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NEUROLOGIC MUSIC THERAPY TO IMPROVE SPEAKING VOICE IN INDIVIDUALS WITH PARKINSON'S DISEASE

A Thesis
by
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Abstract

NEUROLOGIC MUSIC THERAPY TO IMPROVE SPEAKING VOICE IN INDIVIDUALS WITH PARKINSON'S DISEASE:

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Parkinson's disease (PD) is a neurodegenerative disease that affects dopamine production in the motor areas of the brain leading to impairments in muscular control (Parkinson's Foundation, 2018). Impairments in motor functioning can also impact respiratory control and voice production (America Speech-Language-Hearing Association, 2018). Neurologic Music Therapy (NMT) techniques have demonstrated the ability of music-based interventions to improve maximum phonation time, voice quality, articulatory control, and quality of life in people with PD (Azekawa, & LaGasse, 2018; Haneishi, 2001; Tamplin, 2008; Shih et al., 2012; Elefant, Baker, Lotan, Lagesen, & Skeie, 2012). This study sought to investigate how a music therapy protocol using NMT techniques impacts vocal functioning in people with PD. The effectiveness of specific Neurologic Music Therapy techniques targeting respiratory control and improving vocal functioning was explored. Six persons with idiopathic PD were enrolled in weekly one-hour music therapy sessions for 6 weeks. Data collection consisted of acoustic, perceptual, and self-report measures of voice were collected before and after a NMT intervention protocol. The acoustic and self-report measures were found to have no statistically significant differences from pre to post-intervention testing. The results from the perceptual measures yielded statistically significant differences for characteristics of breathiness, pitch, loudness, and overall severity of voice functioning. The results indicate that Neurologic Music Therapy interventions may be beneficial in improving speaking voice in individuals with PD. Further research with larger sample sizes and control groups are necessary to determine if resulting statistically significant differences are generalizable to the PD population to yield clinically relevant changes.

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Lastly, the author would like to extend her deepest gratitude to her husband, Nate, for his unfailing support and encouragement, and to her friends and family for being her pillars of strength during every twist and turn.

Dedication

This work is dedicated to the people of the Parkinson's Support Group in Boone, NC, and to the Park Nicollet Struthers Parkinson's Center for awakening a passion within me to use my voice to help other find theirs. Each person I have had the pleasure of working with has had a marked effect on who I am today as a person and as a music therapist.

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Chapter One

Introduction

Parkinson's disease (PD) is a neurodegenerative disease that affects the dopamine-producing neurons in the substantia nigra portion of the basal ganglia in the midbrain. This degeneration of dopamine production leads to tremor, bradykinesia, rigidity, gait and balance problems, and difficulties with speech and swallowing (Parkinson's Foundation, 2018). In addition to impairments in motor functioning, people with PD often experience behavioral symptoms such as apathy, depression, cognitive impairment, and difficulty with emotional regulation. Emotional regulation and controlled response of movements are the primary functions of the neurotransmitter dopamine (Parkinson's Foundation, 2018). The Centers for Disease Control (2013) reported that PD is the second most common neurodegenerative disease, second only to Alzheimer's disease, with its associated complications making it the 14^{th} leading cause of death in the United States.

According to the National Institute of Health (2010), nearly 500,000 people in the United States have PD with 50,000 new diagnoses a year. Across the world, there are more than 10 million people living with PD. The Parkinson's Foundation (2018) reported the disease is 1.5 times more likely to affect men than women with incidence increasing with age. The American Speech-Language-Hearing Association (ASHA) (2018) reported that 70%-100% of people diagnosed with PD experience dysarthria, or speech changes and impairments affecting voice. Treatment for the disease is highly variable and often includes the use of dopamine promoting medications, such as Levadopa and Carbidoba. These medications can assist with a number of signs and symptoms including tremor, rigidity, and coordination of movement. Medications must be on a strict schedule to appropriately manage the reduction of debilitating signs and symptoms.

In addition to pharmacological treatments, there are two surgical options for people who have exhausted medical treatment or whose motor symptoms fluctuate and significantly affect their quality of daily living. The most common surgical option, deep brain stimulation, is only effective in treating symptoms that have positively responded to previous medical treatments. The second surgical option involves inserting a tube into the intestine that will automatically administer medication to the patient through an external pump. In addition to these treatments, it is recommended by the Parkinson's Foundation recommends people with PD begin regular exercise for 2.5 hours per week focusing on flexibility, cardiovascular activities, and strength training. Symptoms affecting speech, voice, and swallowing require interventions by speech-language pathologists, or other related rehabilitation professionals, such as music therapists (Parkinson's Foundation, 2018).

Laryngeal Phonation

Laryngeal structure and musculature. The laryngeal complex is comprised of several muscles, cartilages, and one bone. The single hyoid bone is located between the mandible and the thyroid cartilage. There are two unpaired cartilages, the thyroid and the cricoid cartilage. The thyroid cartilage is oriented superior to the cricoid cartilage. In addition to these cartilages, there is one pair of cartilages called the arytenoid cartilage. When phonation is initiated, the cartilages' positions are adjusted using a combination of muscle movements. Muscles are responsible for bringing the vocal folds together and closing the glottis, which is the space between the vocal folds, are the thyroarytenoid muscles, the lateral cricoarytenoid muscle, and the inter-arytenoid muscles (transverse and oblique). The names of the muscles indicate the muscular origin and insertion attachments on the cartilages. The only muscle responsible for adduction of the vocal folds is the posterior cricoarytenoid muscle. The muscles responsible for lengthening and shortening the vocal folds are the thyrovocalis muscle, also known as the deep fibers of the thyroarytenoid muscle, and the cricothyroid muscle (Sapienza & Ruddy, 2018, pp. 21-58).

Aerodynamic Principles of Phonation. Laryngeal aerodynamics help to explain the relationship between air flow and pressure during respiration and phonation. The aerodynamic principle of phonation states that when resistance is increased in the laryngeal framework the flow of air is restricted forcing the need for additional pressure to produce phonation (Sapienza & Ruddy, p. 88, 2018). Age and voice disorders can have a marked effect on the aerodynamic functioning of the laryngeal framework. As an individual ages the cartilage in the larynx begins to ossify. This ossification process can lead to changes in how the larynx functions biomechanically (Sapienza & Ruddy, p. 96, 2018). Different measures help determine laryngeal aerodynamic changes and the presence of voice disorders. Maximum phonation time (MPT) and s/z ratio are both useful tools in examining a patients aerodynamic functioning. Maximum phonation time, or the greatest amount of time a person can sustain a vowel after maximum inhalation, indicates the persons vital capacity, or how much air can be exhaled after inspiration. The s/z ratio is measured by dividing the duration of the voiceless fricative /s/ by the voiced fricative /z/. The higher the ratio score the more likely the presence of a voice disorder (Sapienza & Ruddy, p. 97, 2018).

Acoustic Variables of Phonation. The acoustic variables in this study include: fundamental frequency (F_o), jitter, shimmer, maximum phonation time, and s/z ratio. The fundamental frequency (F_o) refers to the speed of the vocal fold vibration which relates to the pitch of the voice and is measured in Hertz (Sapienza & Ruddy, p. 445, 2018). The variability of fundamental frequency indicates the amount of prosodic change to the voice during typical speaking. Lowered variability of the fundamental frequency may be an indication of a voice disorder and is present in changes to the voice from Parkinson's disease. Decreased range of the fundamental frequency can also be indicative of a reduction in the useable vocal range during speech (Bowen, Hands, Pradhan, & Stepp, 2013).

Increased jitter, as an indicator of cycle-to-cycle variation of fundamental frequency, indicates the presence of vocal pathology (Sapienza & Ruddy, 2018, p. 447). Shimmer is the cycle-to-cycle variation of voice waveform amplitude. When increased, it also indicates the presence of vocal pathology (Sapienza & Ruddy, p. 454, 2018). A study which compared tremulous voice common in PD to healthy controls found that people with PD presented with irregular sound waveforms, as well as, higher scores and greater variability in percent shimmer and jitter when compared to healthy controls. The authors also found that people with PD had higher instances of long-term tremor frequency modulation (Fftr) (MacCallum, Zhang, & Jiang, 2010). The findings of this study indicate that people with PD have statistically significant instances of tremulous voice when compared to healthy adults.

Increased maximum phonation time from pre- to post-test indicates improved functionality of the respiratory system. A person's maximum phonation time indicates their individual lung capacity and ability to control their laryngeal framework. Abnormality and impairment of the laryngeal framework and valving may lead to decreases in maximum phonation time (Sapienza & Ruddy, 2018, p. 97). Motta, Cesari, Paternoster, Motta, and Orefice (2018) studied the correlation between aerodynamic measures and vocal disability in people with Parkinson's disease. There were 15 male participants in the study diagnosed with Parkinson's disease. Aerodynamic measures of maximum phonation time, subglottal pressure, phonatory power, and phonatory resistance were taken using a computerized speech system. The findings indicated that the patients all had statistically significant reductions in their maximum phonation time as compared to healthy controls. The authors noted that this reduction in MPT is indicative of functional changes within the laryngeal mechanism.

The s/z ratio compares expiratory control during an unvoiced consonant to sustained phonation on a voiced consonant. An increased score on the s/z ratio can indicate the presence of vocal pathology because of the inefficiency of the vocal fold adduction (Eckel & Boone, 1981). Decreased s/z ratio from pre- to post-test indicates improved adduction of the vocal folds during phonation.

Voice

Voice is created through the combination of air through the larynx which vibrates the vocal folds. When the breath is expired, the diaphragm contracts with assistance from the abdominal muscles and expels the air through the laryngeal glottis, the space between the vocal folds, and out of the mouth and nose. During phonation, the vocal cords are brought together and create an undulating vibration resulting in phonation. The act of phonation requires great coordination between the laryngeal muscles, cartilages, and hyoid bone, as well as, organizing the dynamic movement of the diaphragm and lungs (Sapienza & Ruddy, 2018, pp. 1-20). When used for communication, the voice includes variation in perceptions of pitch, perception of loudness, and perception of inflection that can be indicative of patient's identified gender and age.

Speech

The National Institute on Deafness and Other Communication Disorders (NIDCD; 2017) stated that speech is personal expression through the coordination of the voice, speech articulators, and breath into discernible patterns which indicate specific messages. The articulators of speech are the lips, teeth, tongue, jaw, and velum. The head, neck, chest, and abdomen are all involved in the production of speech.

Singing

Garcia-López and Gavilàn Bouzas (2009) investigated the physiological changes that occur in the laryngeal complex and speech mechanisms when singing. Both singing and speaking voice requires breath, resonation, posture, emission, and articulation. Singing, however, requires greater use of the abdominal muscles to maintain a specific musical note and phonatory intensity. Furthermore, complete glottic closure must be maintained for longer periods of time when singing and is necessary to progress through the vocal range. Resonance is required for both singing and speaking and is partially responsible for our ability to differentiate between two individuals' voices. When singing, resonation helps the singer amplify their tone with minimal muscular effort. These changes in tone act to express different emotion when singing, and also to project tones to the listeners. Therefore, the muscular demands needed when singing are greater than those needed for speech.

Music Therapy

The American Music Therapy Association (AMTA, 2018) defines music therapy as the use of music interventions based on clinical and scientific evidence to address individual goals and built on a therapeutic relationship between client and music therapist. Music therapy must be administered by a board-certified music therapist who has completed a bachelor's degree of higher education from a music therapy program approved by the American Music Therapy Association. Music therapy techniques can be beneficial for a wide range of populations including children, adolescents, adults, and older adults. Evidence has shown that music therapy strategies can address psychosocial well-being, physical rehabilitation, and communication problems (AMTA, 2018). It is important to differentiate music therapy from supportive musicians with specific populations. For example, a musician who performs music at an assisted living facility would not be considered a music therapist if they have not received the required education and completed the board certification process. The use of music in a therapeutic setting requires significant knowledge of musical structures as well as training in anatomy and physiology and psychology. Music therapy offers a unique opportunity for vocal rehabilitation as an activity to improve quality of life for people with PD. A study looking at the effectiveness of singing-based interventions on communication and voice in people with PD (2019) stated:

> Singing demands increased respiratory support, louder and more sustained phonation, and greater pitch variation and articulation than talking, thus theoretically targeting many elements of impaired speech in PD. (Tamplin, Morris, Marigliani, Baker, and Vogel, p. 454, 2019)

The multi-faceted nature of music makes it a unique treatment strategy to treat speech impairments, however, these same aspects of music therapy make it conducive to therapeutic change for voice disorders, as well. Therefore, given the known decreased laryngeal functioning and reduction in vocal fold adduction for people with PD and the known positive effects of these variables using specific music therapy intervention, there is a need for research investigating music therapy interventions for individuals with PD.

