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Effect of Consistent Singing on Maintenance of Speech Intelligibility Following LSVT®: A Retrospective Longitudinal Case Study

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Effect of Consistent Singing on Maintenance of Speech Intelligibility Following LSVT®:
A Retrospective Longitudinal Case Study

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Abstract

Parkinson’s Disease is a common neurodegenerative disease affecting one’s ability to hone and refine volitional movement. Many with Parkinson’s report significant effects on voice and communication. Speech-language pathologists have long targeted the achievement of increased vocal volume through intensive voice therapy, with the most common program being Lee Silverman Voice Treatment® (LSVT®) (Ramig et al., 1994). While LSVT® is the most prominent type of voice therapy for individuals with Parkinson’s, other researchers have begun investigating therapeutic singing because of the similar functions it employs (e.g., increased breath support, utilization of entire vocal range).

The current project is a retrospective, longitudinal study that aims to observe effects of singing in conjunction with LSVT®. Researchers followed a trained singer with Parkinson’s disease who underwent LSVT® for four years to observe vocal performance across time. First, this study aimed to identify if there is a relationship between frequency of singing and vocal performance. Secondly, because Parkinson’s disease is neurodegenerative and symptoms worsen over time, this study charted vocal progress and identified any influencing factors that would increase or decrease vocal performance and intelligibility. Researchers measured vocal intensity and pitch ranges at monthly intervals while also collecting subjective data including report of any health or social changes.

Results showed frequency of proper singing affected maintenance and even improvement of vocal performance in intensity and pitch ranges and intelligibility, though not always consistent. Inversely, as expected, a decline in mobility, overall health, and medication was shown to negatively affect vocal performance. This study is an introductory look into how vocal performance and intelligibility are affected by various factors. Thus, this project will inform further research investigating appropriate voice treatment for individuals with Parkinson’s Disease.

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List of Abbreviations and Terms

ADL	Activities of Daily Living
dB SPL	Decibels of Sound Pressure Level
GRBAS	Grade: Roughness, Breathiness, Asthenia, Strain rating scale
Hz	Hertz
LSVT®	Lee Silverman Voice Treatment
MPT	Maximum Phonation Time
OT	Occupational Therapy
PD	Parkinson’s Disease
PT	Physical Therapy
PWA	People with Aphasia
PWS	People who Stutter
QOL	Quality of Life
ROM	Range of Motion
SD	Standard Deviation
SLP	Speech-Language Pathologist
UPDRS	Unified Parkinson’s Disease Rating Scale
VHI	Voice Handicap Index
VRQOL	Voice Related Quality of Life
VRP	Voice Range Profile

Introduction

Communication serves individuals with the ability to inform, to convey wants and needs, to persuade, and to socially interact. Communication is significantly altered in those with Parkinson's disease (PD), specifically through decline in both volume and pitch ranges when speaking. The present study concentrates on investigating trends of vocal performance and different variables that might impact vocal maintenance in PD. Vocal maintenance, in this study, is defined by performance on various singing and speaking tasks including maximum phonation time, pitch range, amplitude range, and intelligibility/audibility in conversation. We aim to seek the effect consistent singing has on vocal maintenance as well as chart vocal quality across time through a retrospective, longitudinal case study.

Parkinson's Disease

Parkinson's disease (PD) is a neurodegenerative disease affecting neurons in the basal ganglia deep within the brain, particularly the substantia nigra, the area that produces dopamine. In Parkinson's disease, these dopaminergic (dopamine producing) neurons die. The basal ganglia are part of our extrapyramidal system that produces refined, smooth purposeful movement. With decreased dopamine production, the basal ganglia cannot function properly in honing our skilled voluntary movement. This leads to the hallmark symptoms of PD including bradykinesia (slow movement), tremor at rest (commonly a "pill-rolling" tremor of the forefinger and thumb), rigidity, and postural instability and imbalance (Mayfield Clinic, 2018). Other potential symptoms of Parkinson's disease are shuffled gait, stooped posture, cognitive impairment, difficulty swallowing, excessive drooling, difficulty speaking, pain, loss of smell, dementia, and hypomimia (masked expression) (Parkinson's Foundation, 2018). These symptoms may progress slowly or quickly, depending on the severity of the disease and are both motor and non-motor in nature.

While every individual with PD presents and develops symptoms differently, there are typical markers of disease progression. Early upon receiving the diagnosis, the individual will likely notice the symptoms, but symptoms will not interfere with activities of daily living (ADL). Initial symptoms include handwriting becoming smaller, stooped posture, and more difficulty making facial expressions, and these symptoms tend to be unilateral. Further along, the individual will be at a higher risk of falls due to imbalance issues, will have slower movements, and more difficulty with speech. During the latter development of the disease, individuals will no longer be able to live independently, will need help with ADL and are limited to a bed or wheelchair. However, it is not always the case that every individual will progress to this level of symptomatology. In 1967, Hoen and Yahr developed a staging scale to quantify the decline of Parkinson's disease, called the Hoen-Yar scale. It ranges from stages I-V, with I including unilateral involvement only, usually with minimal or no functional impairment, to V having the individual confined to their bed or wheelchair unless aided. In general, individuals will progress through the stages though some will never reach stage V. Another scale for staging PD is the Unified Parkinson's Disease Rating Scale (UPDRS). Rather than rating the severity of symptoms overall, this scale clusters symptoms and rates each grouping on a scale from 1-4, with 1 being the mildest and 4 being the most severe. These groupings include intellectual function, ADL, motor examination, and assessment of motor complications, including dyskinesia and/or motor fluctuations. Due to the variable nature of this disease, there is not a typical progression of symptomatic experience.

Today, Parkinson's disease affects roughly 1 million Americans and 10 million people worldwide. Every year, approximately 60,000 Americans are diagnosed with PD (Parkinson's Foundation, 2018). Within those diagnosed, an estimated 89% experience difficulty with their speech (Trail et al., 2005).

