THE EFFECT OF FILTERING ON AUDITORY-PERCEPTUAL RATINGS OF SEVERITY IN HYPOFUNCTIONAL VOICES

by

Candice M. George

Bachelor of Science in Communication Sciences & Disorders, 2008
Texas Christian University
Fort Worth, Texas

Submitted to the Graduate Faculty of
The Harris College of Nursing & Health Sciences
Texas Christian University
in partial fulfillment of the requirements
for the degree of

Masters of Science in Communication Sciences and Disorders
May 2010

THE EFFECT OF FILTERING ON AUDITORY-PERCEPTUAL RATINGS OF SEVERITY IN HYPOFUNCTIONAL VOICES

Thesis Approved:

Major Professor

Committee Member

Committee Member

College of Nursing & Health Sciences

ACKNOWLEDGMENTS

I would like to thank everyone that has participated in putting this thesis together. Specifically I would like to thank Dr. Christopher Watts for his tireless patience with me and for all the time and effort in helping me finish in time to graduate. I would also like to thank Dr. Raul Prezas and Dr. Helen Morrison for agreeing to be on my thesis committee. I appreciate all the time spent reading my document and wading through my difficult writing style. Thank you to Emily Lambert for the constant help through these two years. Thank you for lending me an ear to ask questions, vent, and grumble. I appreciate everything that everyone has done to help me through this whole process. I cannot thank you enough.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1

INTRODUCTION

Voice disorders can have a negative impact on communication. There are many types of voice disorders, such as those with functional and organic etiologies, which may lead to a perceptually inferior voice quality. Voice quality is largely a perceptual phenomenon whose judgment relies on the subjective assessment of a listener. The perceptual correlates of voice quality include hoarseness, breathiness, and roughness, while vocal pitch and loudness are also perceptual phenomena of which most listeners are most aware of. Voice disorders may affect all of these perceptual attributes. Mechanical devices have been developed to augment the voice and improve vocal quality in certain voice disordered individuals through filtering the noise component out of a breathy voice. The impact of selective filtering and manipulation of a vocal signal on perceptual ratings of vocal severity is still unclear, due to the fact that manipulations performed by these machines have not been empirically tested. An understanding of sound perception, sound production, and acoustic correlates of the voice (specifically breathiness for this study) are paramount to discovering effective ways to improve voice quality. This study reviews those topics and attempts to investigate whether or not selective manipulation of breathy vocal signals has a significant impact on ratings of vocal severity. The purpose of this study was to determine if signal modification, characterized by amplifying alone, filtering alone, and/or filtering with amplification, would have an effect on perceived severity of voice quality in breathy voices. This investigation was conducted in order to gain knowledge of possible performance of external devices in regards of improving vocal quality in persons with confirmed hypofunctional voices, resulting in a breathy quality.

CHAPTER II

REVIEW OF LITERATURE

Auditory perception of Vocal Signals

As with all sounds, the awareness and interpretation of speech is first stimulated by peripheral sound waves stimulating the nervous system. This is accomplished in humans by sound waves being funneled through the outer, middle, and inner ear (Martin & Clark, 2006), followed by stimulation of the Vestibulocochlear (Eighth cranial) nerve, brainstem, and then higher cortical centers (Seikel, King, & Drumright, 2005). Although the neural pathway stimulated by peripheral sounds is the same in all humans, the resulting perception of sound can vary widely from individual to individual. This variability has resulted in challenges when comparing perceptual attributes of voice perceived by one listener to another.

Evaluating one's perception of a patient's voice quality is an important clinical operation in the process of evaluating and treating individuals with voice problems. Because perception is based on subjective interpretation by an individual, intra-rater reliability is often quite variable when comparing perception of voice quality. In a review of previous work, Kreiman, Gerratt, Kempster, Erman, and Berke (1993) found that intra-rater reliability could range (using Pearson's *r*) between first and second ratings as much as 68% for pathological voices and 91% for normal voices for expert listeners. Gerratt, Krieman, Antonanzas-Farroso, and Burke (1993) suggested this variability is due to the listener comparing the speech sound to an internal standard of what is normal or disordered and that these standards are developed through experience. Based on the research, it would make sense that these internal standards would vary between listeners.

Although this inconsistency between listeners exists, Eadie and Baylor (2006) found that pre-measurement training of overall severity and dimensional aspects of voice quality helped improve intra-rater reliability. They noted that the most improvement was found when rating overall severity, but there were also improvements among other dimensions of voice quality (e.g. roughness, breathiness) (Eadie & Baylor, 2006). The investigators found perception of voice quality is highly variable between listeners, but pre-measurement training appears to achieve greater consistency among judges.

I. Physiological Substrates of Voice Production

Anatomical Structures

Voice production is achieved via a combination of both respiration and laryngeal action. The production of voice starts with the expiration of air from the lungs through the trachea. This rush of air passes through the vocal folds, which protrude into the airway and causes them to vibrate. Ongoing vibration results from multiple factors, including elastic recoil, the Bernoulli Effect, and the continuous supply of air from the lower airway (Seikel, King, & Drumright, 2005). At the point directly below the vocal folds, air pressure is increased when the vocal folds are in an adducted position. The build-up of air pressure eventually overcomes the force of adduction, blowing the vocal folds apart from bottom-to-top, resulting in phonation (Seikel, King, & Drumright, 2005). This vibration is the source of voiced phonemes, while non-phonated air is the source of voiceless phonemes. As the air passes through the vocal folds into supraglottal spaces, it is shaped by the articulators and filtered. The selective filtering of sound results in some frequencies being resonated (increase in amplitude), while others are attenuated, with the end result being differences on the acoustic spectrum based on articulatory positioning (Stemple, Glaze, & Klaben, 2000).

The structures of voice production are combinations of hard and soft tissues that harmoniously move when the larynx is used for voicing. The larynx is comprised of cartilages and muscles. There are three unpaired and three paired cartilages. The most inferior cartilage is the cricoid cartilage. The cricoid is shaped like a signet ring and sits on the top of the tracheal rings. Articulating superiorly to the cricoid cartilage is the thyroid cartilage (Seikel, King, & Drumright, 2005). This is also an unpaired cartilage, and it is comprised of three sides (Seikel, King, & Drumright, 2005; Stemple, Glaze, & Klaben, 2000). The thyroid cartilage's paired inferior cornu articulate with one of the cricoid's paired facets. This allows for a rocking motion to take place on that joint (Stemple, Glaze, & Klaben, 2000).