Neurologic Music Therapy (NMT)

According to the *Handbook of Neurologic Music Therapy*, Neurologic Music Therapy (NMT) is the use of standardized music therapy techniques that can address functional physical, speech, and cognitive abilities. There are 20 techniques included in the NMT handbook, all with extensive research backing their effectiveness. The techniques included in NMT are focused on neuroanatomy and development and have substantial scientific evidence supporting their use with a multitude of populations and ages. NMT is particularly effective as treatment for neurological disorders affecting movement and functioning including voice disorders and gait from PD (Thaut & Hoemberg, 2015).

Voice, Music Therapy, and PD

Music therapy through singing and respiratory exercises can be a beneficial non-pharmacological intervention to improve voice in people diagnosed with Parkinson's disease. A literature review (García-Casares, Martín-Colom, & García-Arnés, 2018) studying the therapeutic effects of music therapy in Parkinson's disease found that interventions with non-motor symptoms, such as, voice quality, respiration, and quality of life, showed seven articles found statistically significant improvement in symptoms after interventions lasting longer than one month. The authors of the review stated that MT may be beneficial in improving vocal functioning and respiratory strength.

Stegemöller et al. (2017) conducted a descriptive study by interview of the experiences of people diagnosed with Parkinson's disease who had undergone group singing music therapy. The questions in the interviews involved categories of program enrollment, engagement, participation, and evaluation. The findings indicated that the participants stressed the importance of alternative treatments to improve quality of life through voice and lifestyle, among others. The participants in the reviewed study also found that the group aspect of the singing intervention provided opportunities for positive social interaction. The participants also expressed feeling that the singing interventions were most beneficial in helping them train and improve their voices and respiration. Overall, the participants reported that the music therapy interventions gave them the opportunity to improve their vocal functioning and quality of life.

Stegemöller, Radig, Hibbing, Wingate, and Sapienza (2017) studied the effectiveness of a singing intervention on vocal outcome measures and quality of life in individuals diagnosed with Parkinson's disease in either a low dosage or high dosage intervention. The authors hypothesized that vocal, respiratory, and quality of life measures would improve across dosages. There were 27 total participants in the study who were selected to participate in either the low dosage or the high dosage treatment conditions. Low dosage participants received 60-minute group sessions once per week, and high dosage participants participated in 60 minutes group sessions twice per week. Measures were taken pre and post-intervention and included measurements of phonation duration, lowest and highest fundamental frequency, vocal intensity, respiratory pressure, and quality of life. The intervention was administered by board-certified music therapists and included exercises designed to address breath support, vocal intensity, and range. In addition to the weekly sessions, participants were asked to perform at-home exercises and results of this practice were self-reported by the participants. The results of the study indicated that there was no statistical difference between the high and low dosage singing interventions. Maximum phonation time and the Voice-Related Quality of Life measure both showed statistically significant improvements from pre to post-intervention testing. Respiratory measures also showed a statistically significant improvement. The results of this study suggest that singing interventions led by board-certified music therapists may help to improve focal and respiratory functioning in people diagnosed with Parkinson's disease.

Voice-Related Quality of Life

Takahashi, Kamide, Suzuki, and Fukuda (2016) studied the importance of communication and relationships in the quality of life of people diagnosed with Parkinson's disease. The researchers utilized a not previously studied quality of life measure aimed at measuring all quality of life domains for people with Parkinson's disease. The effectiveness of this measure was compared to other disease specific questionnaires measuring motor functioning, activities of daily living, and quality of life. There were fifteen participants in the study diagnosed with idiopathic Parkinson's disease. The study found that a lack of social relationships significantly impacts quality of life in individuals with Parkinson's disease. An ability to communicate was also found to be a significant factor in the forming of important social relationships. The results of their study found that this new questionnaire was strongly correlated to domains associated with social relationships. The authors noted, however, that this study was conducted in Japan indicating that cultural differences may affect the importance of different domains.

McAuliffe, Baylor, and Yorkston (2017) investigated the relationship between the Communication Participation Item Bank (CPIB) and other health-related quality of life measures. There were 378 participants in the studied diagnosed with Parkinson's disease from the US and New Zealand. The CPIB is a self-report measure designed to rate how much a voice disorder affects daily communication. The results of this study found that a higher rating of perceived speech impairment indicated reduced communication. The study also indicated that a person's perception of their voice impairment may be a better indicator of reduced communication than other measurements. The study concludes that the CPIB may be effective in determining the multi-faceted complexity of communication difficulties in individuals with Parkinson's disease. It further posited that a person's perceived difficulties with communication may negatively affect their quality of life.

Confounding Factors

There are several biases which may have impacted the design of this study. All participants were obtained from a convenience sample, which may have increased the inclusive sampling bias of the participants. The small demographic range makes the results of the data not generalizable to the general population. Response bias of the participants on the self-report measures may have also skewed the impact of the participant's vocal impairment on their daily lives. A final confounding factor is the possible measurement error due to random responses to medication resulting in dyskinesia during final measurements.

Research Question

How will a music therapy protocol using NMT techniques improve vocal functioning in people with PD?

Statement of Purpose

The purpose of this study was to explore the impact of how a music therapy protocol using NMT techniques impacts speaking voice and voice-related quality of life in individuals with PD based on acoustic, perceptual, and self-report measures before and after treatment. Singing interventions (Azekawa & LaGasse, 2018; Haneishi, 2001; Tamplin, 2008; Shih et al., 2012; Elefant et al., 2012) have been shown to improve functionality of the vocal mechanism for people with PD; therefore, our overarching hypothesis is that music therapy interventions focusing on phonation will have a positive effect on the client's communication in daily life. Improved communication in people with PD has been shown to improve daily quality of life and increase effective communication of wants and needs (Takahashi et al., 2016; McAuliffe et al., 2017)

This study will address the following specific aims:

Specific Aim 1: To examine the effects of NMT techniques on voice production following an 6-week treatment period as measured by acoustic variables.

It is hypothesized that participants will have

a. decreased frequency of tremor at F_0
b. decreased percent jitter during sustained vowel phonation and standardized reading passage.
c. decreased percent shimmer during sustained vowel phonation and standardized reading passage.
d. decreased F_0 variability during a sustained vowel /a/ phonation.
e. increased maximum phonation time (MPT) (seconds) during sustained vowel phonation of /a/.
f. increased range of fundamental frequency (PFT) in semi-tones during standardized reading passage.
g. increased average intensity (dB) during sustained vowel phonation and standardized reading passage.
h. change in average F_0 during a standardized reading passage
    a. men will experience a decrease in average F_0
i. maintain an s/z ratio less than 1:4 across two trials.

Specific Aim 2: To examine the effect of NMT voice protocol on perception of voice quality following 6-week intervention period as measured by CAPE-V.

It is hypothesized that participants will have a decreased score on the CAPE-V.

Specific Aim 3: To examine the effect of NMT voice protocol on voice-related quality of life as measured by VR-QOL and VHI.

It is hypothesized that participants will have a decreased score on the VR-QOL and VHI.

Chapter Two

Literature Review

This chapter is a review of the literature of traditional speech-language pathology methods used to address voice disorders in people with PD. This review also includes a discussion of music therapy strategies used with this population.

Aerodynamics and Phonation in Parkinson's Disease

A study of the aerodynamic changes in people with PD by Ikui et al. (2014) investigated the differences in vocal frequency changes, expiratory pressure during phonation, and vocal intensity during phonation between people diagnosed with PD and health age- and gender-matched controls. All 30 participants in the experimental group had been diagnosed with PD and visited the outpatient clinic at the Oklahoma City University Hospital. A special instrument, the Vocal Function Analyzer, was developed to take acoustic and respiratory measurements simultaneously and noninvasively. In relation to voice pitch, the results showed that people with PD had no significant difference in pitch range compared to their healthy controls, however, highest pitch range was notably lower in people with PD across genders. The lowest pitch was significantly higher in the experimental group versus the control group. There were no notable differences between the comparison and experimental groups in reference to expiratory pressure or vocal intensity during phonation. The authors hypothesized that this lack of statistical difference in expiratory pressure and vocal intensity could be explained by the reduced oral cavity opening common in people with PD. The authors also posited that continuing to encourage the use of effortful speech during conversation might assist in increased speech intelligibility and vocal intensity in patients with PD. PD affects muscle functioning, including vocal rehabilitation techniques have been developed to address decreased laryngeal muscle functioning in people with PD. These techniques and have been found to be particularly beneficial in maintaining appropriate vocal functioning in people with Parkinson's disease as they age.

Fang, Hwang, and Chen (2014) measured differences in voice quality, maximum sound prolongation, and s/z ratio between people diagnosed with PD and a healthy control. The study included 16 men with an average age of 68 diagnosed with PD varying from stages 2 to 4 on the Hoehn and Yahr scale. There was also a healthy control group matched for age and gender. An audio recording was taken of maximum phonation of the phonemes /a/, /f/, /s/, and /s/, and monosyllable sounds of /pa/, /ta/, and /ka/, and trisyllables of /pataka/ as fast as possible in a single breath for three trials. Measurements of average fundamental frequency (F_o), jitter, shimmer, and noise-to-harmonics ratio (NHR) were taken using a standardized computer program. The s/z ratio was measured by dividing the duration of the voiceless fricative /s/ by the voiced fricative /z/. The results indicated that the healthy control had a greater duration of sustained vowel phonation that the individuals diagnosed with PD across phonemes and fricative trials. The s/z ratio findings showed that there were no statistically significant differences between groups. Furthermore, voice quality in F_o and NHR were found to have no significant differences. The authors stated that their findings in regards to jitter, shimmer, and s/z ratiowere contrary to previous studies and suggested that the small sample size could have attributed to the lack of statistically significant findings. They suggest further research to determine further differences in aerodynamic changes for people diagnosed with PD and healthy controls.

Speech-Language Pathology Interventions

Matheron, Stathopoulos, Huber and Sussman (2017) found healthy older adults had better laryngeal control when compared to adults with PD when increasing sound pressure level of speech. The study measured 20 healthy older adults with an age range of 60 to 81 years and even gender distribution, and 42 adults with PD with an age range of 37 to 86 years and predominantly male. Participants were required to be native speakers of English with no history of neurological disease besides PD, no respiratory disease, functional hearing in at least one ear, and no history of smoking in the past 5 years. Additionally, for the individuals with PD, a diagnosis by a speech-language pathologist or a self-perception of hypophonia was needed. Subglottal pressure, intraoral air pressure, and laryngeal airflow were measured for speech-in-quiet and speech-in-noise during a standardized speech task. The results showed no significant differences between the groups for mean sound pressure level, maximum flow declination rate, and minimum flow; however, statistically significant differences were found between groups for estimated subglottal pressure, peak-to-peak flow, and open quotient, or the ratio of how long the vocal cords are open during a cycle to the time of the entire cycle, in the speech-in quiet condition. The participants with PD showed significantly decreased open quotient measures from speech-in-quiet to speech-in-noise conditions. Significant differences were found in all measures except the minimum flow measure in the speech-in-noise condition. The results indicated that when speaking at a normal, comfortable level there were no significant differences in the rate of vocal fold closure to midline and airflow at maximal vocal fold closure between the control and the PD group; however, the open quotient differences indicated that healthy older adults show more ability to control muscles associated with laryngeal adduction. This suggested that individuals with PD spent more time on average with vocal folds open than their healthy controls resulting in vocal fatigue and decreased vocal intensity during conversation. Furthermore, estimated subglottal pressure may be affected by difficulties with adductor muscle control in the laryngeal mechanism in people with PD. These findings indicated that healthy older adults may have more laryngeal efficiency in regard to vocal fold closure and therefore do not tire as easily when talking. Based on their findings, the researchers suggested vocal rehabilitation techniques that promote increases in vocal intensity while speaking. Voice strengthening therapy provided by a speech-language pathologist is especially effective in the treatment of vocal disorders for people with PD.