Hypokinetic Dysarthria

Classic speech symptoms of PD are classified as a form of hypokinetic dysarthria. As defined by Darley, Aronson, and Brown (1969), the cluster of symptoms common to hypokinetic dysarthria includes hoarse, harsh, breathy voice, decreased pitch, increased rate of speech, imprecise consonants, and distorted vowels. A distinctive characteristic of this dysarthria is the rapid rate, which causes “blurred” or mumbled speech. People with hypokinetic dysarthria often also display hypophonia, or diminished speech intensity. They speak at a much quieter volume because of a sensorimotor deficit resulting in improper auditory feedback. Due to this deficit, individuals feel as if they are speaking louder than they actually are, creating difficulty with producing audible speech (Andreetta, Adams, Dykstra, & Jog, 2016). Other speech changes associated with hypokinetic dysarthria include a decrease in variability within fundamental frequency of connected speech. A study conducted by Bowen, Hands, Pradhan, and Stepp (2013) discovered a significant difference depending on medication and when compared to healthy controls. When subjects with PD were using dopaminergic drugs, their variability of frequency increased. However, when comparing both PD groups (on or off medication) to healthy controls, individuals with PD demonstrated a decrease in variability regardless of medication status (Bowen et al., 2013).

Research conducted by Kempler and Van Lancker (2002) demonstrates how hypokinetic dysarthria in PD affects intelligibility differently for different speech tasks. They evaluated intelligibility across five speech production tasks (spontaneous speech, reading, repeated spoken and singing, and spontaneous singing) in an individual with PD. Sixty-four novel listeners listened to the subject’s five speech samples and transcribed the samples they heard. Researchers discovered the mean percentage of intelligibility varied for the tasks. Participants were able to correctly identify 29% of spontaneous utterances, 78% of read utterances, 79% of repeated spoken utterances, 80% of repeated sung samples, and 88% of spontaneously sung samples. The intelligibility of conversational speech is significantly less than other speaking/singing tasks. Researchers highlight the “identifiable differences” of the production tasks in relation to initiation of the movement: the spontaneous samples requiring internally generated models of the target production versus the read or repeated samples having a model provided. Existing research in relation to musculoskeletal limb movements reports that movement is more fluid when there is a model provided or when the cognitive load of initiation is reduced (Kempler & Van Lancker, 2002). In the repeated tasks or read tasks, the cognitive load is reduced because there is a provided model of the target, and researchers propose that the research on musculoskeletal movement can be applied to articulatory placement and production of speech. This explanation does not, however, elucidate the occurrence of increased intelligibility of the spontaneous singing task. Based on the aforementioned initiation theory, the spontaneity of the task should require a similar overall motor plan as spontaneous speech and thus, actually decrease intelligibility. A potential factor to explain the intelligibility of spontaneous singing is that singing requires increased respiration which is also associated with increased volume and clarity. Also, when singing, even spontaneously, individuals utilize continuously varying prosody or inflection, also known as “pitch contours”. Researchers note that this chunking of larger units lowers the demand for “initiation of internal sequences” and thus, ongoing movement is smoother. Kempler and Van Lancker (2002) hypothesize that the combination of these two factors (i.e. increased respiration and continuous pitch contours) accounts for the increased intelligibility of the spontaneous singing condition. Research cited by Kempler and Van Lancker (2002) compares people with aphasia (PWA) and people who stutter (PWS) in speech versus singing conditions. It shows that both groups tend to perform better on singing tasks than speech tasks. This signals that perhaps singing and speech are primarily controlled from “different brain mechanisms.”

To further understand why spontaneous singing was more intelligible compared to spontaneous utterances, consider Luria and Vygotsky's research on Parkinson's (Moskovich, Bougakov, DeFina, & Goldberg, 2002). Researchers conducted studies on individuals with PD who had difficulty walking and had an increase in falls. Luria and Vygotsky aimed to examine if engaging different sensorimotor areas than is typical for such an automatized function as walking, would increase smoothness of gait. Luria and Vygotsky increased cortical control of the task by instructing patients to step over pieces of scattered paper on the floor. Thus, de-automatizing the task, and researchers were hopeful that would increase higher level sensorimotor activity. They found that they were, in fact, able to recruit higher neural functioning that compensated for an impaired automatized process, resulting in improved gait (Moskovich et al., 2002). This thought could be applied to the Kempler and Van Lancker (2002) study, as speaking generally begins to occur a similar time as walking. It could be argued that speech is equally as much of an automatized action. Perhaps by incorporating higher cortical processes through thoughts of inflection and increased respiration, individuals are then able to overcome any impairments producing more intelligible utterances.

As shown above, intelligibility is affected differently based on the speech task. From the research by Kempler and Van Lanker (2002), we see that hypokinetic dysarthria in PD most severely affects spontaneous utterances, which consequently, is the most frequently used condition in natural settings. These dysarthric deficits affecting spontaneous speech are shown to create a decline of communication for people with PD, consequently affecting their quality of life. Across two studies conducted by Miller and colleagues, (Miller, Noble, Jones, & Burn, 2006; Miller, Noble, Jones, Allcock, & Burn, 2008), researchers surveyed 213 people with PD and caregivers about the implications of PD on their communication. They reported that 90% of responders noted how PD impacts a person's willingness to speak up and initiate conversation before any articulatory issues even arise. This hesitancy to engage in conversation is known to have adverse effects on the individual's quality of life (Shih et al. 2012). As a result, researchers desired to examine the breakdown of speech in individuals with PD to further inform proactive treatment.