The inner surface of the thyroid cartilage is the point of anterior attachment for the vocal folds (Seikel, King, & Drumright, 2005). The rocking motion of the thyroid is what allows the vocal folds to stretch, which changes the mass and tension of the vocal folds and creates pitch variation. The thyroid cartilage is made of a hyaline cartilage which ossifies as a person ages and restricts the movement of the thyroid cartilage (Stemple, Glaze, & Klaben, 2000). Located behind the thyroid cartilage are the arytenoid cartilages. The arytenoids articulate with the superior posterior portion of the cricoid and form the cricoarytneoid joint. The vocal process portions of the arytenoids form the posterior point of attachment for the vocal folds. The other two pairs of cartilages are the corniculate cartilages and the cuneiform cartilages. The cornicualtes articulate with the superior surface of the arytenoids and the cuneiforms are embedded in the muscles above the corniculates. These cartilages help make up the aryepiglottic folds (Seikel, King, & Drumright, 2005). The most superior cartilage of the larynx is the epiglottis. Its base is attached to the superior anterior portion of the thyroid cartilage, and its function is to protect the airway during a swallow. There is one bone, the hyoid bone, which forms the upper attachment of the larynx. It is connected to the superior cornu of the thyroid cartilage via ligaments and anchors the larynx in the neck. It also serves as a point of attachment for many of the muscles in the larynx (Stemple, Glaze, & Klaben, 2000).

The musculature of the larynx is comprised of intrinsic and extrinsic muscles. The intrinsic muscles, those whose origin and attachment are both within the larynx, are divided into adductors, abductors, and those that change the shape of the vocal folds. One adductor is the lateral cricoarytenoid muscles. These muscles originate from the superior-lateral surface of the cricoid cartilage, and inserts into the muscular process of the arytenoid cartilage. The contraction of this muscle creates an inward-and-downward rocking motion of the arytenoid helping to adduct the vocal folds (Seikel, King, & Drumright, 2005). The transverse arytenoid muscle originates from the lateral-posterior surface on one arytenoid and inserts on the corresponding place of the other arytenoids. When contracted, it approximates the arytenoids bringing the vocal folds together (Stemple, Glaze, & Klaben, 2000). This muscle is important for medial compression which contributes to intensity changes during vocal production. The oblique arytenoid muscles are the last of the adductors. They originate from the posterior base of the muscular process then cross upward to insert into the opposite arytenoid apex. These muscles serve much the same function as the transverse arytenoids by approximating the apexes of the arytenoids and rocking them down-and-in (Seikel, King, & Drumright, 2005).

The sole abductor of the vocal folds is the posterior cricoarytenoid muscle. This muscle originates on the posterior cricoid lamina and inserts into the posterior portion of the muscular process of the arytenoid cartilages (Stemple, Glaze, & Klaben, 2000). When this muscle contracts, it pulls the muscular process posteriorly bringing the vocal folds apart and acting in direct opposition of the lateral cricoarytenoids. The primary tensor of the vocal folds is the cricothyroid muscle. Its two divisions both originate on the cricoid cartilage and insert into the inferior portion of the thyroid cartilage. When contracted, it rocks the thyroid cartilage forward and down which stretches the vocal folds and contributes to pitch changes during vocal production (Seikel, King, & Drumright, 2005). The thyroarytenoid muscle is the muscular portion of the vocal folds. It attaches to the thyroid cartilage and to the posterior portion of the vocal process to the arytenoids. It is divided into the thyrovocalis and the thyromuscularis. When contracted, the muscles shortens the vocal folds by moving the arytenoids anteriorly and thickness the folds which contributes to pitch changes during vocalization (Stemple, Glaze, & Klaben, 2000). The intrinsic muscles play a vital role in the production of speech by influencing intensity and pitch.

The extrinsic muscles are those that have one point of attachment outside the larynx. They may be classified as either suprahyoid (above) or infrahyoid (below) extrinsic muscles. The suprahyoid muscles are the stylohyoid, mylohyoid, digastric, and geniohyoid. The stylohyoid originates at the temporal lobe and inserts into the hyoid. Its function is to retract the hyoid bone posteriorly. Another suprahyoid muscle is the mylohyoid which attaches at the mandible and the hyoid. This muscle raises the hyoid anteriorly (Stemple, Glaze, & Klaben, 2000). The digastric has an anterior portion and a posterior portion. The anterior portion originates at the mandible and inserts into the hyoid. Its purpose is to raise the hyoid bone upward and forward. The posterior portion originates at the mastoid process of the temporal bone and inserts into the hyoid. When contracted, it draws the hyoid upward and backward (Seikel, King, & Drumright, 2005). The last of the suprahyoid muscles is the geniohyoid. It originates from the mandible and also inserts into the hyoid. It elevates and draws the hyoid forward when contracted. The purpose of the suprahyoid muscles in general is to elevate the hyoid usually as a function of the swallow reflex (Stemple, Glaze, & Klaben, 2000).

The infrahyoid muscles are also know as the laryngeal depressors. This grouping includes the thyrohyoid which attaches to the thyroid and the hyoid. It brings the thyroid cartilages and hyoid closer (Stemple, Glaze, & Klaben, 2000). Another is the sternothyroid. It originates at the sternum and inserts at the thyroid. Its purpose is to lower the thyroid cartilage (Seikel, King, & Drumright, 2005). The sternohyoid attaches to the sternum and the hyoid and lowers the hyoid. The last of the depressors is the omohyoid which attaches to the scapula and the hyoid which also depresses the hyoid. These depressors generally lower and stabilize the larynx and also help to stabilize the tongue by being antagonistic to the laryngeal elevators (suprahyoid muscles) (Stemple, Glaze, & Klaben, 2000).

Neurological Pathways

Peripheral

The nerves that innervate the laryngeal area are important for the production of sound. The superior laryngeal (SLN) and recurrent (RLN) branches of the vagus nerve innervate the larynx peripherally. The SLN is also compromised of two branches: the internal and external branches (Stemple, Glaze, & Klaben, 2000). The internal branch provides sensory supply to the larynx and inserts through the thyroid membrane superior to the vocal folds. The external branch provides motor supply to the cricothryoid muscle, which is the primary tensor of the vocal folds (Seikel, King, & Drumright, 2005). The RLN provides all sensory information below the vocal folds, and provides motor supply to the posterior cricoarytenoid, thyroarytenoid, lateral cricoarytenoid, and interarytenoid muscles (Stemple, Glaze, & Klaben, 2000). These two branches of the vagus nerve allow for fine motor control and rapid movement of the vocal folds which is crucial to producing the changes in voicing during connected speech (Stemple, Glaze, & Klaben, 2000).

Central

Speech production is a process that is controlled and regulated by multiple areas of the cerebral cortex. Initiation of a motoric act is begun in the frontal lobe. The supplemental motor area and pre-motor area are important for the strategic formulations of the motor act. The supplemental motor area programs speech and other sequential movements. The pre-motor region organizes the motor acts for skilled, volitional movements. These areas also receive integrated sensory information from the parietal lobe which may change the planning for execution of the next motor act. The supplemental motor area and the pre-motor area send input to the primary motor cortex. Broca's area, which is responsible for motor planning for speech, also sends input to the primary motor cortex. The primary motor cortex receives the information about the state of the muscles and other structures and the actual motor plan. It initiates the motor impulse which is the finale of the programming and planning. After the motor act is sent form the primary motor cortex to the muscles, afferent information is gathered and the process (planning or programming) may be modified to satisfy a person's internal standard of what speech should sound like. It is essentially a loop that integrates execution of a motor act and sensory information to produce and modify speech (Seikel, King, & Drumright, 2005).

