will be tested using these frequencies. These frequencies and the amplitude are based on normal hearing parameters given by ASHA.

Breathing Screening

The different types of breathing were measured in the participants to assess whether the participant could continue to participate in the study with a short task with the help of Lady Catherine Cantor Cutiva. The breathing types of an individual can include: diaphragmatic (inhale pushes diaphragm outwards), thoracic (chest expands outward to accommodate the air that fills the lungs), clavicular (during inhale the clavicle rises to accommodate for the space filling the upper part of the lungs) and paradoxical (the chest compresses on an inhale rather than expands). Any participants who show clavicular or paradoxical breathing will be excluded from the study because it is considered abnormal (for at rest; clavicular would not be unusual after very heavy exertion) and does not reflect the typical breathing type. Additionally, the area of inhalation and exhalation of breathing was assessed in participants. The patterns, or areas of inhalation and exhalation can be nasal-nasal, oral-nasal or oral-oral, in terms of the upper airway posturing during inhalation and exhalation.

Vocal Loading Task

The vocal loading task was approximately 35 minutes of speaking at an amplitude range of 72 and 76 decibels. Participants were asked to complete the task; however, if they are unable or become too fatigued, they were allowed to leave at any time and were compensated for their time.

The vocal loading tasks are designed to purposefully vocally fatigue the participants. Each participant participated in an approximate 35-minute vocal-loading task. LingWAVES was used to analyze and compare the recordings to the vocal fatigue ratings before and after the vocal loading tasks. The participants were given instruction on this task prior to the recording portion with a practice task. This is the experimental task of the study where each participant was required to complete the tasks as explained below.

During the approximate 35-minute vocal loading task, the participants were to alternate vocal intensity between 72.0 dB and 76.0 dB every five minutes, as based on the ISO standard of normal and raised speech level (ISO 1921, 2003). The participants will be seated in a sound-treated booth, with a microphone approximately 30 centimeters from their mouth, and their reading material as well as SPL levels were displayed on a computer screen. During the task, the lingWAVES software monitored the participant's vocal intensity, and the software Reaper recorded the participant's audio output. Participants will read from passages commonly used in voice research (i.e., Rainbow Passage, Marvin Williams Passage, etc.) and would rate their vocal fatigue (from 1 through 10) every few minutes.

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