Smith, Ramig, Dromey, Perez, and Samandari (1995) investigated the effect of intensive voice treatment for people with PD based on rigid and flexible laryngostroboscopic measurements. Laryngostoboscopy is the use of a scope to visualize vocal cord functioning. The scope is equipped with a stroboscopic light output that that allows the movement of the vocal cords to be visualized with the naked eye. The authors used two treatment strategies to address phonation in persons with PD. The two treatment protocols were respiratory interventions and voice and respiratory therapy. Laryngostroboscopic measurements were taken pre- and post-intervention. The authors hypothesized that voice and respiration therapy would have a greater impact on laryngeal adduction and improved sound-pressure level based on increased vocal effort when compared to respiratory interventions alone. Twenty-two patients diagnosed with PD participated in the study with a representative sampling based on gender, age, and stage of the disease. Initial laryngostroboscopic measurements and preliminary voice-recording sessions were taken one month prior to the beginning of therapy. The initial findings determined inadequate glottal functioning and hyperfunctioning of the larynx. Measurements were also taken to determine the amount of vocal cord bowing and other vocal abnormalities apparent in each participant. The subjects participated in 16 treatment sessions across a 4-week period. Laryngostroboscopic measurements and voice-recording sessions were taken post-treatment and compared to the results of the pre-treatment measurements. The findings indicated participants receiving vocal and respiratory interventions demonstrated greater improvements in laryngeal adduction and glottal closure than those who received respiratory therapy alone. These progressions in vocal fold functioning led to increased vocal intensity. The authors concluded that the evidence supported the hypothesis that the combination of voice and respiratory interventions can help to improve vocal fold adduction and be beneficial in the treatment of voice changes in people with PD.

De Angelis et al. (1997) examined the effect of a group vocal rehabilitation program on patients with PD. There were 20 participants in the study, all of whom had a stable pharmacological regimen. The participants attended three 45-minute sessions a week for one month. Measurements were taken pre- and post-intervention to determine peak phonation time based on sustained vowels and the phonemes /s/ and /z/, and rate of air flow. Participants also completed a self-evaluation of swallowing and level of oral communication before and after treatment. The interventions included asking the participants to push their arms from an upright to a lowered position while phonating. The authors reported that this pushing exercise had a marked effect on the patient's loudness and resonation. Over-articulation of phonemes was also used to improve glottic closure. After treatment, the post-intervention measurements indicated that the intensive vocal rehabilitation protocol produced increased vocal intensity, more effective vocal cord closure and subglottic pressure and efficiency, wider pitch range, and secondarily, improved swallowing function. A month following the treatment, the researchers repeated their measurements and found that the improvements were maintained. Additionally, alternative treatments, such as voice therapy and therapeutic singing, have shown to help improve articulation and intelligibility, vocal intensity, and quality of life in people living with PD.

Simberg, Rae, Kallvik, Salo, and Martikainen (2012) studied the effects of a 15-day intensive speech therapy intervention on vocal functioning of people diagnosed with PD. The study included six participants, four men and two women, with an average age of 64 years, who had no signs of dementia and no previous speech therapy. The study was conducted at a rehabilitation center in which the participants resided for the duration of treatment. The treatment included 10 individual 30-minutes speech therapy sessions, nine 60-minute sessions in a group setting, and two one-hour evening sessions as a group with a focus on speech and voice exercises. The treatment was subdivided into two parts of 10 and 5 days respectively with a 3-month interlude in between treatments during which time the participants were given at home exercises. Acoustic measurements of fundamental frequency, vocal range, sound pressure levels, and quality of speech (breathy, strain, roughness, etc.) were taken using recordings of range of speech through sentence reading, spontaneous speech, and glissandi from highest to lowest pitch in both a weak and loud voice. These recordings were taken the second day of the first part of treatment, the last day of the first part of treatment, and the beginning of the second part of treatment. In addition to these recordings, participants also completed the Voice Activity and Participation Profile four weeks prior to beginning treatment, 6 months after treatment, and 1 year after treatment.

Simberg et al. (2012) study showed that the average fundamental frequency increased from 130.27 Hz at the start of treatment (SD = 40.15) to 150.64 Hz (SD = 47.54) 3 months past beginning of treatment. Sound pressure levels were shown to increase from the beginning to the end of the first part of treatment but returned to baseline following the 3-month break. Vocal range increased for all participants. The self-reported questionnaires indicated the participants perceived their symptoms to be less severe after receiving treatment. Responses indicated an improvement in quality of life through reduction of symptoms and increase in peer support through the group treatment. In addition to these findings, improvements in voice grade, roughness and instability maintained three months after the first part of treatment. The authors concluded that intensive vocal rehabilitation can be effective in improving vocal functioning in people diagnosed with PD; however, because of the small sample size, they suggest caution in generalizing the results. Additionally, negative carryover effects were seen through the deterioration of abilities between the two parts of the rehabilitation treatment.

Lee Silverman Voice Treatment (LSVT-Loud)

Dromey, Ramig, and Johnson (1995), studied the use of the Lee Silverman Voice Treatment on the phonatory and articulatory changes common among people diagnosed with PD. The study followed the progression of one patient with PD while he underwent the intensive Lee Silverman Treatment. According to the LSVT Global website, the Lee Silverman Voice Treatment is a comprehensive vocal rehabilitation strategy focused on addressing vocal intensity, articulation, and quality for people with PD (LSVT Global, 2018). The patient attended 16 sessions over a 4-week period. Pre- and post-treatment measurements were taken to determine phonatory and articulatory behavior. Post-treatment measures were conducted a week after treatment ended, and 6 and 12 months after treatment to ascertain carryover effects after significant time without treatment. The data included measures of sound pressure level for sustained phonation, conversational speech through reading and a monologue, and syllable repetition. Articulatory acoustics were determined using the recitation of a series of 70 monosyllabic words with a direction to read clearly. The data showed that after treatment vocal intensity increased during sustained vowels, reading, and monologue recitation. These changes were still apparent at the 6-month and 12-month time points. Sub-glottal air pressure also increased from pre- to post-testing and remained at later testing. Vocal fold adduction also improved after treatment and continued at further measures. The authors hypothesized vocal and laryngeal musculature became stronger because of the intensive vocal treatment. The data indicated that intensive vocal interventions had a significant effect on vocal intensity and articulation apparent in people with PD.

Sackley et al. (2018) compared the Lee Silverman Voice Technique (LSVT Loud) to traditional speech and language therapies and no treatment in people diagnosed with PD. The study included 27 participants randomly assigned to receive LSVT Loud, 27 to speech therapy, and 29 to the no treatment control group. The participants had an average age of 67 years and were mostly male across conditions. All participants had idiopathic PD with no dementia, self- or caregiver reports of speech problems, and no previous laryngeal pathology. The treatments were provided either at community-based healthcare establishments or outpatient neurology units in the United Kingdom. Participants in the LSVT Loud treatment condition received four 50–60 minutes sessions per week for 4 weeks by a registered speech-language pathology with a certification in LSVT. In addition to these treatments, participants received 5–10 minutes of homework on treatment days and up to 30 minutes of homework on nontreatment days. The treatments consisted of maximum effort nonspeech and speech drills. The participants in the speech-language therapy (SLT) condition received one 45-minute session per week for 6–8 weeks with varying content based on patient need. This content could include exercises in respiration, phonation, articulation, behavioral strategies to reduce prosodic abnormality, and use of augmentative and alternative communication strategies. The no treatment control group continued to receive their usual PD treatment and were prohibited from receiving speech therapy services until at least 6-months poststudy unless deemed medically necessary. Patients completed the Voice Handicap Index (VHI), and the voice-related quality of life (V-RQOL) questionnaire among others and further perceptual measurements of vocal loudness, comprehension assessments, and assessment of intelligibility of dysarthric speech were recorded. The Vocal Handicap Index results showed a reduction in total scores for the LSVT Loud and speech therapy conditions from baseline to three months post treatment. The largest difference was seen in the LSVT results with greater reduction of scores for participants receiving LSVT than those receiving speech therapy. The findings indicated that both LSVT Loud and traditional speech therapy treatment options may be effective in improving voice for people with PD; however, there was high attrition for individuals receiving LSVT treatment, which suggested the intensity of the treatment may increase participant drop out.

Singing as a Therapeutic Intervention for Voice Disorders

Non-Music Therapy Studies. Shih, et al., (2012) compared the use of group singing as a treatment strategy to address communication impairments to the Lee Silverman Voice Treatment in people with PD. There were 13 subjects who participated in the duration of the study for all assessment measurements. The authors hypothesized that the measurements taken pre-, post-, and after an additional 12 weeks post-treatment would be similar to the findings associated with the LSVT treatment. In this study, the subjects participated in 90-minute singing intervention one time weekly for 12 weeks. The findings, however, did not support the hypotheses. Measurements of vocal intensity, articulation, fundamental frequency, and pitch range showed no significant improvements from pre- to post-test measurements. The authors stated that these findings could be caused by the less intensive training of this study as compared to LSVT. Further research which includes comparison groups, a larger sample size, and increased frequency of treatment to further investigate the use of group singing as a valid treatment option for communication impairments in people with PD is needed.

Harris, Leenders, and de Jong (2016) studied the effectiveness of singing familiar melodies on vocal behavior during vocal improvisation for people diagnosed with PD. The rationale for the study was based on the findings of music therapy for Rhythmic Auditory Stimulation for gait training described in the *Handbook of Neurologic Music Therapy* (Thaut & Hoemberg, 2015). Emphasis within the study was not given to vocal performance ability, but to functional vocal behaviors. Most of the participants had a history of singing or playing a music instrument and had a mean age of 65 years. Inclusion criteria included no other neurological pathologies, no additional treatment for symptoms, such as deep brain stimulation, and the clients could not be professional or semi-professional musicians. During treatment, participants continued to take their regular dosage of dopamine repletion medication. The treatment measures included two speech tasks and two music tasks to compare differences between type of vocal usage. Measures were taken pre and posttest and randomly compared to the control group measures. Skilled assessors, neurologists and neurology students, listened to the speech and instrumental musical task recordings of both the treatment and control conditions and attempted to distinguish the two conditions from each other.

Harris, Leenders, and de Jong (2016) reported that 8 out of 15 PD patients were identified as “probably or definitely” having PD. Two patients with PD were misidentified as healthy control participants. In the control group, eight participants were identified as “probably or definitely” healthy and one was misidentified as a patient with PD. The speech task of rhythmically reciting lyrics to a preferred song showed little difference between the treatment and control groups; however, the treatment group should have a more limited pitch range. There were not statistically significant differences found between the treatment and control groups in melodic tasks, and they were reliably distinguishable from each other according to aural perception of their speech. The results indicated that the majority of patients with PD exhibited slower speech rates than their controls, and greater pitch variability for the control group during the lyric recitation. The authors concluded that, as seen in gait training, musical behaviors are not affected by the neurological impairments apparent in PD. They suggest that the use of singing and music may help to improve the prosody of speech in individuals with PD.

Music Therapy Studies. Haneishi (2001) investigated the use of music therapy vocal techniques on intelligibility with vocal acoustic measures in four women with ages ranging from 67 to 77 years. The author also studied how these music therapy techniques would additional affect the mood of individuals with PD. The author developed the Music Therapy Voice Protocol (MTVP) as a pilot program that which utilized vocal and singing exercises with a focus on phonation and respiration to address speech intelligibility and vocal intensity. All participants had a diagnosis of PD and had reported symptoms of voice quality changes, reduced volume, impacted articulation, and difficulty breathing and none had previously received speech therapy services. In addition, the participants had no diagnosis of dementia. The protocol included opening and closing conversations, breath warm-up, vocal warm-up exercises, singing exercises, sustained vowel phonation, and speech exercises. Each participant underwent 12 to 14 MTVP session for a duration of 60 minutes, and pre- and posttest measurements. The treatment lasted for one month on average. Data were collected for speech intelligibility, vocal intensity, fundamental frequency, maximum vocal range, and the duration of maximum sustained vowel phonation. In addition to the vocal measures, an 11-point mood measure was administered pre- and posttest. The results indicated that the participants experienced increases in speech intelligibility and vocal intensity from baseline to posttest. The mood measurements showed that there were positive reactions to the treatment; however, these findings were not statistically significant. The author suggested additional studies with larger sample sizes that account for variability and increase generalizability of the findings.

Tamplin (2008) studied the effects of singing based vocal exercises on intelligibility and speech naturalness in 4 participants, ages 19-55, with dysarthria from traumatic brain injury or stroke. Inclusion criteria included dysarthria from acquired neurological damage, fewer than 18 months post onset, and minimal difficulty in initiating speech and following directions. The treatment consisted of three 30-minute individual music therapy sessions per week for a duration of 8 weeks. The sessions included vocal exercises, oral motor respiratory exercises, rhythmic and melodic articulation exercises, rhythmic speech cueing, vocal intonation therapy, and singing three familiar songs. Assessment measure of speech intelligibility, rate of speech, and communication efficiency were taken pre-, mid-, and posttreatment was made using the Sentence Intelligibility Test and the Picture Description Task. The results showed a statistically significant improvement in speech intelligibility for the spontaneous speech task between pre- and posttest. Other results showed improvements in the measures, but no statistical significance. The author posited that the small sample size explained the lack of statistical significance. Effect size for the findings showed intriguing evidence of improvement in the measures. The author concluded that music therapy singing-based treatments were effective in improving speech intelligibility in spontaneous speech samples. The improvements in speech intelligibility may have been in part because of the use of rhythm to cue phrase lengths, and also in part because of the client’s awareness of the nature of the testing. This awareness might have increased tension in the pretest measurements and skewed pretest results. Oral and motor respiratory exercises increase conscious control over automatic breathing patterns and might increase respiratory control through singing. Carry-over effects were seen posttreatment in clients' everyday use of speech. The author suggested that further research is needed with larger sample sizes to increase the generalizability of these findings and distinguish between spontaneous speech and read speech intelligibility.