II. Vocal Sound Spectrum and Supraglottic Influence

Source Filter Theory

The Source-Filer theory states that, sound, created by the vocal folds, is shaped by the different configurations of the articulators. This shaping is what causes the different resonance characteristics unique to each speech sound. The spectral characteristics of the glottal source (the sound created by the vibrating vocal folds) and the influence of that spectrum by the supraglottal vocal track (changes in the placement of the tongue, jaw, and other articulators) can influence sound identity (e.g., hearing/i/ versus /u/) and sound quality (e.g., hearing a backed voice quality versus a resonant voice quality (Seikel, King, & Drumright, 2005).

Glottal Source Characteristics

Voice production begins with the vibration of the vocal folds. The oscillation of the vocal folds creates the pulses of air which travel into supraglottic spaces. The voice in its barest state, at the level of the vocal folds, is nothing more than a buzz. The spectral characteristics of this sound are characterized by a complex wave with intensity dropping off at the rate of 12dB per octave. The spectral characteristics of the glottal source can be manipulated with focal fold shape changes. The vocal folds change in tension, mass, and length to create the pitch variations and the overall intensity of voiced sound can be manipulated by increased adduction force (Stemple, Glaze, & Klaben, 2000). Once voiced sound produced by the glottis enters supraglottal spaces (the upper vocal tract), the influence on this sound will result in recognizable speech sounds.

Vocal Tract Influences

As the vibration created at the level of the vocal folds moves through the vocal tract, distinct sounds are created. The physical structures in the vocal tract (the tongue, jaw, velum, lips and teeth) fluidly move from one articulatory position the next to create speech. The shape and movement of the cavities and the articulators play an important role in resonance. Resonance is the excited air particles moving through the pharynx, oral and nasal cavities that are shaped by the variations of movement and shape of the articulators. The articulators create a natural filter for the vibrated air which reinforces the formants and frequencies of each specific speech sound and diminishes those that are not as important. The position of the articulators and the changes in the formations of the articulators are one of the reasons individuals have their own distinct voices (Stemple, Glaze, & Klaben, 2000). It is the influence of the vocal tract that creates the sounds perceived as speech.

III. Voice Quality

Categories of Voice Quality

The perceptual traits that may be considered when determining vocal severity are roughness, breathiness, strain, pitch, loudness, and overall severity. While studying the reliability of the Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V) where the deviations of these traits are measured to determine voice variance, Kempester, Gerratt, Verdolini Abbot, Barkmeier-Kraemer, and Hillman (2009) describe these terms as: roughness (perceived irregularity in the voicing source), breathiness (audible air escape in the voice), strain (perception of excessive vocal effort), loudness (perceptual correlate of sound intensity), and overall severity (global, integrated impression of voice deviance) (Kempester, Gerratt, Verdolini Abbot, Barkmeier-Kraemer & Hillman, 2009). Another common severity qualifier is hoarseness which is the combination of roughness and breathiness. Not all those with voice disorders have deviations in all dimensions. Deviations in one or two dimensions could influence a listener's perception of the speaker's overall severity.

Mechanisms Related to Production of Breathy Voice

There are numerous pathologies that could contribute to the production of a breathy voice. A breathy voice is an inadequate adduction of the vocal folds that allows excessive amounts of air to escape between the folds. Breathiness in itself is not a disorder; however, it may be an indicator of a more serious matter (Seikel, King, & Drumright, 2005). Some of the pathologies which underlie breathiness include those where there are structural changes to the vocal folds. The changes may be a growth on the vocal fold(s) or a change in the elasticity or soft tissue of the folds. These disorders include vocal nodules, polyps, granulomas, contact ulcers, cysts, sulcus vocalis, and presbylaryngis. Neurogenic disorders are those that are caused by direct interruptions to the peripheral and central nerves innervating the larynx or they may be a result of another disorder that causes a larger degeneration of the motor functions that include functions to the laryngeal area. These disorders are unilateral and bilateral paralysis due to an injury to the RLN or SLN, Myasthenia gravis, Parkinson disease, and Amyotrophic lateral sclerosis (Stemple, Glaze, & Klaben, 2000).

Perception of Breathy Voice

Researchers have examined the components of breathy and/or low volume voices and some of the mechanical augmentation that may help with voice quality. Specifically, the investigators have analyzed the acoustics of a breathy voice and its relationship to severity and intelligibility and the effects of filtering on breathy voices. These studies were used to understand the potential effects of amplification with filtering of breathy, low volume disordered voices.

Severity and Intelligibility

Breathiness is only one characteristic considered in vocal quality. Several researchers have investigated the effects of breathiness on severity and intelligibility and the acoustic properties of breathy voices. Eskenazi, Childers, and Hicks (1990) discovered that the acoustic correlate that is the best predictor for breathiness is a high percent jitter. The effect of breathy voices on intelligibility was studied by Javkin, Hanson, and Kaun (1991). They found that breathiness did not have an effect on intelligibility in synthesized vowels and speech although there was some degradation of intelligibility at the most severe levels. This demonstrates that breathiness is not necessarily a large contributing factor to decreased intelligibility (Javkin, Hanson, & Kaun, 1991). However, the researchers did not examine breathiness in conjunction with low volume. This combination may affect intelligibility to a greater degree.

Filtering Noise

Filtering the noise component (e.g., breathiness) out of a spoken communication should theoretically improve vocal clarity. Espy-Wilson, Chari, MacAuslan, Huang, and Walsh (1998) researched the effects of noise filtering on intelligibility. They found there was a 60% to 93% preference for the filtered Transcutaneous Artificial Larynges (TAL) speech. However, they did not find significant results in increased intelligibility. The filtering did not result in degradation in intelligibility. Although listeners in the study preferred the filtered speech, it did not necessarily improve intelligibility. No reference was made about the effects of filtering on improving perceived severity.

Niu, Wan, Wang, and Liu (2003) studied filtering electrolarynx speech using adaptive noise cancelling. The authors were concerned with the degradation of voice quality and decreased speech intelligibility due to the extra vibration of surrounding neck tissue which created interfering noise. Through the measures that were used to decrease noise, the researchers a significant measured reduction of noise. This helped improve intelligibility and acceptability of the electrolarynx speech (Niu, Wan, Wang, & Liu, 2003). Other researchers also examined electrolarynx speech. They were concerned about reduced intelligibility, artificial quality and poor audibility. While using various algorithms to enhance speech by reducing or eliminating additive noise and radiated noise, they found that there was a significant difference between original speech and enhanced speech in listener acceptability. Also, the authors concluded that by using certain algorithms they were able to reduce background noise without distorting speech acceptability (Liu, Zhao, Wan, & Wang, 2006). These findings suggest that voice quality and intelligibility can be improved through filtering of noise in those with altered communication abilities. However, studies where investigators have evaluated changes in the perceived severity of voice quality secondary to filtered breathy voices have not been reported.