Speech impairment in PD

In 2013, Skodda and colleagues attempted to analyze the progression of speech impairment in individuals with Parkinson's disease. Participants were recruited from 2002-2012, including 80 individuals diagnosed with idiopathic Parkinson's disease and 60 age-matched healthy controls. Researchers aimed to monitor the changes in voice and speech performance on sustained vowels and connected speech tasks. Subjects were first examined upon their intake, and then again at a minimum of 12 months later. At both evaluations, participants underwent a neurological examination and received a Unified Parkinson's Disease Rating Scale (UPDRS) Motor Score (including a speech component) and a Hoen-Yahr rating at both visits. Skodda et al. (2013) compared participants with PD (ages ranging from 40-80) to their age matched peers on their UPDS perceptual speech score. At baseline, they found that participants with PD scored worse than their age matched peers. When evaluating the two groups across time, they found that participants with PD showed a significant decrease in overall UPDS perceptual score as well as within individual speech modalities (voice, articulation, fluency, prosody), whereas the control group showed no such differences. Their research also revealed a correlation between speech deficits and the participants' Hoen-Yahr stage of PD. Skodda et al. (2013) found the farther along the individual was in their Hoen-Yahr staging, the worse the speech symptoms were. Because of the progressive nature of the disorder and the negative communication symptoms associated, clinician-researchers desired to determine an effective course of treatment for Parkinson's Disease. The primary methods investigated are both medication and rehabilitative therapy, which have the potential to both slow and reverse some symptoms (Hinz, Stein, Cole, McDougall, & Westway, 2016). Speech therapy techniques have been thoroughly researched and shown to have positive results combatting vocal decline in Parkinson's disease. Speech-language pathologists have long targeted the achievement and maintenance of increased speaking intensity in patients with Parkinson's disease due to the hallmark PD characteristic of quiet speech (Scott & Caird, 1983; Robertson & Thompson, 1984). In 1994, this technique was standardized and formalized as an official treatment.

Treatment

Lee Silverman Voice Treatment (LSVT®)

Dr. Lorraine Ramig (1994) developed the Lee Silverman Voice Treatment (LSVT®) program to target maintaining increased intensity while speaking with increased breath support. It consists of emphasizing loud speech in individual therapy sessions, four days a week, for four consecutive weeks. During these therapy sessions, the individual will practice a loud voice for sustained vowels, glides up and down their full pitch range, frequently-used functional phrases, as well as gradually increasing the length of utterance. These are all maximum effort tasks, with the phrases and conversation pieces being the most functional for communication. The individual is also encouraged to practice exercises daily outside of the therapy session to gain the highest benefit from the program. LSVT® encompasses 3 main foci in treatment: (1) it specifically targets increased amplitude to enhance voice and to trigger improved articulation, vocal quality, intonation and reduced rate, (2) it focuses on recalibrating the patient's perception of their own loudness to reinforce that they are, in fact, communicating within normal limits although they may feel loud, and finally (3) it targets increasing self-cueing to facilitate generalization of these practices and continued use of increased volume outside the therapy setting (Fox, Ebersbach, Ramig & Sapir, 2011).

In 1995, Dr. Ramig and colleagues investigated the effect of her LSVT® treatment methodology as compared to intensive speech therapy targeting respiratory muscle activity alone. Forty-five subjects split into the two treatment groups and underwent the same amount of therapy for a month in their respective conditions. Researchers measured intensity and duration during maximum sustained phonation, as well as intensity, habitual frequency and variability of fundamental frequency during connected speech. They also took pre- and post-treatment self-ratings in a patient and family questionnaire rating perceptual variables and inquiring to what degree Parkinson's disease affects their communication. Results showed a significant increase in pre- and post- treatment across more measurements and with greater magnitude for the LSVT® group as compared to the controls. The subjects in the LSVT® condition reported a significant decrease in the effect PD has on their communication. Researchers reported that variables such as stage of disease, severity rating, and time since diagnosis did not predict effectiveness of treatment. Overall, results display that intensive treatment focusing on respiration paired with phonation (i.e., LSVT®) is more effective than simply targeting respiration alone for increasing vocal intensity and decreasing the negative impact PD has on communication (Ramig, Countryman, Thompson, & Horii, 1995). This early research shows the effectiveness of LSVT® immediately after treatment but does not show long-term effects of the treatment approach.

In 1996, Ramig et al. then conducted further research to determine both the effectiveness of LSVT® and the extent that the positive effects of LSVT® would remain. They measured 35 subjects assigned to one of two conditions: targeting respiration alone or LSVT®. They measured vocal intensity at pre- and immediately post- treatment and again at 6- and 12-months post-treatment. They found that only subjects in the LSVT® group maintained gains above pre-treatment levels after the 12 month period (Ramig, Countryman, O'Brien, Hoehn, & Thompson, 1996). Ramig and colleagues conducted a similar study again in 2001, this time including a measurement of 24 months post-treatment. The researchers measured intensity and inflection in fundamental frequency across time. The LSVT® group was found to be statistically significant in improving and maintaining both intensity and inflection immediately post-treatment and 24 months post-treatment. The results of measures taken at 6- and 12-months post-treatment were not included in this study. This combined research shows the longevity of LSVT® treatment in relation to intensity and fundamental frequency, but no measures of connected speech tasks were included.

Researchers Wight and Miller (2015) attempted to bolster the existing research by providing additional measures to evaluate change after LSVT®, including connected speech tasks. They measured maximum intensity (in dB) and duration of sustained phonation, habitual intensity (in dB) of connected speech tasks, and a self-rated Voice Handicap Index (VHI). These measures were recorded immediately after receiving LSVT®, and again at 12- and 24-months post treatment. They found that all gains were maintained 12 months after completing LSVT®. Improvements in duration of sustained phonation were maintained at 24 months post treatment. Connected speech scores, however, reflected closer to baseline when measured at 24 months post-treatment showing that significant progress was not maintained from initial treatment (Wight & Miller, 2015). Their reports on the Voice Handicap Index (VHI) reflect a similar trend of returning back to baseline at 24 months post-treatment.

Along with the increases in acoustic measures, studies have shown physiological changes immediately after treatment including: larger excursion of the rib cage when breathing for speech, increased subglottal pressure, and stronger and more symmetrical closure of the vocal folds (Fox et al., 2011). Other positive changes from LSVT® include improved consonant articulation, facial expression, tongue strength, rate of speech, and some improvement in the oral phase of swallowing (Fox et al., 2011). Finally, perceptual ratings of speech also showed improvements. Participants who completed the program showed a decrease in vowel centralization and increase the quality of vowels (Sapir, Spielman, Ramig, Story, & Fox, 2007; Sapir, Ramig, Spielman, and Fox, 2010). Listeners also rated improved loudness and vocal quality immediately after participants received treatment (Fox, Morrison, Ramig, & Sapir, 2002).