Yinger and Lapointe (2012) adapted the Group Music Therapy Protocol (G-MTVP) developed by Haneishi (2001) and studied the effects of this adapted protocol on symptoms of voice disorders in people with PD. The study included 10 people with PD with ages ranging from 59–84 years. None of the clients experienced any type, timing, or dosage changes for medications during the treatment. The participants attended weekly 50-minute choir rehearsals for people with PD at a hospital over a 6-week period. Acoustic measurements of intensity, fundamental frequency, and fundamental frequency variability were taken pre- and posttest, and a self-report measure of mood. The interventions included introductory conversation, physical warm-ups, breathing exercises, speech exercises, vocal singing warm-ups, singing of preferred songs, and closing conversations with encouragement of at-home use of the techniques. The results of the study indicated a statistically significant increase in intensity from pre- to posttest measurements. Intensity of conversational speech also increased from pre- to posttest; however, these results were not statistically significant. The findings also indicated that there was no significant change in fundamental frequency from pre- to posttest measurements for both males and females. Fundamental frequency variability of conversational speech showed some increases. However, the results were also not statistically significant. The authors recognize limitation to the study including small sample size and no control group. They also encouraged future studies with more gender balance and participants who have not participated in a

Parkinson's choir prior to the study. The researchers concluded, that because of the degenerative nature of PD any improvement or maintenance of current functioning is important for this population. Furthermore, inclusion of caregivers within the choir help to promote cohesion and participation in leisure activities. Because of the prevalence of apathy for people with PD, leisure activity participation is incredibly important to reduce instances of symptoms of depression. The social and enjoyable nature of a Parkinson's disease choir offers patients the opportunity to practice techniques to maintain current vocal functioning through neuroplasticity before impaired speech progresses to impairments in daily quality of life.

Elefant et al. (2012) studied the effects of group singing and other voice interventions on signing and speech vocal abilities, and depressive symptoms in 10 people with PD with ages ranging from 55–84 years. All clients were assessed at Stage 2–3 on the Hoehn and Yahr Parkinson's scale and were stable responders to Levodopa. The study utilized a single-group repeated measures design. Participants were divided into two equal size groups that received the same weekly 60-minutes intervention for 20 weeks. Collection of acoustic and self-reported data occurred at baseline, after 10 weeks of weekly music therapy, and after 20 weeks of weekly music therapy. Acoustic data measured fluency, mean pitch, pitch variability, vocal range, and mean intensity. Clients filled out the Vocal Handicap Index (VHI) to access how symptoms affected their daily lives and the Montgomery and Åsberg Depression rating scale to determine the severity of depressive episodes. The intervention included introductory conversation, breathing exercises, vocal exercises, singing of client preferred music, and closing conversation.

The results from the Elefant et al. (2012) study showed that there were significant findings for the majority of variables in the singing measurements. Participants were found to be closer to singing the target note at the end of the study. Furthermore, loudness increased in the second measurement as compared to baseline with decibel levels remaining stable. Voice range measures indicated there was no statistically significant changes from baseline to final measurement. According to the VHI findings, the physical subscale showed significant change from pre- to posttest measurements. Other results showed that the participants recognized functional improvements in their voices posttest; however, these findings were not statistically significant. The depression rating scale showed no significant changes; however, there were two outliers, which may have contributed to the stable mean change scores. The authors noted that there were no significant decreases in speech function during the treatment period, which might indicate that singing interventions help to maintain speech function. Increases in vocal intensity, consistency of vocal volume, pitch accuracy, and voice range support the initial hypothesis of improved vocal functioning post-treatment using music therapy. The authors concluded that the changes that contradict their initial hypotheses, could have been in part because of the less-intense structure of this study (i.e., one weekly session instead of multiple weekly sessions and group setting instead of individual). Larger carry-over effects also might have been found with increased vocal practice. The authors suggested a future randomized-controlled trial and increasing the frequency and duration of sessions to more directly investigate the effects of singing interventions compared to other treatment protocols. The small sample size may have impacted the lack of significant findings related to the VHI and depression rating scale. The authors suggested larger sample sizes and different rating scales to address depressive symptoms in treatment.

Ang, Maddocks, Zu, and Higginson (2017) reviewed current literature on the use of singing and wind instrument playing to improve respiratory functioning in people with long-term neurological diseases. Voice production requires the coordination of the respiratory system with the laryngeal mechanism, as such, the use of wind instruments could help improve respiratory functionality. The authors found that there was a limited amount of randomized controlled studies available with this topic, so all studies found were included in the review. Measures of respiratory functioning included maximum inspiratory pressure, maximum expiratory pressure, sniff nasal inspiratory pressure, and spirometry measures such as forced expiratory volume, and forced vital capacity. The researchers utilized an adapted Cochrane review style and included five articles for review. There was a total of 109 participants in all studies, two randomized controlled studies, three pretest-posttest quasi-experimental studies, and two studies included people with PD. All studies spanned at least 12 weeks. Results from the studies showed that group voice and choral singing treatment showed statistically significant increases in maximum expiratory pressure and maximum inspiratory pressure. A study that included playing the recorder showed increases in vital capacity for two adults with PD. The authors concluded that the five identified studies utilizing singing or wind instrument interventions showed improvements in respiratory function for people with long-term neurological conditions. The authors also noted that the study showing improvements in vital capacity for people with Parkinson's disease did not include the effects on functional outcomes for the participants. Because of this, it is unclear if the improvements seen in the results were beneficial to daily functioning. Intervention dosages, complexity of interventions, and study architecture varied across studies and may indicate the need for further research. Further research into the effectiveness of systematized singing and wind instrument interventions is needed to further the understanding of the effectiveness of these interventions on people with long-term neurological conditions, such as PD.

Tamplin et al., (2019) studied the effects of a singing-based therapy on vocal intensity, maximum phonation time, expiratory and inspiratory pressure, and voice-related quality of life in people with PD. Weekly and monthly singing interventions were compared to weekly and monthly active control groups. There were 75 participants in the study with an average age of 74 years. It is important to note that this study was a 3-month check-in for yearlong intervention protocol. The participants were not randomly assigned to their conditions and chose which activity they wished to pursue. The singing condition involved 30 minutes of high intensity vocal exercises to target respiratory control and vocal loudness, among others. Participants then spent 60 minutes engaging in singing of popular and traditional songs. At the conclusion of each session, participants engaged in social interaction and peer conversation. Weekly singing interventions were facilitated by board certified music therapists and speech pathologists, while the monthly group facilitated volunteer musicians with training in the intervention protocol. Both the monthly and weekly groups receive the same treatment protocol. The weekly control group attended painting, dancing, or tai chi sessions, and the monthly controls group participated in a monthly peer support group. Results showed that participants in the weekly singing group had higher scores for vocal intensity and a decrease in negative emotions about their voice problem according to the voice-related quality of life questionnaire when compared to the monthly singing group and control groups. The weekly singing condition also experienced an increase in expiratory pressure, indicating a correlation between expiratory pressure and vocal intensity. The authors suggested that future studies employ randomization of participants to conditions. They also suggested that both the monthly and weekly conditions be facilitated by fully qualified facilitators (Tamplin, et al., 2019).

Neurologic Music Therapy

Azekawa and LaGasse (2018) investigated the effectiveness of Neurologic Music Therapy (NMT) interventions to address voice deficits in five people, ages 57–81 with hypokinetic dysarthria, as seen in PD. All participants had typical hypokinetic dysarthria characteristics, such as reduced volume of speech, monotone pitch, reduced stress in speech pattern, breathy and hoarse voice quality, imprecise articulation, and a varied rate of speech, which is common with PD. All participants had a current diagnosis of PD and no co-morbidity with other neurological impairments or cognitive deficits. A pre-intervention questionnaire was distributed to all participants to determine client preferred music, and musical history. A brief interview also was conducted to determine important demographic information about the participants' disease experience. Three speech tasks were administered pre- and post-intervention to determine changes in vocal functioning, voice quality, articulatory control ability, and connected speech intelligibility. The study included weekly 50-minute group music therapy treatments for a duration of 6 weeks. The sessions included warm-up stretches, Vocal Intonation Therapy, Therapeutic Singing, and closing stretches. The results indicated that maximum phonation time, voice quality, and articulatory control either improved or maintained levels compared to pre-test measurements. It is important to note that because of the degenerative nature of PD a result of maintaining current functioning is important. Measures of connected speech intelligibility indicated a significant difference between pre-post difference for pause time. Statistical analysis also showed a large effect size for the maximum phonation time measurements. Anecdotally, the authors reported that participants expressed a desire to continue treatment poststudy and had frequent positive statements about the treatment protocol. Maximum phonation time had the greatest pre-post improvements and one male client showed improvements to the point that he was approaching normal phonation time. Statistically significant positive changes in speech pauses and connected speech intelligibility were also found. The authors reported that further research is needed with larger sample sizes and a control group to determine the true effectiveness of this treatment and that additional at-home exercises between sessions might help to increase the benefits found in this study.

Perceptual Analysis

The Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V; ASHA, 2006) is a short perceptual clinical evaluation of voice to rate overall severity, roughness, breathiness, strain, pitch, and loudness. The measurements are based on a visual analog scale with measures: not deviant, mildly deviant, moderately deviant, and severely deviant. The metric is also used as a visual analog scale, as a clinician marks on the line and measures the gradation of the disorder using location of the marks as measured by millimeters. Higher scores are indicative of more disorder, with the highest possible score of 100. A determination of the presence of a disorder is will be determined to be consistent or intermittent, based on the voice sample collected at the screening meeting. The CAPE-V was chosen for this study because its interrater reliability scores were slightly higher when compared to another perceptual measure. Furthermore, the CAPE-V has been found to have empirical validity. The measure was also chosen because of its clear protocol and ability to measure conversational speech and differing voice contexts. (Zraick, R. et al., 2011). A study comparing the reliability of the CAPE-V rating system to another called the GRBAS found that the CAPE-V had high reliability when rating dysphonia in clients with impairment and their healthy controls (Karnell et al., 2006).

Self-Report Measure

The Voice-Related Quality of Life (V-RQOL; Hogikyan & Sethuraman, 1999) is a 10-item self-report Likert-scale questionnaire that determines the level of a client's self-perceived voice disorder and its impact on quality of life. Scores range from 0 to 100 with higher scores indicative of a higher level of perceived severity of voice disorder. The current 10-item questionnaire was found to have strong internal consistency and reproducibility, indicating its reliability, and also clear construct validity. This measure was chosen because of its sensitivity to self-perceived voice related issues over general health measures and its measured reliability and validity. A study comparing the V-RQOL and a separate self-report measure of voice functioning found that the V-RQOL total score had a better representation of how the client perceives their voice and its impact on their daily life compared to the other self-report measure (Karnell et al., 2006).

The Vocal Handicap Index (VHI) is a 30-item Likert-scale questionnaire with sub-scales in the functional, emotional and physical domains (Jacobson et al., 1997). The questionnaire was developed to measure the impact of a person's voice disorder on their daily activities, their emotional responses to their voice disorder, and any physical changes that had occurred because of the voice disorder. The test has strong test-retest reliability and the study by Jacobson et al., indicated that the participants of the study indicated that the questionnaire increased their awareness of the implications of their voice disorders. In a recent study measuring the effectiveness of the VHI to measure the psychological impact of voice changes associated with Parkinson's disease found that the questionnaire was a consistent and reliable tool with the PD population (Guimaraes, Cardoso, Pinto, & Ferreira, 2017). A study of the relationship between Parkinson's disease and scores in aerodynamic measures and the VHI (Motta, Cersari, Paternoster, Motta, & Orefice, 2018) found that the 15 male participants diagnosed with PD reported statistically significant increases in scores on the VHI when compared to healthy adults.