CHAPTER III

Statement of Purpose

Although prior investigators have not found a significant increase in intelligibility for breathy voices which have been filtered, no study to date has been conducted to investigate the influence of filtering in breathy voices on perceived ratings of severity (e.g, the degree of deviation from normal). The purpose of this study was to investigate whether signal modification, characterized by amplification alone, filtering alone and/or filtering with amplification, will have an effect on perceived severity of voice quality in breathy voices. As new products are being developed and marketed which claim to filter breathy voices in a way which makes the voice quality improve and the intelligibility of speech increase, it would be important to distinguish if there is a measurable effect with the methodology comparable to what these devices use via testing it with the scientific method. The results of this study could also have the following implications: (1) whether mechanical augmentation would improve voice quality and if so, (2) which type would be best for clients. The specific research question to be addressed is: Are ratings of vocal severity different for breathy voices which have not been modified compared to those that have had amplitude reinforcement, been low passed filtered, and those that have been low pass filtered and amplified?

Hypothesis

Based on previous research, modification of vocal signals via amplitude reinforcement (amplification), filtering and filtering with amplitude reinforcement will improve auditory-perceptual ratings of vocal severity.

Methodology

Participants

Two types of participants were recruited for this study: (1) Speaking participants and (2) Perceptual judges.

Speaking participants consisted of eight individuals with confirmed laryngeal pathology that caused a hypofunctional voice disorder with a confirmed breathy voice quality (disordered speakers). Disordered speakers were recruited from the local community via treatment seeking populations (e.g., those seeking evaluation and/or treatment from a speech-language pathologist for a self-perceived voice problem). In addition, existing recordings of disordered speakers from the Kay Disordered Voice Database (a commercially available recording of a variety of disordered voices) were used. Inclusion criteria for all recorded disordered voices included: (1) diagnosed laryngeal pathology by an otolaryngologist, (2) an etiological diagnosis of unilateral recurrent laryngeal nerve paresis/paralysis, Parkinson's disease, or presbylaryngis, and (3) predominantly breathy voice quality which is confirmed via auditory-perceptual analysis by perceptual judges.

Perceptual judges consisted of 20 college students recruited from the population at Texas Christian University. Both undergraduate and graduate students were eligible for participation in the study, as previous experience in academic voice coursework or clinical voice training had not been found to have a significant effect on auditory-perceptual judgments of voice. Ten judges rated voice quality and severity of recorded signals in order to determine inclusion eligibility of those signals (see inclusion criteria #3 above). The remaining 10 judges rated the severity of signals used in the experimental phase of the study (see "signal manipulation" in procedures below). Inclusion criteria for perceptual judges were (1) passed hearing screening at 25dBSPL at 500Hz, 1KHz, 2Khz, and 4KHz, (2) no history of hearing disorder, (3) no current reported hearing problems, and (4) no history of neurological disorder.

Instrumentation

All voice recordings were digitized using hardware and/or software produced by KayPentax (Lincoln Park, NJ), which will include the Computerized Speech Lab (CSL) and Sonaspeech. This software digitized speech produced by individuals in the hypofunctional and control groups at a 50KHz sampling rate. A Shure head-mounted microphone was used to record all participants.

Custom software called Anchors, developed by Dr. Shaheen Awan at Bloomsburg University, was used for auditory-perceptual measurements of breathiness and vocal severity (that is, the perceptual judges used this software to rate voices). The validity of the software for use in auditory-perceptual ratings had been established in previous studies (Awan & Roy, 2005; Awan & Roy, 2006; Awan & Lawson, 2009, Watts, et al., 2008). A complete description of the auditory-perceptual rating task is described further below.

For perceptual training sessions and experimental data collection sessions, a standard desktop computer wired to circumaural headphones was used to present auditory stimuli to the perceptual judges at a comfortable listening level, as established by individual judges. Additionally, signal processing software called Adobe Audition (Adobe Systems Inc., San Jose, CA) was used to manipulate the frequency and amplitude spectra of the original recordings so that three different sets of signals were created for use in the experimental phase of the study.

Procedures

Vocal Recordings: Participants were recorded in a quiet room with a background noise level no greater than 40dBSPL, as measured with a sound pressure level meter. The head-mounted microphone was worn and placed with the microphone head off-center at the right mouth corner, with a mouth-to-microphone distance of approximately 3-8cm. The microphone had a direct line input to the CSL or Sonaspeech. Participants were asked to produce and sustain the vowel /a/ at a self-reported comfortable pitch and loudness, held as steady as possible. Sustained vowel productions were used for the pre-experimental judgments of breathiness and the experimental judgments of severity.

Pre-experimental judgments of breathiness: Prior to experimental data collection, ratings of breathiness or normal voice quality were confirmed in the recorded hypofunctional voices by 10 perceptual judges. An explanation of the study procedures and associated risks was given to the participants and the consent form was signed. Prior to the judgment task, judges participated in a 20-minute training session. During the training session, instructions regarding use of the Anchors software and a review of the operational definitions for voice quality types (i.e., normal, breathy) and severity (i.e., normal, mild, moderate, severe) were provided. The perceptual judgments made by the judges were a two-item forced choice task (i.e., normal, breathy) and a rating of severity (i.e.,deviation from normal) along a 100mm line. Voice quality types were defined for each judge as they appeared in the Anchors software: (1) Normal - "The voice does not differ substantially from your expectations in terms of parameters such as quality", and (2) Breathy – "Commonly perceived as a whispery or airy voice; associated with hypoadduction (Awan & Roy, 2005). Each judge then listened to recorded voice samples which were representative for the range of voice types (normal and breathy) and severities (normal, moderate, severe-deviation from normal) possible for individuals sustaining the vowel /a/. These representative stimuli have been validated in three published studies (Awan & Roy, 2005; Awan & Roy, 2006, Watts, et al., 2008).

Once the training session was complete, judges then listened to the recorded sustained /a/ vowels of the hypofunctional voices, one stimulus at a time, while seated and wearing circumaural headphones. The Anchors software allowed the user to select samples for playback, in an order that was randomized for each judge. After listening to each stimulus, the judges were asked to make ratings regarding the quality and severity of that voice. For voice quality ratings, judges could choose "normal" or "breathy". For severity ratings, judges placed a curser along a 100mm visual analog scale, anchored with labels of "mild", "moderate", and "severe". Judges were allowed to replay each sample as many times as necessary before rating it. In addition, judges were allowed to compare each voice sample with two pre-selected "normal" voice samples (i.e., normal male, normal female) used in the training session. These samples served as an external auditory standard (e.g., a perceptual anchor). The use of perceptual anchors in this way had been shown to be beneficial to auditory-perceptual judgments of voice quality and severity as they help to reduce listener-related variability (Awan & Lawson, 2009; Awan & Roy, 2006; Eadie & Baylor, 2006). The same two normal perceptual anchors were used for all judgments. In addition to the perceptual anchor, judges also had access to the operational definitions for each rating category, as reviewed in the training session. For purposes of measuring intra-judge reliability, every judge listened to and rated each voice sample twice (i.e., first rating, second rating).