While extensive research over the past 24 years shows the LSVT® program's clinical merit, there are limitations, including the potential for publication bias as well as relatively small sample sizes (Tomlinson et al., 2014). The most significant clinical weakness thus far, is the challenge of maintaining vocal gains following LSVT® due to the nature and progression of PD. Because of this, researchers have begun examining other approaches containing similar elements to that of LSVT® to explore potential treatment methods for PD. Singing, for example, targets proper abdominal breathing, sustained phonation, and incorporates the individual's full pitch and dynamic ranges. While these tasks are not functional for treating communication directly, they share elements with tasks of maximum phonation time and pitch range tasks in the LSVT® protocol. The differences between singing and LSVT® tasks lie primarily within targeting speech intelligibility. LSVT® targets commonly used phrases, monologue, and increases progression toward using a strong voice in conversational speech, whereas singing does not. Because of the similarities between the two, though, researchers desire to see if utilizing singing from a therapeutic approach can have similar benefit to people with PD that LSVT® does.

Therapeutic Singing

Shih et al. (2012) measured the effects of group-based singing intervention on 15 subjects. They underwent choral therapy sessions for 12 weeks, being required to attend at least 10 out of the 12 sessions. These therapy sessions consisted of 10 minutes of stretching, 10 minutes of vocal exercises, and 70 minutes of singing familiar songs. The sessions were administered by an SLP and a singing instructor experienced in working with patients with PD. Subjects were provided with handouts outlining practice procedures and exercises to be completed during the week outside the group therapy sessions. Measures were taken at baseline and then again at 12 weeks when treatment ceased. The primary outcome measure was vocal loudness and secondary measures were pitch range, phonation time, maximum loudness, voice related quality of life (VRQOL) as well as the VHI. No speech intelligibility measures were taken, and there was no inclusion of other factors that may contribute to the progression or decline of the individuals' voice symptoms. After treatment, no significant difference was found between pre- and post-treatment across any measures taken.

In another study conducted by Stegemöller, Radig, Hibbing, Wingate, and Sapienza (2017), researchers proposed that the inclusion of a more engaging treatment approach could simultaneously combat attrition, increase motivation and practice outside of therapy, increase quality of life (QOL), all while improving vocal function. In their study they assessed voice, respiratory control and QOL after participating in therapeutic singing. Their 27 participants engaged in therapeutic group singing for 8 weeks, either in a low dose setting (1 hr 1x/wk) or a high dose setting (1 hr 2x/wk). Participants were not classically trained singers and had not received any speech therapy within the past 2 years. Nine participants had received LSVT® in the 5 years prior to the study, but did not continue engaging in the LSVT® exercises post-treatment. The singing intervention was administered by board-certified music therapists. Intervention targeted vocal intensity, vocal range, articulation, facial expression, and proper breathing through a variety of vocal exercises for warmup and group singing of familiar songs. Researchers took voice measures at pre- and post-treatment of sustained phonation, maximum inspiratory and expiratory pressure, intensity, range, and quality of life. Results did show a significant increase in both inspiratory and expiratory pressures along with an increase in sustained phonation of /a/. Individuals' quality of life was shown to have improved between pre- and post-testing as well. There was not, however, a statistically significant difference in other vocal measures including intensity measured in decibels, duration of /i/, and range measured in semitones. Furthermore, there was no inclusion of measures to assess intelligibility or any effect of participant’s speech. This study noted that therapeutic singing can have a positive effect on quality of life, but further research on the interaction of singing and PD symptoms is needed to determine if it can be used to increase intelligibility.

Current Study

The primary purpose of the current study is to evaluate the long-term functioning of a trained singer with PD who underwent LSVT® and attended monthly follow-up sessions to monitor vocal performance on a variety of tasks. Variation in singing and speech performance will be assessed across time. Any indications of vocal decline will be identified. For this project, subjective ratings of intelligibility and vocal quality as well as objective measures such as amplitude and pitch, maximum phonation time were considered as vocal maintenance. Specific research questions include:

1. Does frequency of singing practice increase maintenance of performance on speech/singing tasks including pitch range and audibility?

2. How are pitch range, audibility, and intelligibility affected by disease progression and other social/environmental factors?

This retroactive longitudinal case study will bolster the existing research by providing additional data, including both quantitative and qualitative longitudinal measures. By isolating variables affecting voice both positively and negatively, further research with larger studies could examine the variables in question. Practicing speech-language pathologists will then be able to utilize this information to more thoroughly educate their patients and families of people with PD. The hope is this study to maintain both research and clinical merit.

Methodology

Subject

This project involves one adult male PA, age 89, who began experiencing symptoms of Parkinson's disease in 2012 at the age of 82. His son had been diagnosed with PD several years earlier, making him aware of the early PD indicators he was experiencing. Although he was not experiencing the classic tremor, he was diagnosed shortly after reporting symptoms. PA was referred for LSVT® in February 2014 by his Ear Nose and Throat (ENT) physician who noticed a reduction in loudness and intelligibility in conversation. His speech diagnostic was conducted at a private practice clinic. At time of evaluation, PA was at the PD Hoehn-Yahr stage 2 (bilateral or midline involvement without impairment of balance). He displayed loss of facial expression, bilateral stiffness, slow movement, reduction of spontaneous movements, and difficulty with speech. He did not experience tremor and was capable of completing all activities of daily living. PA is a trained singer and has been singing from an early age. At the time of evaluation, he sang up to 5 times each week, performing in barbershop quartets and church choirs. PA did not report significant awareness of his speech changes but reported a decrease in pitch range when singing. He also reported others having difficulty hearing him and difficulty being understood on the telephone. Upon evaluation, PA had not yet begun physical therapy for assessing and treating gross motor movement. He began Lee Silverman Voice Treatment on March 5, 2014.

Reports indicate successful completion of the LSVT® program. PA's wife is his main communication partner and was considered a potential obstacle to progress due to his report that she consistently demonstrated a quiet voice. It was noted that the PA did not perform homework as requested due to his wife's objections that he was too loud. PA later stated that he attempted to match the loudness of others and felt he was able to adjust appropriately. Due to

PA's age and concerns regarding maintenance of his ability to communication and sing, he attended monthly sessions to monitor his speech and singing.