Summary

Individuals with PD have significant decreases in pitch range (Ikui et al., 2014), and decreased laryngeal functioning (Smith et al., 1995) specifically affecting the intrinsic and extrinsic muscles in the laryngeal framework (Matheron et al., 2017). Singing directly engages the muscles of the laryngeal mechanism (Sapienza & Ruddy, 2018, pp. 21-58). While traditional speech-language pathology interventions (Simberg et al., 2012; De Angelis et al., 1997), and Lee Silverman Voice Treatment (Dromey et al., 1995; Sackley et al., 2018) can be effective in treating voice disorders and improving vocal functioning, music therapy can also address these speech needs and physical changes (Harris et al., 2016). Singing-based interventions (Haneishi, 2001; Tamplin, 2008) and respiratory exercises (Ang et al., 2017) have also been shown to improve speech intelligibility, and vocal acoustic measures in people with PD and other neurological conditions. Less intensive singing interventions have not been as effective as other vocal rehabilitation therapies (Shih et al., 2012), however, improvement or maintenance of symptoms are still apparent. Group singing has been shown to positively impact both vocal rehabilitation in people with PD (Elefant et al., 2012). Neurologic music therapy techniques have recently demonstrated the unique ability of music-based interventions to improve maximum phonation time, voice quality, and articulatory control in people with PD (Azekawa, & LaGasse, 2018; Tamplin, et al., 2019). Music therapy can offer a unique combination of singing and respiratory therapies to address rhythm, respiration, and phonation in the treatment of individuals experiencing voice disorders results from PD. Further research is needed to develop a standardized treatment protocol for singing based therapies to determine its true effectiveness on voice disorders from PD.

Chapter Three

Method

This chapter will describe the research design, participants, procedure, and music therapy intervention to be used for addressing the research questions. The measures and data analysis will be discussed and outlined.

Research Design

This study was an exploratory analysis employing single-group repeated measures for hypothesis testing. Data collection of acoustic measures and self-report measures were collected before and after a music therapy protocol using NMT techniques. The independent variable was the NMT protocol. The dependent variables included acoustic, perceptual, and quality of life metrics related to speaking voice.

Participants from Specific Aim 1, 2, and 3

There were six community-dwelling participants diagnosed with PD who reported experiencing voice changes within the past year. Volunteers were recruited through a local community Parkinson's disease support group, or from referral from local speech-language pathologists. This sample was limited leading to possible sampling bias based on the convenience of inclusion. Inclusion criteria included:

1. Diagnosed with Stage 2 or 3 PD based on the Hoehn and Yahr scale (Hoehn & Yahr, 1967). Information about participants' rating score was obtained through a signed Release of Information form giving permission for the researcher to contact their neurologist
2. No previous music therapy services to address speaking voice
3. Willing to sing to participate in a vocal protocol utilizing NMT techniques

4. English as first language
5. Age range of 45-80 years old
6. No reported co-morbidity of a respiratory disorder/disease
7. Ability to follow 2-3 step commands without repetition
8. Not currently receiving speech-language pathology services

Exclusion criteria include:

1. Diagnosed with Stage 4 PD based on the Hoehn and Yahr scale
2. Currently receiving speech-language pathology or music therapy to address voice disorders

Participant #1: Brian

Brian is a 78-year-old man diagnosed with Stage 3 Parkinson's disease according to the Hoehn and Yahr scale. He presented with minimal essential tremor in his right hand. Brian reported that he had noticed changes in his vocal range and a lowering of his voice over the past few years. He reported a history of music experience including singing lessons, playing the guitar and piano, and performing in musicals and at church. His musical preferences included country, rock and roll, jazz, and religious music.

Participant #2: Roy

Roy is a 75-year-old man diagnosed with Stage 3 Parkinson's disease according to the Hoehn and Yahr scale. He presented with a soft-spoken voice, shuffling gait, and slumping of the shoulders and upper back. Roy reported his voice had become increasingly soft as the disease progressed. Roy stated that he continues to work as an engineer and presents regularly at conferences. He has a history of playing percussion and piano. His musical preferences include praise and worship music, children's songs to play with his grandchildren, and some classical music.

Participant #3: Jake

Jake is an 80-year-old man diagnosed with Stage 2 Parkinson's disease. He presented without tremor, reported a reduction in vocal volume, and a slight shuffling gait. Jake reported that he has no history of playing a musical instrument or singing, but he enjoys country and old-time music, especially that of Burl Ives. He reported that his favorite activity is gardening, which has become increasingly difficult because of the disease progression.

Participant #4: Daniel

Daniel is an 80-year-old man diagnosed with Stage 3 Parkinson's disease. He has a love of listening to classical music and hymns, especially "Beautiful Savior," and used to work as a pastor. Daniel received the Lee Silverman Vocal Technique in previous years and experienced a positive change in vocal functioning while receiving the treatment, but it was difficult to maintain the positive effects after treatment ended. He presented with impairments in articulation, breath control, and his chart reported impairment in cognitive functioning. He also experiences significant rigidity and difficulty with balance and walking. He has diplopia and oropharyngeal dysphagia. Daniel received music therapy treatment sessions in his residence with his wife present.

Participant #5: Clint

Clint is a 69-year-old man with a diagnosis of Stage 2 Parkinson's disease. He presented with bilateral tremor when reaching and resting tremor in right hand. He reported that he has difficulty processing new information. Clint stated that his vocal intensity fluctuates throughout the day, and he has difficulty being heard after prolonged use of his voice. His musical preferences include Motown and music from the 1950's and 1960's. Clint also reported feelings of anxiety, especially when trying new things.

Participant #6: Josh

Josh is a 69-year-old man with a diagnosis of Stage 3 Parkinson's disease. He presented with tremor on the right side, difficulty with balance, rigidity, oropharyngeal dysphagia with decreased secretion management. He also had instances of dyskinesia which made it difficult to obtain the final measurements for this study. His wife was present for all study intervention sessions. His voice was quiet in volume and had imprecise articulation leading to decreased conversational intelligibility. He previously worked in agriculture and reported that the disease has taken away a lot of his previous functionality. During the first study intervention session, Josh became visibly upset and teary-eyed when speaking about the functionality he had lost because of the disease. Josh reported he enjoyed music from the 1950's and 1960's and has never played an instrument or taken singing lessons.

Procedure

Volunteers participated in an initial screening meeting at which time they were informed about the purpose of the study and provided with an informed consent document (Appendix A), detailing the risks and benefits of the proposed treatment, reasonable alternative treatments, and consequences of no treatment. The document included full disclosure of the nature of the research and the expected involvement of the participant. The explanation of the research was presented in easily understood terminology to improve comprehension. Participation in the study was voluntary after informed consent had been established, and participants were informed that they could freely cease or refuse treatment at any time. Participants were encouraged to ask questions about the study and all concerns were addressed thoroughly. Participants were provided with information about confidentiality practices and data management. Participants were also informed of the study protocol regarding audio or visual recording. A Release of Information form was be provided for their signature so the researcher could contact each individual's provider. Participants performed the V-RQOL to determine self-perceived effects of their voice changes. Last, a voice recording was gathered from each participant for analysis use the CAPE-V by a research team speech-language pathologist. After the screening meeting determined inclusion in the study, acoustic measures were taken at the Communication Disorders Clinic at Appalachian State University to determine baseline vocal functioning.

Clients received one individual 60-minute music therapy session each week for 6 weeks. The number of weeks was chosen after reviewing suggestions from previous research and based on client availability. Sessions took place in the Interdisciplinary Clinic at Appalachian State University in Boone, North Carolina. In addition, clients were given 10–15 minutes of homework after each session to encourage transfer into daily life.

Post-intervention, a secondary recording was obtained for blind-rating by a research team speech-language pathologist using the CAPE-V measurement tool. Acoustic measures were taken again, and data were compared to pre-intervention measurements. The VHI and the V-RQOL were also re-administered and compared to pre-intervention measures.

Music Therapy Intervention Protocol Utilizing NMT Techniques

The Music Therapy Intervention protocol is presented in Table 1.

Table 1

Neurologic Music Therapy Protocol

Technique	Description	Length
Introductory Conversation	Progress on homework and any perceived vocal changes as well as general well-being of participant will be discussed.	5 minutes
Vocal Intonation Therapy (VIT)	Physical warm-ups and 4-point grounding through music: Gentle movement of the torso, neck, and facial muscles with emphasis on relaxation of the jaw and neck and use of the diaphragm and abdominal muscles. Four-point grounding emphasizes proper posture and support of the respiratory system. Breathing exercises and music: The participants were asked to breathe deeply through the nose attending to the abdominal muscles by placing their hands on the abdomen while inhaling and exhaling for immediate feedback. Roman vowel breathing to promote full inhalations was utilized. Articulation exercises and music (5 minutes): Rhythmic speaking through commonly known tongue twisters to coordinate articulators (tongue, lips, jaw), breath, and phonation. Vocal warm-ups: These exercises included gentle sirens from highest pitch to lowest pitch, yawning while vocalizing, glissandi, both ascending and descending, and ascending and descending octaves on /a/. Use of the articulators with phonation will be used to increase awareness of articulation.	18 minutes

Table 1 (continued.)

Therapeutic Singing (TS)	Singing one to three client-preferred songs with emphasis on clear articulation and phrasing through breath and phonation coordination. Songs chosen included key phrases chosen by the client and therapist to address specific communication goals and specific keys will be chosen based on clients comfortable singing range.	15 minutes
Oral Motor and Respiratory Exercises (OMREX)	Harmonica playing of 2 to 3 client preferred songs to promote breath support and controlled exhalation.	10 minutes
Relaxation and Transition	Short cool-down exercises helped relax the voice after treatment. When necessary, a short music-assisted relaxation was offered if excess bodily tension or tremor was observed during the session.	5 minutes
Closing Conversation	Assigned homework and strategies for using interventions during daily life are discussed.	2 minutes

Measures

Acoustic Measures

Acoustic measures were captured using voice samples of isolated vowels, words, sentences, and paragraphs before and after the intervention. Measurements were captured using the Pentax Medical Computerized Speech Lab™ Model 4150B hardware with the Multi- Dimensional Voice Program (MDVP™) Version 4.0 analysis software (PENTAX Medical, Montvale, New Jersey, USA). Measurements were compared to normative data and analyzed for change based on sex and age to determine clinically significant changes within each patient. Acoustic variables collected are found in Table 2.

Table 2

Acoustic Measure Table with Descriptions and Norms

Task	Measures	Normal Values for Males Ages 65-80*	Clinical Significance
		Sustained Vowel /a/:	
Jitter	%	.589 $\pm$ .535	Increased jitter, as an indicator of cycle-to-cycle variation of fundamental frequency, indicates the presence of vocal pathology.[c]
Shimmer (%)	%	2.523 $\pm$ .997	Shimmer is the cycle-to-cycle variation of voice waveform amplitude. When increased, it also indicates the presence of vocal pathology.[d]
F_0 – Tremor Frequency (Fftr)	Hz	3.655 $\pm$ 3.731	This parameter measures the long-term frequency modulation of the fundamental frequency. People with PD demonstrate significantly higher Fftr scores than control groups.[e]
Maximum Phonation Time	Sec	>20 sec	Increased maximum phonation time from pre- to post-test indicates improved functionality of the respiratory system.

Table 2 (continued.

	Sustained Vowel /i/		
Maximum Phonation Range	Low	140.418±23.729	Decreased phonatory F0 range indicates a reduction in useable vocal range and could be indicative of a voice disorder.
	High	150.080±24.362	
	Standardized Reading Passage: Rainbow Passage		
Mean Fundamental Frequency (F_0)	Hz	141.743±21.136	Increased variability may be an indication of a voice disorder from Parkinson's disease.[f]
Mean F_0 Range (PFT)	Semitones	2.095±1.064	Mean fundamental frequency range in semitones is the measure of the fundamental frequency pitch variability available to an individual. People with PD present with significantly reduced variability when compared to healthy controls.[g]
Mean Intensity	dB	.311±.139	Average loudness, when impaired, indicates decreased control of the respiratory muscles necessary to produce volume.
S/Z Ratio			The s/z ratio compares expiratory control during an unvoiced consonant to sustained phonation on a voiced consonant. An increased score on the s/z ratio can indicate the presence of vocal pathology because of the inefficiency of the vocal fold adduction.[h]

Table 2 (continued.)