For hypofunctional voices to be included in the study, it was a requirement for them to be rated as "breathy" for voice quality by 80% (8/10) of the perceptual judges and with an average severity rating of at least 30 on the visual analog scale for those voices rated as breathy. Any voices failing to meet these criteria were replaced with subsequent voices which did meet criteria using the same procedures.

Signal Manipulation: For the experimental phase of the study, the eight included voice signals (8 hypofunctional) underwent signal manipulation using Adobe Audition to create three different sets of stimuli: (1) original recordings [**OR**], (2) low pass filtered [**LPF**], and (3) low pass filtered + amplitude reinforced [**LPFAR**]. OR signals (n=10) were unfiltered in their original state. LPF signals (n = 10) were modified versions of the original files which were passed through a 4000Hz low pass filter (e.g., only frequencies at 4000Hz and below remained as part of the signal file). LPFAR signals (n = 10) were modified versions of the original files which were passed through a 4000Hz low pass filter and further manipulated by doubling the amplitude of the harmonics within the signal between 100Hz and 300Hz. This LPFAR manipulation corresponded to boosting the energy of the fundamental frequency of female and male voices, and possibly boosting the first formant of the male voices. The final result of signal manipulation was 32 signals available for use in the experimental phase of the study.

Experimental Severity Judgments: Once all stimuli sets were created, 10 new perceptual judges participated in the experimental phase of the study. All judges underwent the same training procedure as those in the pre-experimental phase. The Anchors software was used to present the 32 stimuli twice each in random order to each perceptual judge, using the same methodology as that in the pre-experimental phase. Judges were only asked to rate the severity of each signal they heard. Ratings were stored in a data file and retrieved for later analysis.

Analysis

The design of this study was a within-subject repeated measures design with stimulus type (OR, LPF, LPFAR) as the within-subject factor. The dependent variable for this study was the severity ratings, which was measured as a ratio scale (e.g., there is a zero on the scale of measurement). An omnibus one-way repeated measures analysis of variance (ANOVA) was used to determine if significant differences were present for the main effect (stimulus type). Alpha level for statistical significance was set at 0.05 for all analyses. In addition to the main effect of stimulus type, planned contrasts were utilized to compare the levels of the independent variable with each other to determine if differences exist. In these planned comparisons, each stimulus type was compared with each other. To assess reliability of pre-experimental and experimental perceptual tasks, a Pearson-product moment correlation was used to assess the degree of relationship between the 1^{st} and 2^{nd} ratings across all perceptual judges.

CHAPTER IV

RESULTS

Reliability

The Pearson-product moment correlation used to assess the degree of relationship between the 1st and 2nd ratings across all perceptual judges revealed a significant (p < .001) correlation coefficient (r) of .854, which is a strong correlation explaining 73% (r2=.73). of the variability in the perceptual ratings.*Analysis*

The design of this study utilized one independent variable, stimulus type, with four levels: original recording (OR), amplitude reinforced (AR), low-pass filtered (LPF), and low-pass filtered plus amplitude reinforced (LPFAR). A one-way repeated measures ANOVA was performed to investigate the effect of stimulus type on ratings of vocal severity. Additional planned comparisons investigated possible differences between each level of the independent variable. Table 1 lists demographic information related to the vocal recordings which were utilized for stimulus purposes (age and diagnoses of the recorded speaker). Descriptive statistics summarizing the resulting raw data from the perceptual judges is summarized in Table 2.

Table 1. Demographic Information for Voice Samples

Subject	Gender	Age	Diagnosis
1	Female	42	UVFP
2	Female	59	UVFP
3	Male	52	UVFP
4	Female	42	UVFP
5	Female	49	UVFP
6	Male	43	UVFP
7	Female	42	UVFP
8	Female	51	UVFP

Table 2. Descriptive Statistics summarizing mean severity ratings

(along 100mm visual analog scale: minimum possible = 0; maximum possible = 100).

	Mean	Standard Deviation	N
Original Recording	53.2000	7.95587	10
Amplitude Reinforced	52.0000	10.25796	10
Low Pass Filter	49.2375	10.91403	10
Low Pass Filter + Amp. Reinforced	49.4875	7.62112	10

The raw data shows that the original recordings were judged as most severe (*M* = 53.2, SD = 7.96) by the perceptual judges. Amplitude reinforced recordings were the second most severe (*M* = 52.0, SD = 10.25, and the low pass filtered with amplitude reinforcement followed (*M* = 49.48, SD = 7.62). The recording rated as least severe was the low pass filtered recordings (*M* = 49.23, SD = 10.91).

The one-way repeated measure ANOVA was applied to the data to investigate a possible main effect. The resulting ANOVA table is illustrated in Table 3, along with results from the planned contrast analysis and resulting planned comparisons.

Table 3. Statistical Analyses

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
TESTS OF WITHIN-SUBJECT EFFECTS						
Severity	Sphericity Assumed	112.327	3	37.442	2.726	0.064
PAIRWISE COMPARISONS						
			95% Confidence Interval for Difference[a]			
(I) Severity	(J) Severity	Sig. [a]	Lower Bound	Upper Bound		
OR	AR	0.367	-1.658	4.058		
	LPF	0.037	0.296	7.629		
	LPFAR	0.059	-0.174	7.599		
AR	OR	0.367	-4.068	1.658		
	LPF	0.073	-0.31	5.835		
	LPFAR	0.157	-1.172	6.197		
LPF	OR	0.037	-7.692	-0.296		
	AR	0.073	-5.835	0.31		
	LPFAR	0.912	-5.211	4.711		
LPFAR	OR	0.059	-7.599	0.174		
	AR	0.157	-6.197	1.172		
	LPF	0.912	-4.711	5.211		

[a] – Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Results indicated that a significant main effect was not present ($F[3,27] = 2.73$, $p = 0.64$) although it was approaching significance. However, planned contrasts pairing each level of stimulus type against each other did reveal a significant difference between individual levels ($F[1,9] = 7.72$, $p = .02$). Pairwise comparisons revealed that this effect was due to a significant difference between the severity ratings for the OR and the LPF stimuli (mean difference = 3.96, $p = .037$, 95% confidence interval = .296 – 7.629).

There were no differences found between any other comparisons.

CHAPTER V

DISCUSSION

The purpose of this study was to determine if signal modification, characterized by amplifying alone, filtering alone and/or filtering with amplification, would have an effect on perceived severity of voice quality in breathy voices. This investigation was conducted in order to gain knowledge of possible performance of external devices in regards of improving vocal quality in persons with confirmed hypofunctional voices, resulting in a breathy quality. The specific research question was as follows: Are ratings of vocal severity different for breathy voices which have not been modified compared to those that have been amplitude reinforced, low passed filtered and those that have been low pass filtered and amplified?

The results of the experiment did not indicate a significant difference in severity ratings when all four conditions were combined. However, upon further investigation of the results, there was a significant difference in the ratings of the low pass filter in comparison to the original recordings.