Measurements/Data Collection

Monthly data of PA's vocal capability was collected at a University Speech and Hearing Clinic by a certified speech language pathologist (SLP) who specialized in voice disorders. This data spans across the dates of PA's first and second participation in LSVT®, from February 2014 to May 2018). Records of his performance during follow-up sessions on various LSVT® and singing tasks were used to obtain subjective and objective measures. Any variation in these measures that corresponds to disease progression will be identified. All measures were collected in a quiet therapy room.

Subjective measures

At the beginning of each session, PA practiced loud speech in conversation, in monologue, and in frequently used functional phrases. Functional phrases were previously determined by primary SLP and PA. Perceptual characteristics of PA's vocal quality, audibility, and intelligibility were subjectively judged in conversation, monologue, and in functional phrases. This dialogue served as a sample to rate the subject's voice on the GRBAS rating scale. This scale represents: Grade, Roughness, Breathiness, Asthenia, Strain, and rates each measure on a scale of 1-3, with 0= normal, 1=slight degree, 2=medium degree, and 3=high degree. PA reported any changes in his perceived singing and speaking ability, such as vocal quality, range, pitch, and volume. PA noted frequency of singing practice and health or social/environmental changes, as well as his spouse's report of change in audibility or intelligibility. PA also reported his medical condition/status and other relevant symptoms or treatments, including gross motor ability, physical therapy, and general health.

Objective measures

Sustained phonation of vowels for maximum phonation time (MPT) was measured with an average of four vowels being reported. PA was instructed to hold /a/, /i/, /u/, and /o/ for as long as he could, using a loud, strong voice. MPT was recorded on a stopwatch. PA then performed pitch glides up and down the scale at a loud volume with various vowels. This was utilized as a warmup before recording his voice range profile (VRP). Finally, a singing measure of pitch range and dynamic range was recorded on the Computerized Speech Lab (CSL) by PENTAX Medical hardware with VRP software, generating PA's VRP. Within the VRP, range of intensity, or amplitude, was recorded in dB SPL, and range of fundamental frequency, or pitch, was recorded in Hz. Pitch range includes both total semitones and fundamental frequency. VRP results were obtained with PA standing in a position he indicated was similar to that used when singing, with the microphone at a 45-degree angle in a stand placed at a distance PA determined was comfortable. A constant mouth-to-microphone distance was not reported, due to changes in PA's ability to maintain position as his disease progressed. PA indicated that he did not feel comfortable using a head microphone.

Analysis

After gathering and compiling each month's objective and subjective measures, multiple variables were analyzed in attempt to discover any potential relationships. PA's voice range profile including maximum, minimum, and ranges of both frequency and amplitude were charted to show trends of growth or decline across time. Frequency range paired with amplitude range demonstrates vocal control; specifically, the larger the amplitude ranges, the more control PA maintains over his vocal volume.

PA's performance on these ranges will first be compared to norms for frequency and amplitude ranges as set by Hallin, Fröst, Holmberg, & Södersen (2012). These norms were created with 30 healthy male controls and are shown in Table 1. The standard deviation for frequency range in Hz was not included in the paper.

Table1
Frequency and Amplitude norms on VRP - Hallin, Fröst, Holmberg, & Södersen, 2012

	Mean Min (SD)	Mean Max (SD)	Mean Range (SD)
Frequency (in Hz)	76.4 (12.33)	811.3 (209.21)	735 Hz
Amplitude (in dB)	43.6 (3.65)	109.3 (1.77)	67.7 (4.11)

Once the VRP data points were charted, they were then compared against MPT and subjective measures including GRBAS scales, overall intelligibility, and self-reported variables such as frequency of singing, medication changes, mobility, general health, other therapies, etc. Researchers evaluated if frequency of singing practice increased performance or maintenance of pitch range, amplitude range, maximum phonation time, and/or intelligibility/audibility in conversation. Then, subject report of severity of PD (i.e., general mobility, cognitive changes, dysphagia or excess saliva, facial expression, or other health factors) was overlaid on the charts to evaluate if singing performance reflected indicators of disease progression. Subject report of health and social/environmental factors including mobility, activity level, social interaction or hobbies was also taken into consideration. These factors were compared with vocal performance to see if an increase or decrease in those factors would be mirrored by performance vocal on tasks during the monthly sessions. This showed if there is a relationship between health or social/environmental factors and any variation in speech and singing tasks. Researchers aimed to identify any change in variables indicating that the LSVT® program should be reintroduced. Evaluating such data points will provide answers to the proposed questions and shed light on the effect of Parkinson’s Disease on an individual’s voice over time.

Subjective profile of participant

In order to provide a more robust understanding of how PA's vocal function fluctuated across the study and how that corresponded with any objective measures, all subjective report was gathered and complied in chronological order. At each session PA provided subjective information regarding vocal performance, frequency of singing practice, any changes in health status, spousal report of voice changes in PA, and any other potentially relevant factors PA experienced.

PA did not consistently report subjective measures at each follow-up session but was able to note changes regarding his health and other contributing factors. He performed variably on speech and singing tasks periodically throughout the sessions. As a general note, the frequency of PA's singing was consistent, ranging up to 5 times per week, in men's groups, barbershop quartet, and a church choir. He reported increased singing during the Easter and Christmas holidays with his church choir. Throughout all sessions, whether sitting or standing, PA exhibited proper abdominal breathing during speech and singing.

PA described his vocal function as being relatively consistent, but still displaying increases and decreases throughout this project. He reported on numerous occasions an awareness of his low vocal volume and the need to match others' loudness in conversation. Despite his wife vocalizing her aversion toward his loud practice, upon noticing a decline in his voice, she began to speak louder herself in order to provide an adequate model for PA.