Voice-Related Quality of Life (V-RQOL)	59.1± 20.2[a]	The V-RQOL is a 10-item self-report measure of vocal functioning with sub-categories in the physical, emotional, and functional domains.[i]
Vocal Handicap Index (VHI)	2.83±3.93[b]	The VHI is a 30-item self-report measure of vocal functioning with sub-categories in functional, physical, and emotional domains.[j]
Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V)		The CAPE-V is a clinician's perceptual evaluation of an vocal impairment based on perceived overall severity, roughness, breathiness, strain, loudness, and pitch.[k]

* Normative values for acoustic measures obtained from Pentax Medical Computerized Speech Lab™ Model 4150B hardware with the Multi- Dimensional Voice Program (MDVP™) Version 4.0 analysis software (PENTAX Medical, Montvale, New Jersey, USA)
[a] Han, Yun, Chong, & Choi, 2018
[b]Arffa, Krishna, Gartner-Schmidt, & Rosen, 2012
[c] Sapienza & Ruddy, 2018, p. 447
[d] Sapienza & Ruddy,, p. 454
[e] MacCallum, Zhang, & Jiang, 2010
[f] Bowen et al., 2013
[g] Bowen et al., 2013
[h] Eckel & Boone, 1981
[i] Hogikyan & Sethuraman, 1999
[j] Jacobson, Johnson, Grywalski, Silbergleit, Jacobson, Benninger, 1997
[k] Zraick, Kempster, Connor, Klaben, Bursac, Glaze, 2011

Perceptual Analysis. A blind rating of the Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V; ASHA, 2006) was performed at pre-intervention and post-intervention by an experienced speech-language pathologist in the Communication Disorders Department at Appalachian State University.

Self-Report Measure. The Voice-Related Quality of Life (V-RQOL; Hogikyan & Sethuraman, 1999) and the Voice Handicap Index (Jacobson et al., 1997) were administered during the screening meeting and post-intervention.

Data Analysis

Non-parametric statistics were conducted using a paired sample Wilcoxon Sign Ranks test for two dependent measures for each measure was administered to determine if statistical significance was present for each hypothesis ($p < 0.05$). Any findings resulting in statistical significance ($p < .05$) was not generalizable based on no statistical significance, but could be used to inform future research with this particular population. Effect size (*r*) indicates the relationship between the independent variable (NMT intervention) and the dependent variable (acoustic, perceptual, and self-report measures). The effect size indicates the level to which the treatment worked to affect the variables. A significant effect size is closer to one; meaning, $r = .02$ is a small effect size, $r = .5$ is a medium effect, and $r = .9$ is a large effect. Numerical data were presented in graph and table form. Tabular and graphical representation of the data are presented based on the American Psychological Association guidelines outlined in the *Publication Manual of the American Psychological Association, 6th Edition.*

Chapter Four

Results

This chapter presents the results of the acoustic, perceptual, and self-report measures of a Neurologic Music Therapy protocol to improve speaking voice in individuals with Parkinson's disease. The specific aims of the study were threefold:

1. Scores for the acoustic measures of tremor at fundamental frequency (F_0), percent jitter and shimmer, F_0 variability would decrease indicating increased vocal stability, that there would be an increase in maximum phonation time, range of F_0, average intensity, as well as decrease in average F_0 indicating increase vocal flexibility, that participants would maintain an S/Z ratio of less than 1:4 indicating no vocal pathology.
2. Scores for the perceptual measure of the total CAPE-V would decrease indicating an increase in perceived vocal quality.
3. Scores for the self-report scores for the total VHI and total V-RQOL would decrease, indicating a decreased effect voice impairment in daily life and increased voice-related quality of life, respectively.

Participant Flow

There were six participants recruited for this study. All participants received a music therapy protocol using NMT technique designed to strengthen speaking voice over the course of 6 weeks. All six participants received six 1-hour sessions with the music therapy protocol. There was no instances of attrition.

Recruitment

Volunteers were recruited during the first quarter of the year by presenting an informational session at a local community Parkinson's support group meeting. Pamphlets were shared with the group members and interested volunteers were invited to contact the investigator by phone or email. Volunteers who responded were contacted within one week for eligibility screening. Six participants met the criteria for the study and consented to enrollment.

Participants

All participants were men and had an average age of 75 years (range 69–80). All participants were diagnosed with typical PD with scores of 2 or 3 on the Hoehn and Yahr Scale (Hoehn & Yahr, 1967) and expressed experiencing voice changes due to their disease. Participants had a median score of 2.5 on the Hoehn and Yahr scale. Participants were not currently receiving music therapy or speech language pathology services to address voice changes and had no co-morbidity of respiratory disease or disorder. No medication changes were reported during treatment.

Demographic information is presented in Table 3. Fundamental differences between participants on this study were achieved through therapist observations and case history information. All names presented have been changed to maintain confidentiality.

Table 3

Demographic Information

Participants (n = 6)	Age (years)	Sex	Hoehn and Yahr Score[a]
Brian	78	Male	3
Roy	75	Male	3
Jake	80	Male	2
Daniel	80	Male	3
Clint	69	Male	2
Josh	69	Male	3

[a] Hoehn & Yahr, 1967

Statistics and Data Analysis

Acoustic measures. A Wilcoxon signed-rank test was conducted to determine the effect of the intervention on individuals diagnosed with Parkinson's disease. Acoustic measurements of tremor frequency, jitter, shimmer, fundamental frequency variability, maximum phonation time, maximum phonation range in hertz and semitones, mean intensity, and s/z ratio. Scores for shimmer (%), F_0 tremor frequency (Fftr; Hz), maximum phonation time (MPT; seconds), maximum phonation range low (Hz), mean F_0 (Hz), mean F_0 range (semitones), and s/z ratio failed to meet assumptions for normal distribution; therefore, the researcher used nonparametric statistics. See Table 4 for a presentation of medians, ranges and statistical data from pre-intervention to post-intervention.

Commented [CPL1]: I edited this sentence

Table 4

Medians, Ranges, and Wilcoxon Signed Ranks Test for Acoustic Measures for all Participants

Dependent Measures	Pre-Intervention		Post-Intervention		Wilcoxon Signed Ranks Test		
	Mdn	*Range*	*Mdn*	*Range*	*Z*	*p* (2-tailed)	*r*
Jitter (%)	2.08	0.92–3.49	2.71	0.55–6.63	-.73[a]	.46	.21
Shimmer (%)	4.28	2.57–9.16	5.17	3.58–27.40	-1.15[a]	.25	.44
Fftr (Hz)	5.31	3.35–6.82	5.33	3.29–11.11	-.94[a]	.35	.27
MPT (sec.)	21.86	6.09–28.36	19.06	8.16–24.37	-.52[b]	.60	.15
MPR Lowest Note (Hz)	427.65	155.56–622.25	469.32	185.00–436.25	-1.46[a]	.14	.53
MPR Highest Note (Hz)	104.00	73.41–116.54	110.00	82.41–130.81	-1.83[a]	.07	.42
Mean F_0 (Hz)	123.92	108.54–152.99	125.43	105.38–155.71	-.11[a]	.92	.03
Mean F_0 Range (Semitones)	20.00	17.00–26.00	20.00	17.00–30.00	-.41[a]	.68	.12
Mean Intensity (dB)	52.69	50.69–60.46	52.80	50.37–56.07	-.31[a]	.75	.09
s/z Ratio	0.81	0.52–0.89	0.90	0.43–1.31	-1.08[a]	.28	.31

Note

[a] Wilcoxon Signed Ranks Test

[b] Based on negative ranks

[c] Based on positive ranks

[d] The sum of negative ranks equals the sum of positive ranks.

All of the acoustic variables except the maximum phonation range highest note yielded no statistically significant median change (α=.05) from pre-intervention to post-intervention testing based on the Wilcoxon Signed Ranks Test. Reference Table 4 for *z*-scores, *p*-values, and effect sizes.

Of the six participants recruited to the study, two participants saw a decrease in their percent jitter and percent shimmer compared to the four participants who saw increases; however, this decrease was not statistically significant. Three participants had a reduction in tremor frequency. Four participants experienced a reduction in maximum phonation time. Four participants saw an improvement in maximum phonation range high and two participants maintained levels of maximum phonation range high from pre-intervention to post-intervention testing. Two participants' maximum phonation ranges remained the same. Half of the participants saw a decrease in their mean intensity. Of particular note, Participant #6 (Josh) experienced a dyskinetic event during final testing caused by turning off his deep brain stimulator for an appointment before attending his study sessions that day. It is possible that the excess dyskinesia affected the accuracy of his post-intervention data.

Perceptual measures. A rating of the Consensus Auditory-Perceptual Evaluation of Voice (CAPE-V; ASHA, 2006) was completed pre-intervention and post-intervention by an experienced speech-language pathologist in the Communication Disorders Department at Appalachian State University. Deidentified recordings of each participant were analyzed. CAPE-V measurements can result in scores for subdomains in roughness, breathiness, strain, pitch, and loudness, as well as an overall severity of vocal functioning. Participant #4 (Daniel) had increased scores for roughness and strain from pre-test to post-test. Participant #2 (Roy) and Participant #6 (Josh) also had increased scores for strain. There were median group decreases in scores for roughness (*mdn* Δ = 19.5), breathiness (*mdn* Δ = 21.5), physical (*mdn* Δ = 16.5), and loudness (*mdn* Δ = 35.5). The median score for strain increased from 6.5 to 8.0 (out of 100) indicating increased perceived strain (worsening) in the voice. The overall severity median score reduced by 32.5 indicating that the overall severity of the client's voices decreased (improved).

The Wilcoxon Signed Rank test was used to determine statistical significance of the median changes. Breathiness, pitch, loudness, and overall severity yielded statistically significant median changes ($p < .05$) indicating an overall perceived improvement in vocal functioning. The median changes for roughness and strain were not statistically significant. Table 5 outlines the median, ranges, *z*-score, *p*-values, and effect sizes for perceptual measures.

Table 5

Perceptual Measures Test Statistics

	Pre-Intervention		Post-Intervention		Wilcoxon Signed Ranks Test		
	mdn	*Range*	*mdn*	Range	*Z*	*p* (2-tailed)	*r*
Roughness	20.5	1.0–59.0	1.0	0.0–57.0	-1.53[b]	.25	.33
Breathiness	48.0	12.0–85.9	26.5	10.0–50.0	-2.201[b]	.03*	.64
Strain	6.5	1.0–41.0	8.0	1.0–28.0	-.106[a]	.92	.31
Pitch	23.5	4.0–36.0	7.0	0.0–23.0	-2.201[b]	.03*	.64
Loudness	55.5	27.0–92.0	20.0	2.0–47.0	-2.201[b]	.03*	.64
Overall Severity	57.5	13.0–90.0	25.0	11.0–61.9	-2.201[b]	.03*	.64

Note.
[a] Based on negative ranks
[b] Based on positive ranks
* Denotes $p < .05$

Self-Report measures. A Wilcoxon signed-rank test was conducted to determine the effect of the intervention on self-report measures of vocal handicap and voice-related quality of life for the participants. The VHI and the V-RQOL were administered pre-intervention and post-intervention and median changes were compared and analyzed to measure effectiveness of the treatment. Table 6 outlines the medians, ranges, and effect sizes for the subcategories and total scores of the VHI, and the Wilcoxon Signed Ranks Test results.

The Vocal Handicap Index (VHI) was administered pre-intervention and post-intervention and includes subcategories in the functional, physical, and emotional domains, as well as a total score. A Wilcoxon Signed Ranks test was used to determine statistical significance. One participant reported a reduced score in the functional and physical domains from pre-intervention to post-intervention, indicating that this participant perceived an improvement in their perceived physical and functional abilities. Median scores for the functional domain had a negative change ($mdn\ \Delta = 2.50$). The physical domain (mdn $\Delta = 3.50$) and social domains ($mdn\ \Delta = 5.00$) had a similar increase in scores from pre-intervention to post-intervention testing. The total scores yielded a median increase of 9.50 from pre- ($mdn\ \Delta = 49.50$) to post-intervention ($mdn\ \Delta = 59.00$), however, this difference was not found to be statistically significant. Table 6 outlines the medians, ranges, and test statistics for the subcategories of the VHI.