This result supports a logical assumption: the filtering of frequencies 4000Hz and above does take out the 'noise' from a voice sample. As breathy quality is characterized by excessive air flow through the vocal folds which creates extra noise in the voice sample, filtering the breathy aspects of a voice could make the vocal output sound more clear or it could just be less distracting for the listener.

These results do support the hypothesis that modifying vocal signals via amplitude reinforcement, filtering and filtering with amplification does improve auditory-perceptual ratings of vocal severity. However, it must be stated that only a portion of the hypothesis is supported (i.e., improvement of severity ratings via filtering). These results, compared to previous studies, supported similar findings.

This study found that a significant difference in severity ratings for the filtered condition. Niu, Wan, Wang, and Liu (2003) and Liu, Zhao, Wan, and Wang (2006) also found a significant difference in listener acceptability and intelligibility in filtered speech. Severity ratings in the current research were approximately halfway on the scale. Javkin, Hanson, and Kaun (1991) found that intelligibility was affected when severity ratings were more severe. This could be why the more severe samples met the inclusion criteria. The underlying reason for the current study was to examine if external devices could be used by those with hypofunctional voices to decrease their perceived severity. This study supports the theory that a device that LPFs could decrease perceived severity.

CHAPTER VI

LIMITATIONS

Although a significant difference was found when filtering occurred alone, it is possible that different results may have occurred if some conditions were changed. Future research should consider the following limitations. The voice samples in this study were of one second length. It is unclear whether longer samples or connected speech samples would have also significantly decreased in the other conditions (AR and LPFAR) as well. A limited sample sizes (i.e., eight voice samples, 10 perceptual judges) may have influenced the outcome. Had there been more samples to analyze, statistical calculations may have shown a significant difference for more or all of the manipulated conditions. The manipulation of LPFAR was within 0.09 ($p = 0.059$) of also having a statistically significant decrease in severity rating. The limited sample voice sample size was, in some part, due to the perceptual judges having difficulty differentiating between the voice qualities of ‘breathy’ and ‘hoarse’ resulting in variability in categorization of voice types. Although training was provided for each perceptual judge, this appeared to be insufficient as only eight voice samples met the inclusion criteria. A more intense training in recognition and categorization of voice quality types and severity should be included so that a greater number of samples can be evaluated. Also a future study should consider including a greater number of voice samples than the current study’s maximum of 10. Also a change in the specific manipulations of the voice samples could help decrease the severity ratings. Such as increasing the AR or filtering more frequencies.

CHAPTER VII

CONCLUSION

Four manipulations of voice samples were examined in the current study (OR, AR, LPF, LPFAR), and a severity rating was given for each of the manipulations. Each of the severity ratings were compared to the severity rating of the OR. It was found that the only condition to achieve a statistically significant decrease in severity with was the LPF condition. This result is complimentary to previous research that demonstrated similar findings when investigating different aspects of voice quality (Niu, Wan, Wang, & Liu, 2003). It should be noted that there is limited research in this specific area and no previous studies were found that examined the comparisons of severity ratings for the various signal manipulations. Additional research in this area should consider using connected speech instead of a prolonged vowel, incorporating a larger sample size; having a more intense training session for voice quality types and severity ratings for the perceptual judges; and/or changing the specific manipulations of the vocal signals.

REFERENCES

Awan, S. N., Roy, N. (2005). Acoustic prediction of voice type in women with functional dysphonia. *Journal of Voice, 19(2),* 268-283.

Awan, S. N., Roy, N. (2006). Toward the development of an objective index of dysphonia severity: A four-factor acoustic model. *Clinical Linguistics & Phonetics, 20(1),* 35-49.

Awan, S. N., Lawson, L. L. (2009). The effect of Anchor modality on the reliability of vocal severity ratings. *Journal of Voice, 3,* 341-352.

Brookshire, R. H., (2007). Introduction to neurogenic communication disorders (7th ed.) St. Louis, MS: Mosby Elsevier.

Eadie, Tanya L., Baylor, Carolyn. (2006) The effect of perceptual training on inexperienced listeners' judgements of dysphonic voices. *Journal of Voice*, *20, (4),* 527-544.

Epsy-Wilson, Carol Y., Chari, Venkatesh R., MacAuslan, Joel M., Huang, Caroline B., Walsh, Michael J., (1998). Enhancement of electrolaryngeal speech by adaptive filtering. *Journal of Speech, Language, and Hearing Research, 41,* 1253-1264.

Eskenazi, L., Childers, D.G., Hicks, D.M., (1990). Acoustic correlates of vocal quality. *Journal of Speech and Hearing Research*, *33,* 298-306.

Gerratt, B. R., Kreiman, J., Antonanzs-Barroso, N., Berke, G. S., (1993) Comparing internal and external standards in voice quality judgements. *Journal of Speech and Hearing Research, 36,* 14-20.

Javkin, H., Hanson, B., Kaun, A., (1991). The effects of breathy voice on intelligibility. *Speech Communication, 10*, 539-543.

Kempester, G.B., Gerratt, B.R., Verdolini Abbot, K., Barkmeier-Kraemer, J., Hillman, R.E. (2009). Consensus Auditory-Perceptual Evaluation of Voice: Development of a standardized clinical protocol. *American Journal of Speech Language Pathology, 2*, 124-132.

Kreiman, J., Gerratt, Bruce R., Kempster, G. B., Erman, A., Berke, G. S., (1993). Perceptual evaluation of voice quailty: Review, tutorial, and a framework for future research. *Journal of Speech and Hearing Research, 36,* 21-40.

Liu, H.J., Zhao, Q., Wan, M. X., Wang, S. P., (2006). Application of spectral subtraction method on enhancement of electrolarynx speech. *Journal of Acoustical Society of America, 120 (1),* 398-406.

Martin, F. N., Clark, J. G.. (2006). Introduction to audiology (9th ed.) Boston, MA: Allyn and Bacon publishers.

Niu, H. J., Wan, M. X., Wang, S. P., Liu, H.J., (2003). Enhancement of electrolarynx speech using adaptive noise cancelling based on independent component analysis. *Medical and Biological Engineering and Computing. 41,* 670-678.

Seikel, J. A., King, D. W., Drumright, David G., (2005). Anatomy & physiology for speech, language, and hearing (3rd ed.) New York, NY: Thomson Delmar Learning.

Stemple, J.C., Glaze, L.E., Klaben, B.G. (2000). Clinical voice pathology: Theory and management (3rd ed.). San Diego, CA: Singular Publishing Group.