On February 26, 2014 during the intake appointment, his wife reported that she "can't hear or understand him consistently." PA noted that he becomes "short of breath when singing" and reported a loss of vocal range. Subject employs a compensatory strategy of reducing rate to increase intelligibility. He reported no issues of dysphagia but occasional pooling of saliva and anterior spillage. He displayed no mobility issues at this time. Maximum sustained phonation was 12 seconds with a range of 9-12 seconds. He maintained adequate voicing during all tasks this session, including reading more linguistically complex sentences. His pitch range was not recorded through the Voice Range Profile during this session but he demonstrated 21 semitones and showed minimal variation in loudness.

On March 5, 2014, the clinician determined a target loudness for sustained phonation to reach 80-85 dB. He appeared to match his wife's vocal volume and clinician observed PA's wife to speak quietly. PA reported understanding protocol for LSVT® and committed to practicing.

At the next session, March 19, 2014, PA reported practicing vocal exercises without his wife and attempting to increase his volume during practice. PA successfully demonstrated a volume of 80-85 dB during sustained phonation. He utilized a strong, intelligible voice throughout the session. Toward the end of the session, he spoke on the telephone and reverted back to a quiet, rapid rate.

In the beginning of April 2014, PA displayed 24 semitones when assessing dynamic range, showing an increase of 3 since the intake session. Minimal verbal cues were required to maintain appropriate volume and he demonstrated the ability to maintain a loud voice during more complex stimuli this session. PA's wife was also noted to have increased her speaking volume than in previous sessions.

On April 24, 2014, PA arrived to the session utilizing an adequate volume for speech. He maintained vocal loudness in conversation for seven out of eight conversational turns. Subject reported consistent practice following prior session and noted that speaking with an adequately loud voice feels more natural than when first initiating therapy.

After the above spring sessions, PA's overall performance and maximum phonation time on various vowels remained steady through September 2015 maintaining approximately 12 seconds (range 9-12 seconds). No notable changes in intelligibility or vocal performance noted by PA or spouse.

September 16, 2015, PA reported taking a new medication for secretion management. He noticed extreme dryness in his mouth and on his face. He reported “wandering at night” as another side effect from the medication. His wife reported PA using a quieter voice at home since starting the medication. On the GRBAS this session, he was rated as G1R1B1A1S0, showing slight roughness, breathiness, and asthenia. Though the medication had begun to take effect, these GRBAS scores were observed to be due to wet hoarseness associated with increased secretions in the mouth. In conversational speech, he demonstrated a slight increase in rate of speech. Some utterances were inaudible when he spoke on extended breath units. His maximum phonation time was 7 seconds, ranging from 5-7 seconds and demonstrated only slight variation in loudness. The session ended prematurely due to drastic effects of new medication on vocal performance. Clinician determined that the decreased vocal performance was due to side effects from the medication.

Less than a month later on September 30, 2015, he returned back to the clinic for a closer follow-up due to the prior medication effects. PA began preventative physical and occupational therapy, prior to worsening symptoms. Spouse again discussed his difficulty with maintaining loud vocal volume in the home, but PA felt his wife had a hearing impairment. Upon further investigation, spouse’s hearing loss was verified which accounted for the discrepancy between subject and spousal reports. PA noted attempting to match others volume in social situations, particularly in his men’s singing group. While the drying side effects of his medication were still present at this time, PA reported them to be less significant. His performance improved slightly from previous session. His GRBAS rating was 0 for all measures, exhibiting no roughness, breathiness, asthenia, or strain. For maximum phonation time, both average and range were 7 seconds. PA demonstrated appropriate vocal loudness during the session. He adequately matched the loudness of clinicians during conversation as well as adjusted to the distance of any listeners.

The following month, October 2015, PA described positive results from physical and occupational therapy. His wife also reported not having any difficulty hearing or understanding him and that utilizing a louder voice increased intelligibility. His GRBAS ratings were unchanged at 0, reflecting a perceptually normal voice. His maximum phonation time was again 7 seconds during all trials, with no variation between phonemes.

For the next consecutive months, PA remained relatively stable. He continued to demonstrate ratings of G0R0A0B0A0S0 and 7 seconds with his maximum phonation time, ranging from 5-7 seconds for most sessions. Early in 2016, PA reported that he and his wife would be moving to an assisted living community soon but did not actually occur until fall 2016. This move was of relevance because he and his wife became slightly less independent at the living community. Prior to the move, PA remained active in and outside the home, doing yardwork and regularly mowing the law. Once transitioning to assisted living, the frequency with which he was out in the community interacting with peers also changed. PA relied on others to transport him to and from singing practice and other social events and recounted that transportation was not always consistent.

PA mentioned vigorous vocal practice around Easter of 2016, as well as performing four times on Easter day. Through the end of 2016, he appeared to be controlling his maximum phonation time because he consistently reached 7 seconds on every trial. Even with his accuracy of exactly 7 seconds, PA denied intentionally keeping time in his head. During 2016, little variability was reported even when singing more during holiday seasons. He maintained physical therapy throughout 2016 and results were unremarkable. No other particular events were noted.

Beginning in 2017, PA began noticing slight weight gain. He felt that excess weight could be affecting his ability to generate adequate breath support, and by extension, affect his singing. He reported decreased activity level after moving but he continued with physical therapy throughout the year. His maximum phonation time became more variable beginning in early 2017. While his average still maintained 7 seconds, his range was between 5-7 seconds, except surrounding Easter 2017.

On April 17, 2017, PA’s MPT was 11 seconds, significantly longer in than the prior months. He reported singing multiple times over the weekend for Easter church services. His facial expression and movement showed improvement from prior session when a slight left eyelid droop and masked expression were more prominent. Later in the month, PA stated he had almost completed PT but reported they injured his legs. Specifics of the injury were not shared.

Following his injury, mobility continued to decline. He did not seek assistance from a walker at this time. There were no vocal quality changes that were noted until August 2017, when patient experienced pitch break during the session, which was uncharacteristic for PA. August 21, 2017, PA demonstrated a significant change in vocal quality with wet hoarseness during the session due to excess secretions. His GRBAS scale was: G1R1B1A1S0. Though he was still audible and intelligible, he exhibited decreased ROM and reduced loudness when compared to prior session. A significant reduction in pitch range and amplitude range was observed. Continued decrease of mobility reported at this session.