Table 6

VHI Medians, Ranges, and Test Statistics for all Participants

	Pre-Intervention		Post-Intervention		Wilcoxon Signed Ranks Test		
	mdn	*Range*	*mdn*	*Range*	*z*	*p* (2-tailed)	*r*
Functional	17.5	8.0–30.0	19.0	11.0–33.0	-1.89[a]	.06	.03
Physical	17.5	8.0–29.0	21.0	13.0–28.0	-1.80[a]	.07	.52
Emotional	14.5	1.0–28.0	19.5	3.0–26.0	-1.48[b]	.14	.03
Total	49.5	17.0–82.0	59.0	27.0–83.0	-1.48[a]	.14	.43

Note.
[a] Based on negative ranks
[b] Based on positive ranks
[c] The sum of negative ranks equals the sum of positive ranks

The Voice-Related Quality of Life (V-RQOL) questionnaire was administered with domains in physical and social functioning. Within the social domain, there were four participants' score that decreased, one participants' scores that increased, and two participants' scores that remained the same. Within the physical domain, two participants' scores increased and four participants' scores decreased from pre-intervention testing to post-intervention testing, indicating they perceived a reduction in the impact of their disease on their physical quality of life. The total score had four decreases and two increases. A Wilcoxon Signed Ranks test was performed to determine the statistical significance of the intervention on scores for the V-RQOL. The social and physical domains both yielded overall nonsignificant reductions in median scores, with the social domain showing a greater reduction (*mdn* $\Delta = 9.38$) than the physical domain (*mdn* $\Delta = 6.25$). The total median score also reduced from pre-intervention to post-intervention (*mdn* $\Delta = 8.75$). This change, however, did not reveal a statistically significant difference ($p < .05$). No statistically significant differences were found for any of the domains from pre-intervention to post-intervention. Table 7 outlines *z*-scores, *p*-value, and effect sizes.

Table 7

V-RQOL Medians, Ranges, and Test Statistics

	Pre-intervention		Post-intervention		Wilcoxon Signed Ranks Test		
	Mdn	*Range*	*Mdn*	*Range*	*z*	*p* (2-tailed)	*r*
Social	84.38	31.25-100	75	6.25-100	-1.1[b]	.27	|.31|
Physical	68.75	16.67-83.33	62.5	41.67-87.5	.00[c]	1	|0|
Total	75	22.5-90	66.25	27.5-92.5	-.11[b]	.92	|.03|

Note.
[a] Based on negative ranks
[b] Based on positive ranks
[c] The sum of negative ranks equals the sum of positive ranks

Chapter Five

Discussion

The purpose of this study was to explore how a music therapy protocol using NMT techniques impacts th speaking voice and quality of life in individuals with PD based on acoustic, perceptual, and self-report measures collected pre-intervention and post-intervention. The use of NMT has been used to improve gait in people diagnosed with Parkinson's; however, there is little research on its effectiveness to address voice changes. By utilizing a series of Neurologic Music Therapy interventions, the researcher hoped to promote respiratory strength and vocal functioning. Acoustic, perceptual, and self-report measures were administered pre-intervention and post-intervention to measure their vocal functionality, the perception of their vocal functioning according to a third-party rater, and the impact of their vocal impairments participants' daily life. This chapter will discuss the findings, their possible impact on vocal functioning in people with PD, future implications and recommendations for music therapy research and clinical practice, and limitations to the current study. The specific aims of the research will serve organize the discussion.

Specific Aim 1: To examine the effects of NMT techniques on voice production following an 8-week treatment period as measured by acoustic variables.

It was hypothesized that scores for the acoustic measures of tremor at fundamental frequency (F_0), percent jitter and shimmer, F_0 variability, maximum phonation range low and average fundamental frequency (F_0) would decrease indicating increased vocal stability and variability. It was also hypothesized that maximum phonation time (MPT), fundamental frequency in semi-tones, maximum phonation range high and average intensity scores would increase from pre-intervention to post-intervention. There were no statistically significant differences found between pre-intervention and post-intervention acoustic measures except for the maximum phonation range high.

Mean scores for tremor at fundamental frequency remained relatively stable suggesting that the intervention may have helped to maintain the participants long-term frequency modulation of the fundamental frequency. It is also possible, however, that the short treatment period may also have prevented the scores from improving further. The degenerative nature of Parkinson's disease makes an outcome of maintenance ideal. Participant #4, Daniel, presented with greater impairments in vocal functioning from pre-intervention to post-intervention, and his data yielded the greatest increase in jitter and shimmer scores. Removing the data points yielded the same results, and statistical significance was not achieved.

Median scores for maximum phonation time decreased from pre to post-intervention; however, the scores were not statistically significant. The statistically significant difference for maximum phonation range high was unexpected. The significant difference could be attributed to a clearer direction during measurements, or to improved vocal range because of increased respiratory strength and more efficient use of the vocal musculature. Increased maximum phonation time would indicate that the participants had better control of their respiratory muscles and were able to regulate the air flow during testing. A decrease in maximum phonation time may be indicative of a loss of control of respiratory musculature. Individual data showed that four of the six participants had decreased scores, and two participants had increased phonation time. The two participants who had increased times were participant #4, Daniel, and participant #6, Josh. The results of these two participants were unexpected. During post-testing, Josh experienced a significant dyskinetic even that may have impacted the results of his other acoustic measures; however, this measure showed a marked improvement. Daniel had the most significant impairment in vocal functioning and respiratory control. While the same directions were given during each testing, the results of the testing may have been influenced by practice effect. The music therapy intervention involved extending expiratory time through muscle and breath control. Participants were given the opportunity to practice this technique during every session. In fact, 4 of the 6 participants experienced decreases in MPT, indicating this practice may not have had an effect on the total study population; however, it could have impacted individual scores. The results of these two participants is promising; however, in that, they were observed has having the most impairment in vocal functioning. Further research by a rater naïve to the identities of the study participants of the acoustic measures and a control group would be necessary to determine if these changes were clinically significant and due to the intervention. While the findings did not reveal statistically significant different, the findings may be clinically relevant because participants noted that the techniques learned in intervention helped them to regularly practice strengthening their voices. In addition to this, participants regularly shared their enjoyment of the intervention, creating a positive experience that participants were more likely to regularly attend for extended periods.

Commented [CPL2]: I feel that this information belongs in the clinically relevant section. And then here just do a one sentence summary of clinical relevance.

Median fundamental frequency range in semi-tones remained the same from pre-intervention to post-intervention; however, the maximum range of the measurement increased from 26 semitones to 30 semitones. Mean fundamental frequency range is the measure of the fundamental frequency variability available to an individual. As stated previously, people with PD present with significantly reduced variability when compared to healthy controls (Bowen et al., 2013). While the participants did not experience an improvement in overall scores for mean fundamental frequency range, the pitch variability available to them did not decrease across the intervention period. It is possible that the intervention helped to maintain pre-intervention level of functionality in the vocal mechanism. Further research with longer intervention periods and testing 3 months post intervention should be employed to determine if this result was indeed indicative of maintenance of vocal functionality and if these changes maintain across time.

Mean fundamental frequency range low, meaning a patient's lowest low note, increased from pre to post-intervention testing. The mean fundamental frequency range high, meaning a patient's highest high note, also increased post-intervention testing. It is important to discuss mean fundamental frequency range as a whole because it is indicative of a patient's highest and lowest notes available. Parkinson's disease is a degenerative disease that affects dopamine production in the basal ganglia. A reduction in dopamine makes use of muscle difficult for the individual. Vocal range is created by the coordinated lengthening and shortening of the muscles that make up the vocal cords. A person diagnosed with PD may experience a reduction in vocal range because of the inability of the vocal cord muscles to properly lengthen and shorten. As such, it is common for individuals with PD to have a shortened vocal range, meaning their highest high note decreases and their lowest low note increases (Bowen et. al., 2013). In men, it is common for the lowest low note to increase substantially. In the current study, the participants were found to have a median increase in their lowest low notes, but also an increase in their highest high now. While this would indicate that the effects of the disease on the lowest low were not improved, it also shows that the intervention may have helped to extend their vocal range in their upper register. While these results are interesting, they were not statistically significant. Improvement of laryngeal muscular control was expected to equally affect the lower and upper registers; however, this was not the case. Further research is needed to determine if these effects would be statistically significant with a larger sample size and in comparison with a control group.

Fundamental frequency is the place in the voice at which a person is most comfortable. This is subjective according to each individual person. The results of this study showed that the mean fundamental frequency increased from pre-intervention to post-intervention. This would indicate that most comfortable note for the participants became higher across the intervention time. The average fundamental frequency for adults in this age range is 141.74 $\pm$ 21.14. While the median of the fundamental frequency increased, this number was still within normal values. Half of the participants saw increases in their fundamental frequency; however, these numbers were not significant. It is important to note that Participant #4 (Daniel) and Participant #6 (Josh) were amongst the three participants who saw decreases in their median fundamental frequency. As discussed above, it is possible that the more advanced the impairment, the more improvement one will see from the intervention. Further testing with a larger sample size and a control group is necessary to determine if these decreases could be generalized to the overall PD population.

Mean intensity (dB) scores showed increases from pre to post-intervention testing. The act of singing requires greater use of the abdominal muscles to maintain the phonatory intensity necessary to maintain phonation (Garcia-López & Gavilàn Bouzas, 2009). The use of singing interventions can help to improve vocal intensity through the training of the muscles necessary for respiration (Stegemöller et al., 2017). The current study found similar results; however, these improvements were not statistically significant. These findings further support the suggestion that signing-based interventions can assist in improving vocal intensity through respiratory muscle strengthening. Further testing is necessary to further support use of singing based interventions for respiratory strength in people diagnosed with PD.

While some of the results were promising, the lack of statistical significance was expected based on the small sample size and relative intensity of the intervention. Furthermore, some of the results were more promising for the patients with greater observed impairment than those who maintained relatively normal functionality in their vocal mechanisms. This may suggest that results may be more significant for those with greater impairment; however, earlier applicability of the intervention exercises may help to maintain vocal functionality as the disease progresses.

Specific Aim 2: To examine the effect of NMT voice protocol on perception of voice quality following 8-week intervention period as measured by CAPE-V.

The results from this study suggest that a music therapy protocol using NMT techniques may be effective in maintaining or improving vocal functioning according to the CAPE-V. The CAPE-V ratings yielded the most statistically significant results of the research study. According to the scores by the rater naïve to the identities of the study participants, there were statistically significant decreases in breathiness, pitch, loudness, and overall severity of voice. The intervention of the present study had exercises focused on improving pitch and breath control. Increased awareness of the respiratory system and control over the respiratory muscle could have contributed to these improved ratings. When clients were tested pre-intervention, the majority had no previous knowledge of singing and breath control. Singing requires use and control of both the respiratory and phonatory muscles (Garcia-López & Gavilàn Bouzas, 2009). Prolonged use and practice using these muscles can help to improve the overall efficiency of the vocal mechanism. As shown by Garcia-López and Gavilàn Bouzas (2009), singing requires greater muscular coordination than speaking. Changes in tone require control of the abdominal and phonatory muscles. As the participants practiced these techniques in session, their control over this musculature could have improved. This improvement in efficiency and coordination of the phonatory and respiratory muscles could have impacted the rater's perception of their vocal function. Further research is needed with a larger sample size to determine if the statistical significance can be generalized to the greater PD population. Research with a control group is also necessary to determine if the results were similar with healthy adults as with those diagnosed with PD. Further research is also needed to compare a matched control group of individuals with PD who do not participate in a singing-based intervention to those who do receive singing interventions.

Three participants had increased (worsening) scores for strain from pre-intervention to post-intervention measures. While these results were unexpected, the increased scores could have been contributed to response bias as the participants strained their voices to make their voices sound different or more improved. The lead researcher also administered the final measurements, which may have impacted the way the participants responded to the directions given. Additional research with both a rater naïve to the identities of the study participants, and a researcher naïve to the identities of the study participants may help to remove any bias associated with the results.

Specific Aim 3: To examine the effect of NMT voice protocol on voice-related quality of life as measured by VR-QOL and VHI.

There were no statistically significant differences for the Vocal Handicap Index (VHI) or the Voice-Related Quality (V-RQOL) of Life self-report measures. The ability to communicate positively impacts a person's quality of life and their ability to build positive social interactions (Takahashi, et al., 2016). When communication is impaired from a degenerative disease, such as PD, that impairment can negatively affect a person's perceived quality of life (McAuliffe et al., 2017).

All of the subscale scores for the V-RQOL were decreased during post-intervention. This would indicate that the participants perceived their vocal impairment as having less of an impact on their quality of life. These scores, however, were not statistically significant. The differences in change between the VHI and the V-RQOL may be attributed to the sensitivity of the measures to report vocal impairment and its effect on quality of life. The V-RQOL is a 10-item questionnaire, whereas, the VHI is a 30-item questionnaire. The results of the current study support the findings that the VHI may be more sensitive to the unique experiences of the PD population and the impact of voice impairment on quality of life. Further research is needed with to determine the effectiveness and sensitivity of each self-report measures of vocal impairment on quality of life within the PD population. See Table 8 for a concise presentation of variables, hypotheses, and findings.