Watts, C.R., Awan, S. N., Marler, J. A., (2006). An investigation of voice quality in individuals with inherited elastin gene abnormalities. *Clinical Linguistics and Phonetics, 3,* 199-213

ABSTRACT

THE EFFECT OF FILTERING ON AUDITORY-PERCEPTUAL RATINGS OF SEVERITY IN HYPOFUNCTIONAL VOICES

By Candice M. George, B.S., 2008
Department of Communication and Sciences and Disorders
Texas Christian University

Thesis Advisor: Christopher R. Watts, Ph.D., Departmental Chair

Voice disorders can have a negative impact on communication. Voice quality is largely a perceptual phenomenon whose judgment relies on the subjective assessment of a listener. Mechanical devices have been developed to augment the voice and improve vocal quality in certain voice disordered individuals. The purpose of this study was to investigate whether signal modification, characterized by amplification alone, filtering alone and/or filtering with amplification, will have an effect on perceived severity of voice quality in breathy voices. Hypofunctional voices were manipulated into four conditions (Original recordings, Amplitude reinforced, Low Pass Filtered, and Low Pass Filtered with Amplitude Reinforcement). Results indicated that a significant main effect was not present ($F[3,27] = 2.73$, $p = 0.64$). Pairwise comparisons revealed that this effect was due to a significant difference between the severity ratings for the OR and the LPF stimuli (mean difference = 3.96, $p = .037$, 95% confidence interval = .296 – 7.629). The results indicate that there was an effect when low pass filtering was present. This condition would help the perceptual quality of a hypofunctional voice if used in an external mechanical device.

APPENDIX A

CONSENT FORM

Acoustic Evaluation of Hypofunctional Voices

Investigator: Christopher R. Watts, Ph.D.

Investigator's Statement

PURPOSE AND BENEFITS

You have been invited to participate in a research project, which investigates vocal function in individuals with and without vocal problems. Your participation, including the resulting data, represents a valuable contribution toward our understanding of the acoustics of voice in normal and vocally-injured populations.

POTENTIAL RISKS

This study does not involve risks or harm any greater than those ordinarily encountered in daily life. The potential benefits from participating in this study are to provide additional theoretical and acoustic information, which may enhance our understanding of the acoustics of voice in normal and vocally-injured populations.

PROCEDURE

Should you decide to participate in this research study as a speaker, you will be asked to sign this consent form once all your questions have been answered to your satisfaction. Before the experiment, you will be asked questions about your medical history. Prior to the experiment, you will be given specific instructions about what is required. We expect the test session to be completed within 10 minutes. You will wear a head-mounted microphone, which will fit over your ears like sunglasses, but with a microphone extending out at the corner of your mouth. You will be asked to perform a number of experimental tasks using your voice, including: saying "ahhh" and "eeee" for three to five seconds three times each, reading six short sentences, and reading a paragraph. When you are done, at a later date, the recordings will be analyzed using two types of software programs designed to analyze acoustic information.

Should you decide to participate in this research study as a listener, you will be asked to sign this consent form once all your questions have been answered to your satisfaction. Prior to the experiment, you will be given specific instructions about what is required. We expect the test session to be completed within 25 minutes. You will be asked to listen to previously recorded vocal samples and make a judgment as to the degree of severity of the voice quality. When you are done, at a later date, your judgments will be analyzed using statistical software.

CONFIDENTIALITY

The results of this research will be presented at conferences. The results of this project will be coded in such a way that your identity will not be attached to the final form of this study. The researcher retains the right to use and publish non-identifiable data. While individual responses are confidential, aggregate data will be presented representing averages or generalizations about the responses as a whole. The principal investigator, co-investigators, and assistants will have access to data, but only the principal investigator will have access to your name. All data will be stored in a secure, locked location only accessible to the researcher. **Final aggregate results will be made available to participants upon request.**

PARTICIPATION & WITHDRAWAL

Your participation is entirely voluntary. You are free to choose not to participate. Should you choose to participate, you can withdraw at any time without consequences of any kind.

QUESTIONS

You may have questions or concerns during the time of your participation in this study, or after its completion. If you have any questions about the study, contact Chris Watts, Ph.D. at 817-257-6878 or c.watts@tcu.edu.

____
Name of Investigator (Printed)

____
Investigators' Signature Date

Subject's Statement

The study described above has been explained to me. I voluntarily consent to participate in this activity. I have had an opportunity to ask questions. I understand that immediate questions I may have about the research or about my rights as a participant will be answered by one of the investigators. I certify that I am at least 18 years of age.

____
Name of Participant (Printed) Date

____
Participant's Signature Date

____
Name of Parent/Caregiver (if child <18) Date

____
Signature of Parent/Caregiver Date

OPTIONAL SUBJECT INFORMATION: Federal guidelines require groups of subjects that participants in research experiments be representative of the general population of this region. In order to achieve this goal, it would be helpful to know the following information.

GENDER: Female_____ Male_____

ETHNIC/RACIAL ORIGIN: African-American_____ Asian/Pacific Islander_____ Caucasian_____ Hispanic_____ Native American_____ Mixed Race_____

For questions about your rights as a research subject, you may contact the chair of TCUs Institutional Review Board (IRB): Dr. Meena Shah, (817) 257-6871, m.shah@tcu.edu.

Copies to: Investigator's file, Participant

APPENDIX B

Additional Speaker and Listener Consent forms and Questionnaires

Texas Christian University
Fort Worth, Texas

CONSENT TO PARTICIPATE IN RESEARCH
Speaker

Title of Research: THE EFFECT OF FILTERING ON AUDITORY-PERCEPTUAL RATINGS OF SEVERITY IN HYPOFUNCTIONAL VOICES

Funding Agency/Sponsor: N/A

Study Investigators: Christopher R. Watts, Ph.D.: Candice George, B.S

What is the purpose of the research?
The purpose of this research is to determine if a difference exists in severity ratings for hypofunctional voices in four conditions (original recordings, amplification, filtering, and filtering with amplification) using digital manipulation.

How many people will participate in this study?
30 total participants: 10 speakers and 20 listeners

What is my involvement for participating in this study?
Should you decide to participate in this research study as a speaker, you will asked to sign this consent form once all your question have been answered to your satisfaction. Before the experiment, you will be asked questions about your medical history. You will wear a microphone, which will fit over your ears like sunglasses. You will be asked to use your voice by saying “ahhh” and “eeee” for three to five seconds, read six short sentences, and read a paragraph. Your voice will be audio recorded.

How long am I expected to be in this study for and how much of my time is required?
We expect the test session to be completed within 10 minutes.

What are the risks of participating in this study and how will they be minimized?
Risks include becoming tired from speaking and/or losing interest in the study during the course of participation.

What are the benefits for participating in this study?
There are no benefits to the participant.

Will I be compensated for participating in this study?
No

What is an alternate procedure(s) that I can choose instead of participating in this study?
N/A

How will my confidentiality be protected?
The principal investigator and assistants will have access to data collected during the course of this study, but only the principal investigator will have access to our name. Speakers' voices will not be identified to any listeners. All data will be stored in a secured, locked location only accessible to the principal investigator. Final aggregate results will be made available to participants upon request. Data will be stored electronically without any identifying information and it will be published or presented in aggregate without any identifying information.

Is my participation voluntary?
Yes

Can I stop taking part in this research?
Yes

What are the procedures for withdrawal?
You may stop at anytime without penalty. Notify the investigator at any point that you wish to withdraw from the study.