PA exhibited and reported increased management of secretions in September 2017 but noted still not feeling his voice was “back to normal.” Spouse reports increased difficulty understanding him when they are home. His GRBAS scale was G1R0B1A1S0. The wet hoarseness observed at the prior session ceased but PA was quieter in conversation than previous sessions. His MPT was 6-7 seconds and clinician recommended ENT examination.

At the start of 2018, PA ceased driving as he had been “passing out” with no known cause and he began to use a walker regularly for safety. Clinician noted cognitive issues, particularly with his memory, in early 2018 sessions. On April 6, 2018, PA demonstrated relatively consistent perceptual measures. His maximum phonation time was 6 seconds, again ranging from 5-7 seconds across various vowels. Despite patient feeling like he was unable to gain adequate breath support, clinician noted proper abdominal breathing. By May 2018 his condition declined more significantly. He became incontinent and soon after entered a memory care center. His maximum phonation time was 4.8 seconds while sitting, which ranged from 4.5-5 seconds. He attempted a longer duration when standing and sustained phonation for 6 seconds (range 5-6), while showing a steady decrease in amplitude at 3 seconds.

Across all sessions, the main variability in PA’s performance on maximum phonation time was shown during periods of sickness or medication changes. As PA’s cognition declined toward the end of the project, along followed the accuracy of report. His actual move date to the memory care center was undetermined. He reported a decrease in singing groups due to difficulty with transportation and arranging a ride to and from rehearsals. Data collection finally ceased when PA moved to Texas for family and financial reasons.

Results

The two types of data collected and analyzed were the objective measures of pitch and amplitude range, and the subjective measures of any contributing variables to vocal performance including frequency of singing, health, social, and environmental factors.

The overall trend of the frequency range is a shallow arc, starting low prior to LSVT®, increasing, then decreasing again toward the end of the project. The mean frequency range of healthy controls, as listed above, is 735 Hz (Hallin et al. 2012). PA's frequency ranges vary from 199.4 - 314.22, which is lower than the mean. The mean minimum and maximum frequencies of the Hallin et al. (2012) study are 76.4 Hz (SD 12.33) and 811.3 Hz (SD 209.21) respectively. PA's minimum frequency is within 1 SD of the study mean at 69.3 Hz, but his maximum frequency lies below the healthy controls at 392.0 Hz.

The amplitude ranges also showed areas of increase and decline, but unlike frequency, amplitude range was overall a slight decline. PA's amplitude range began at a range of 58 dB and ended at a range of 32 dB. The mean for intensity range as shown by Hallin et al. (2012) is 67.7 dB (SD 4.11). PA's amplitude ranges vary from 26-58 dB and are more than 1 SD below control norms. For minimum intensity and maximum intensity means, Hallin et al. (2012) reported 43.6 dB (SD 3.65) and 109.3 dB (1.77), respectively. For minimum and maximum intensity values, PA's maximum values lie near norms shown by Hallin et al. (2012) ranging from 96-112 dB SPL. His minimum values however are more than 2 SD above norms ranging from 52-80 dB SPL.

Significant subjective variables reported were frequency of singing, changes in medication, weight, and mobility as well as beginning physical and occupational therapies. PA reported that surrounding the holidays of Easter and Christmas he consistently sang more frequently at rehearsals and performances. Spousal report also indicated an increase in intelligibility after beginning physical and occupational therapy and PA demonstrated an increase in pitch range at this time.

Upon introduction of a new secretion management medication, subject exhibited a decrease in pitch range. PA received poorer ratings on the GRBAS scale, showing an increase in roughness, breathiness, and asthenia and had a decrease in maximum phonation time. His average prior to the medication change was approximately 12 seconds, and with the new medication, his MPT was 7 seconds. His spouse reported a decrease in vocal volume in the home and PA was observed to have increased rate of speech in his session. He described feeling excessive dryness and an inability to perform well when singing.

Another reported variable noted was weight gain. PA recounted that he could not maintain adequate breath during vocal tasks due to extra weight, and his performance on tasks also decreased. Finally, when moving to an assisted living facility and frequency of activity and mobility was reduced, subject also displayed a decrease in vocal measures. The most significant dip in both subjective and objective measures was the voice break observed in August of 2017. The cause of such was not determined but subject was able to regain adequate vocal control in following sessions.

Figures 1-6 show maximum and minimum frequency in Hz, frequency range in Hz, maximum and minimum amplitude in dB SPL and amplitude range in dB SPL, with descriptors of notable changes in status and performance.

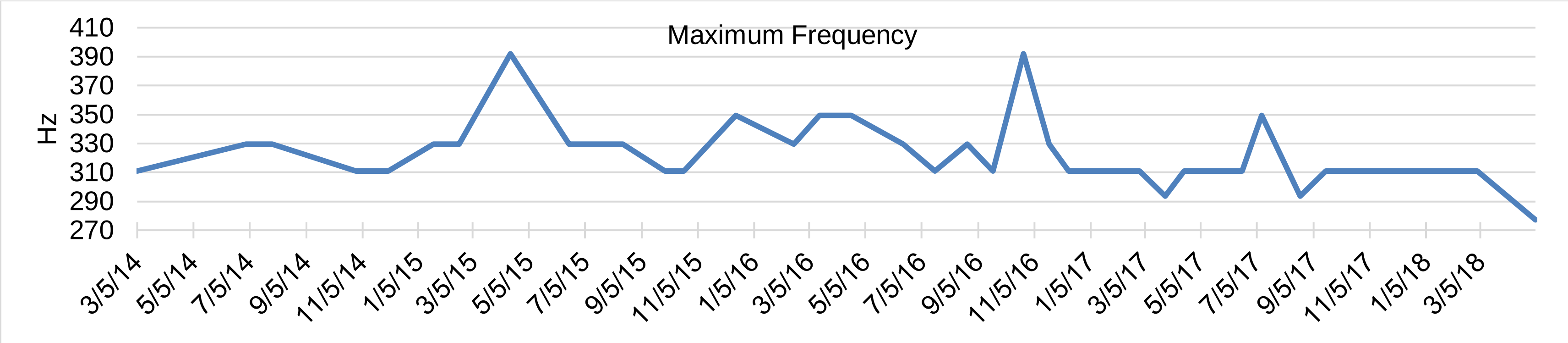

Figure 1
PA's maximum frequency charted at each session, measured in Hz
Highest max frequency: 392 Hz; Lowest max frequency 277.18 Hz