Table 8

Variables, Hypotheses, and Findings

Variables	Hypothesis	Findings
Jitter (%)	Decrease	↓
Shimmer (%)	Decrease	↓
Fftr (Hz)	Decrease	↓
MPT (sec.)	Increase	↓
MPR Lowest Note (Hz)	Lower	↑
MPR Highest Note (Hz)	Higher	↓
Mean F_0 (HZ)	Decrease	↓
Mean F_0 Range (Semitones)	Increase	–
Mean Intensity (dB)	Increase	↓

Table 8 (continued.)

s/z Ratio	Less than 1:4	↓
CAPE-V	Decrease	↑
VHI	Decrease	↓
V-RQOL	Decrease	↑

↑ - improvement ↓ - worsening – - maintaining

Implications for Music Therapy Practice

Tamplin et al. (2019) have begun investigating into singing-based therapy on vocal, intensity, maximum phonation time, expiratory and inspiratory pressure, and voice-related quality of life in people with PD over a period of a year, but this is the first study of its kind in the United States utilizing a control group and longer term treatment period. Current research acknowledges that voice changes occur frequently with PD; however, a treatment strategy using a music therapy protocol using NMT techniques has not been standardized to best benefit this population. This type of research is necessary to further solidify music therapy as a viable treatment option for voice changes in people with PD. Further research by board certified music therapists needs to be conducted with the PD population to focus on voice and voice changes associated with the disease. Music therapy research with PD needs to focus on developing a systematized treatment strategy for voice in collaboration with speech-language pathology.

Limitations

While this research did not yield results revealing many variables with statistically significant differences pre-intervention to post-intervention, it is important to acknowledge the limitations and possible biases that may have impacted the results. Design bias was inherent as there were only six participants in the study who were recruited from a convenience sample of a

Parkinson's support group familiar to the researcher. While none of the participants had received music therapy previously, they were familiar with the treatment method from previous presentations within the group. This may have introduced an inclusion bias into the research. In addition to this limitation, there was not a control group with which to compare the results.

Further limitations were present in procedural bias during testing. The subjects were asked to complete questionnaires within a short time frame and may have adjusted their answers to best fit the aims of the present study. Measurement bias may have also occurred from the principal researcher also taking final measurements and therefore could not be blinded during this assessment. The participants and the researcher built a therapeutic relationship during the course of the study, and the participants may have adjusted their performance during testing to best fit the aims of the study leading to a response bias.

Recommendations for Future Research

While this research did not yield results revealing many variables with statistically significant differences pre-intervention to post-intervention, the results further support that singing-based interventions may be beneficial in improving vocal functionality in people diagnosed with PD. At this time, there has only been one study that has researched the effects of NMT interventions on voice in with a larger population of people diagnosed with PD while also including a control group. There needs to be further research with increased experimental group size and healthy controls. Furthermore, additional measures need to be taken post-intervention to determine if the effects of the treatment will remain long term. Additionally, future studies must include measurements from speech language pathology and encourage the collaboration between these two disciplines. LSVT has proven to be a powerful tool for the improvement of vocal functioning in people with PD, but the intensity of the treatment may make it inaccessible to some patients. The treatment requires multiple weekly sessions with added at-home exercises nightly. This treatment strategy may require too much time for participants to commit fully. A combined treatment option that encourages social interaction and vocal improvement through singing interventions may provide a unique opportunity for beneficial change. Collaborative research with large sample sizes, control groups, and trained raters naïve to the identities of the study participants is necessary to find the most benefit for the patients.

Summary and Conclusion

This study examined the impact a music therapy protocol using NMT techniques on speaking voice and quality of life in individuals with PD based on acoustic, perceptual, and self-report measures taken before and after treatment. While some positive changes were apparent from the current study, the researcher found no statistical significance for the acoustic and self-report measures. While the findings did not reveal statistically significant different, the findings may be clinically relevant because participants noted that the techniques learned in intervention helped them to regularly practice strengthening their voices. Clinically, this finding is relevant because increases the likelihood of the participants future implementation of the techniques in their daily lives. Perceptual measures through the use of the CAPE-V and a qualified rater naïve to the identities of the study participants yielded statistically significant improvement in breathiness, pitch, loudness, and overall severity. Singing interventions utilize training and coordination of phonatory and respiratory muscles. Thus, improvements in the perceptual measures are promising in showing that singing-based interventions may positively impact vocal functioning in people diagnosed with PD.

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Appendix A: Consent to Participate in Research

Information to Consider About this Research

Study Title: Neurologic Music Therapy to Improve Speaking Voice in Individuals with Parkinson's Disease

IRB Number: 19-0215
Principal Investigator: Sarah Swann Solberg, MT-BC
Department: Hayes School of Music
Contact Information:
swannsl@appstate.edu, (828) 231-2562

Faculty Advisor: Dr. Christine Pollard Leist, MT-BC
Department: Hayes School of Music
Contact Information:
leistcp@appstate.edu, (828) 262-6663

What is the purpose of this research?

You are being invited to take part in a research study investigating the effects of neurologic music therapy techniques on speaking voice in people diagnosed with Parkinson's disease. If you take part in this study, you will be one of about 5 people to do so. By completing this study, we hope to: 1) demonstrate music therapy as an effective treatment for voice disorders from Parkinson's disease, 2) explore a standardized treatment method using effective music therapy interventions, and 3) improve the speaking voices of individuals experiencing voice changes from Parkinson's disease.

This study will be conducted by a board-certified music therapist with further certification in neurologic music therapy techniques specifically designed to work with voice disorders.

You will be asked to take part in weekly one-hour music therapy sessions for 8-weeks, as well as to continue practicing the techniques at home. You will also be asked to undergo acoustic measurements of your vocal functioning. Total time commitment will be 9-weeks for one hour per week.

What possible harms or discomforts might I experience during the research?

To the best of our knowledge, the risk of harm for participating in this research study is no more than you would experience in everyday life.

What are the possible benefits of this research?

There may be no personal benefit from your participation in this study. Determining the effectiveness of this treatment will help to inform future research for working with individuals diagnosed with Parkinson's disease.

Will I be paid for taking part in the research?

You will not be paid for completing this study, and there is no cost to you for the music therapy session.

How will you keep my private information confidential?

Personal information will only be shared with the principal investigator. All participants will be assigned a random identification number and any documentation will be coded with this number to ensure anonymity. No other members of the research team will have access to any identifying data. Once the study is completed, aggregate data from the study will be analyzed using this unique identification number. All personalized information will be stored on a password protected encrypted device. All data will be destroyed after one year.

Who can I contact if I have questions?

The people conducting this study will be available to answer any questions concerning this research, now or in the future. You may contact the Principal Investigator, Sarah Swann Solberg, at (828) 231-2562 or through email at swannsl@appstate.edu. If you have questions about your rights as someone taking part in research, contact the Appalachian Institutional Review Board Administrator at (828) 262-2692 or through email at irb@appstate.edu or at Appalachian State University, Office of Research and Sponsored Programs, IRB Administrator, Boone, NC 28608.

Inclusion Criteria

1. Diagnosed with Stage 2 or 3 PD based on the Hoehn and Yahr scale (Hoehn & Yahr, 1967)
2. No previous music therapy services to address speaking voice
3. Willing to sing to participate in a vocal protocol utilizing NMT techniques
4. English as first language
5. Age range: 45-80
6. No reported co-morbidity of a respiratory disorder/disease
7. Can follow 2-3 step commands without repetition
8. Not currently receiving speech-language pathology services

Exclusion Criteria

1. Diagnosed with stage 1 or 4 PD based on the Hoehn and Yahr scale
2. Currently receiving speech-language pathology or music therapy to address voice disorders

Do I have to participate? What else should I know?

Your participation in this research is completely voluntary. If you choose not to volunteer, there will be no penalty and you will not lose any benefits or rights you would normally have. If you decide to take part in the study, you still have the right to decide at any time that you no longer want to continue. There will be no penalty and no loss of benefits or rights if you decide at any time to stop participating in the study. If you decide not to participate in this study, let the research personnel know. You may request a copy of this consent information by contacting the Principal Investigator, Sarah Swann Solberg, at (828) 231-2562 or through email at swannsl@appstate.edu.

This research project has been approved by the Institutional Review Board (IRB) at Appalachian State University.

This study was approved on 2/14/2019.

This approval will expire on 2/14/2020 unless the IRB renews the approval of this research.

Consent to Participate in Research

Information to Consider About this Research

I agree to participate as a participant in this research project, which concerns music therapy techniques to improve speaking voice in people diagnosed with Parkinson's disease. The measurements(s) will take place at the Communication Disorders Clinic at Leon Levine Hall on Appalachian State Campus. Measurements will be taken once prior to treatment and once posttreatment. Each measurement session will last approximately 45 minutes. Treatment will take place in a private room once per week at University Hall at Appalachian State University. Treatment will be for 8-weeks and each treatment session will be approximately 60 minutes. I understand the treatment will be about voice rehabilitation.

I understand that there are no foreseeable risks associated with my participation. I also know that this study may improve my speaking voice and help to inform future treatment options for people experiencing voice disorders from a diagnosis of Parkinson's disease.

I understand that the measurement(s) will be audio recorded and may be published. I understand that the audio recordings of my measurement session may be stored on an encrypted, password protected computer and may be used for presentations or published data if I sign the authorization below.

I give Sarah Swann Solberg, MT-BC ownership of the tapes, transcripts, recordings and/or photographs from the measurement(s) and treatment(s) she conducts with me and understand that tapes and transcripts will be kept in the researcher's possession. I understand that de-identified information or quotations from audio recordings or transcripts will be published. I understand I will not receive compensation for participation in the study.

I understand that the participation is voluntary and there are no consequences if I choose not to participate. I also understand that I do not have to answer any questions and can end the treatment at any time with no consequences.

If I have questions about this research project, I can call the researcher at (828) 231-2562 or the Appalachian Institutional Review Board Administrator at 828-262-2692(days), through email at irb@appstate.edu or at Appalachian State University, Office of Research Protections, IRB Administrator, Boone, NC 28608.

This research project has been approved on _____(date) by the Institutional Review Board (IRB) at Appalachian State University. This approval will expire on [Expiration Date] unless the IRB renews the approval of this research.

☐ I request that my name **<u>not</u>** be used in connection with tapes, transcripts, photographs or publications resulting from this interview.

☐ I request that my name **<u>be used</u>** in connection with tapes, transcripts, photographs or publications resulting from this interview.

By signing this form, I acknowledge that I have read this form, had the opportunity to ask questions about the research and received satisfactory answers, and want to participate. I understand I can keep a copy for my records.

Participant's Name (PRINT) Signature Date

Photography and Video Recording Authorization

With your permission, still pictures (photos) and/or video recordings taken during the study may be used in research presentations of the research findings. Please indicate whether or not you agree to having photos or videos used in research presentations by reviewing the authorization below and signing if you agree.

Authorization

I hereby release, discharge and agree to save harmless Appalachian State University, its successors, assigns, officers, employees or agents, any person(s) or corporation(s) for whom it might be acting, and any firm publishing and/or distributing any photograph or video footage produced as part of this research, in whole or in part, as a finished product, from and against any liability as a result of any distortion, blurring, alteration, visual or auditory illusion, or use in composite form, either intentionally or otherwise, that may occur or be produced in the recording, processing, reproduction, publication or distribution of any photograph, videotape, or interview, even should the same subject me to ridicule, scandal, reproach, scorn or indignity. I hereby agree that the photographs and video footage may be used under the conditions stated herein without blurring my identifying characteristics.

Participant's Name (PRINT) Signature Date

Vita

Sarah Swann Solberg was born in Crossnore, North Carolina, but grew up in Asheville, North Carolina, as the youngest of five children. She was on the Dean's List for Academic Excellence for the duration of her undergraduate career and graduated cum laude from Gettysburg College in Gettysburg, Pennsylvania. She earned a Bachelor of Music degree in vocal performance in May 2011. In December 2013, she began her Master of Music in vocal performance at Appalachian State University and graduated in December 2015. She began the combined Equivalency and Master of Music Therapy program at Appalachian State University in the summer of 2015. She was awarded a Provost Fellowship for the Spring of 2018, and she was a recipient of the Gary "GJ" Leadership and the F.H. "Sammy" Ross, Jr. Memorial Scholarships. She is also a member of the Pi Kappa Lambda Music Honors Society. Mrs. Solberg completed her music therapy internship at Park Nicollet Health Services in January 2018. She earned her music therapy board certification in January of 2018.

Mrs. Solberg currently works as a hospice music therapist for Medi Home Health and Hospice in Boone, North Carolina, and works for Medi Home Health and Hospice as a hospice music therapist. She currently resides with her loving husband, two amazing dogs, and one sweet bunny in Vilas, North Carolina.