Will I be given a copy of the consent document to keep?
Yes

Who should I contact if I have questions regarding the study?
Christopher R. Watts, Ph.D.
TCU Box 297450
Fort Worth, TX 76129
(817) 257-7620- voice
(817) 257-5692- fax
c.watts@tcu.edu

Who should I contact if I have concerns regarding my rights as a study participant?
Dr. Brad Lucas, Chair, TCU Institutional Review Board, Telephone 817-257-6981.
Dr. Janis Morey, Director, Sponsored Research, Telephone 817-257-7516.

Your signature below indicates that you have been read the information provided above, you have received answers to all of your questions and have been told who to call if you have any more questions, you have freely decided to participate in this research, and you understand that you are not giving up any of your legal rights.

Participant's Name (please print):
____

Participant's Signature: ______________________________
Date:_____________

Investigator's Signature: ______________________________
Date:_____________

Texas Christian University
Fort Worth, Texas

CONSENT TO PARTICIPATE IN RESEARCH
Listener

Title of Research: THE EFFECT OF FILTERING ON AUDITORY-PERCEPTUAL RATINGS OF SEVERITY IN HYPOFUNCTIONAL VOICES

Funding Agency/Sponsor: N/A

Study Investigators: Christopher R. Watts, Ph.D.: Candice George, B.S

What is the purpose of the research?
The purpose of this research is to determine if a difference exists in severity ratings for hypofunctional voices in four conditions (original recordings, amplification, filtering, and filtering with amplification) using digital manipulation.

How many people will participate in this study?
30 total participants: 10 speakers and 20 listeners

What is my involvement for participating in this study?
You will be asked to wear headphones while you listen to recorded voices say different sounds, such as vowels and sentences. Then, you will be asked to make a judgment, based on you perception, as to how different from normal they sound. You will record your judgments by pressing keys on a computer keyboard.

How long am I expected to be in this study for and how much of my time is required?
We expect the test session to be completed within 25 minutes

What are the risks of participating in this study and how will they be minimized?
Risks include potential fatigue from listening to recorded voices and/or disinterest in the study during the course of participation.

What are the benefits for participating in this study?
There are no benefits from taking part in this study.

Will I be compensated for participating in this study?

No

What is an alternate procedure(s) that I can choose instead of participating in this study?
N/A

How will my confidentiality be protected?
The principal investigator and assistants will have access to data collected during the course of this study, but only the principal investigator will have access to your name. Speakers' voices will not be identified to any listeners. All data will be stored in a secure, locked location only accessible to the principal investigator. Final aggregate results will be made available to participants upon request. Data will be stored electronically without any identifying information and it will be published or presented in aggregate without any identifying information.

Is my participation voluntary?
Yes. You may stop taking part in the study without penalty.

Can I stop taking part in this research?
Yes

What are the procedures for withdrawal?
Notify the investigator at any point that you wish to withdraw from the study.

Will I be given a copy of the consent document to keep?
Yes

Who should I contact if I have questions regarding the study?
Christopher R. Watts, Ph.D.
TCU Box 297450
Fort Worth, TX 76129
(817) 257-7620- voice
(817) 257-5692- fax
c.watts@tcu.edu

Who should I contact if I have concerns regarding my rights as a study participant?
Dr. Brad Lucas, Chair, TCU Institutional Review Board, Telephone 817-257-6981.
Dr. Janis Morey, Director, Sponsored Research, Telephone 817-257-7516.

Your signature below indicates that you have been read the information provided above, you have received answers to all of your questions and have been told who to call if you have any more questions, you have freely decided to participate in this research, and you understand that you are not giving up any of your legal rights.

Participant's Name (please print):
____

Participant's Signature: ______________________________
Date:_____________

Investigator's Signature: ______________________________
Date:_____________

Participant Questionnaire

Name:_____________________________ Date of Birth (MM/DD/YY): ________________________________

Please check the box that applies to you:

Sex: ☐ MALE ☐FEMALE

Do you have a problem with your voice? ☐ YES ☐NO

Have you ever smoked cigarettes on a daily basis? ☐ YES ☐NO

Do you currently smoke cigarettes? ☐ YES ☐NO

Have you ever been diagnosed with a voice disorder? ☐ YES ☐NO

Have you ever been diagnosed with a neurological disorder? ☐ YES ☐NO

Have you ever been diagnosed with a genetic disorder? ☐ YES ☐NO

PROTECTED HEALTH INFORMATION AUTHORIZATION FORM

Researchers from the study "The Effect of Filtering on Auditory-Perceptual ratings of Severity in Hypofunctional Voices" would like **your permission** to **use your health information** which will be gathered as a part of this study.

The following **health information** will be **gathered** from you:

Do you have a problem with your voice?
Have you ever smoked cigarettes on a daily basis?
Do you currently smoke cigarettes?
Have you ever been diagnosed with a voice disorder?
Have you ever been diagnosed with a genetic or neurological disorder?

The **names of the TCU researchers** who will gather this information from you are (insert the names of all TCU researchers starting with the lead researcher):

Christopher R. Watts
Emily Lambert

Your **health information may be shared** with others who are working with the TCU researchers on this study, institutes that are paying for this study or involved in any other way, or as required by law. The names of these other researchers (include name, affiliation, and role in the study) or institutions (name and role in the study) are listed below.

Shaheen Awan-Bloomsburg University (PA)

The TCU researchers and other researchers who work with TCU will **protect** your **health information** in the following ways:

- Your health information will be kept **private**
- Your **name or any other identifying information will not** be made known
- Your health information may be shown in research papers or meetings **without any information about you** that will link it to you.
- Your health information will be given a **special code** for security

- Your health information will be **grouped together with other people's** health information to form an average
- Your health information will be **locked in a cabinet** and kept safe

You can agree or not agree to sign this form. If you agree to sign this form but change your mind, you can **choose to stop** being in the study at any time. If you decide to stop being in the study, you will need to contact the researcher (insert the name, telephone, and e-mail of the PI):

Christopher R. Watts, Ph.D.
TCU Box 297450
Fort Worth, TX 76129
(817) 257-7620- voice
(817) 257-5692- fax
c.watts@tcu.edu

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

If you have any **questions or concerns** about **your rights** as a study participant, you can contact:
Dr. Brad Lucas, Chair, TCU Institutional Review Board, Phone 817 257-6981.
Dr. Janis Morey, Director, Sponsored Research, Phone 817 257-7516.

By signing your name below, **you are saying** that you **understand what is being said in this form**, you have **received answers** to all your questions, you have **freely agreed to sign** this form, you have been told **who to contact** if you have questions regarding **your rights** as a participant, and you have **allowed TCU to gather, use, and share your health information** as described in the form.

Participant's Name (please print):

____

Participant's Signature: ______________________________ **Date:** ____________

Investigator's Signature: ______________________________ **Date:** ____________

Legal Representative of Research Participant (if applicable):

Legal Representative's Name (please print): __________________________________

Relationship to research participant: _____________________________

I certify that I have the legal authority as a ________________________________ (e.g., parent, legal guardian, person with legal power of attorney, etc.) to make this authorization on behalf of the research participant named above.

Signature of the Legal Representative: ____________________ Date: ___________

Investigator's Signature: ____________________________ .... **Date: _____**