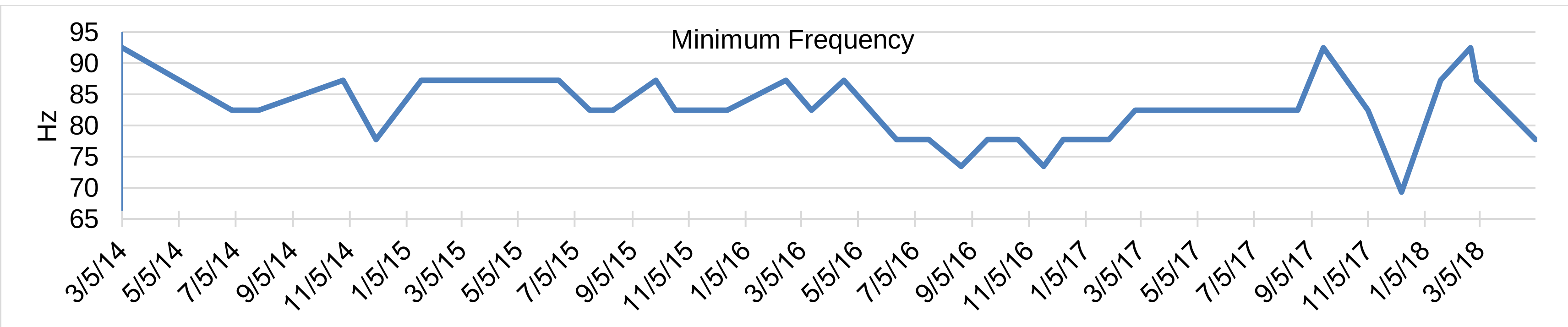

Figure 2
PA's minimum frequency charted at each session, measured in Hz
Highest min frequency: 92.5 Hz; Lowest min frequency: 69.3 Hz

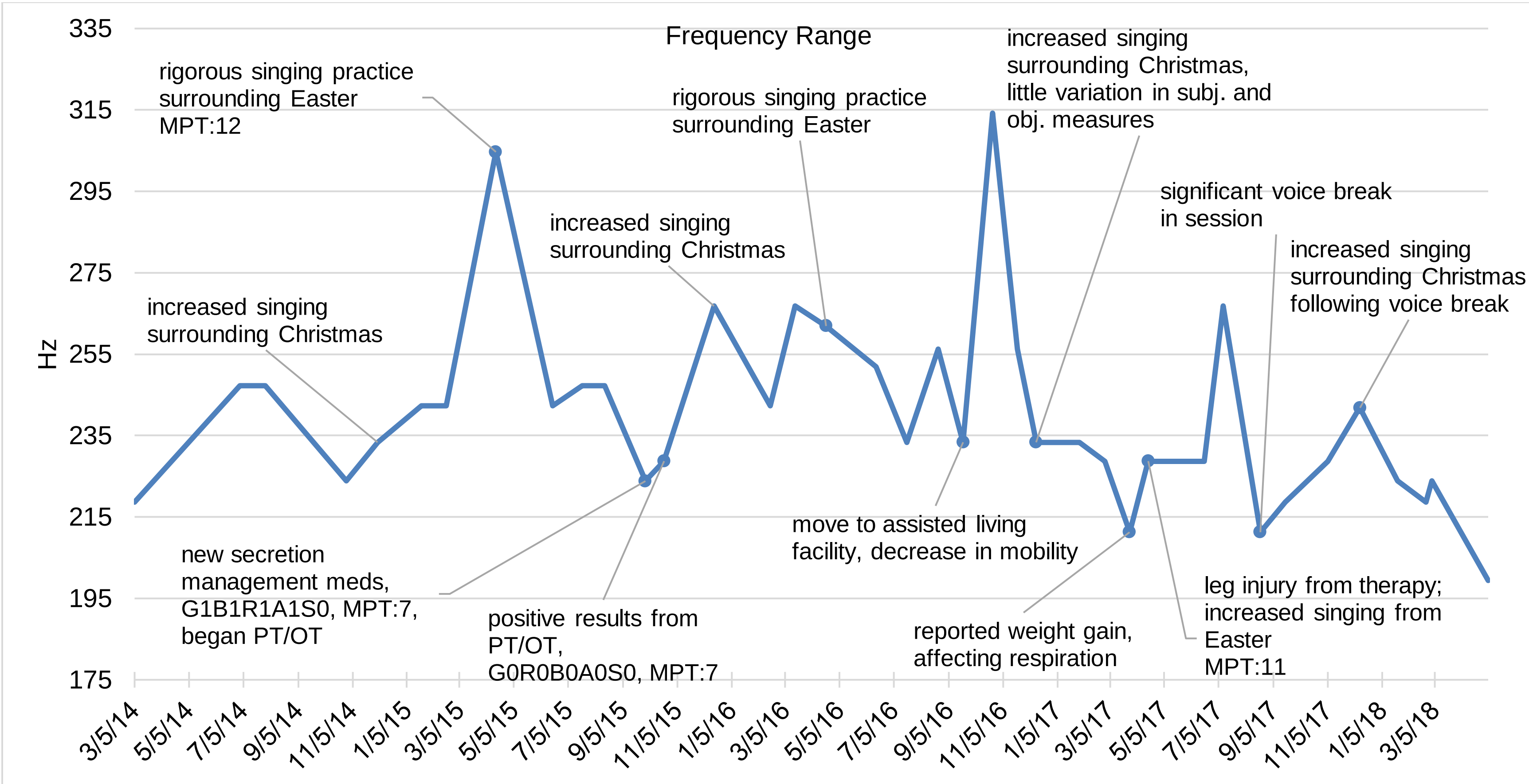

Figure 3
PA’s frequency range at each session, measured in Hz
Maximum range: 314.22 Hz; Minimum range: 199.4 Hz

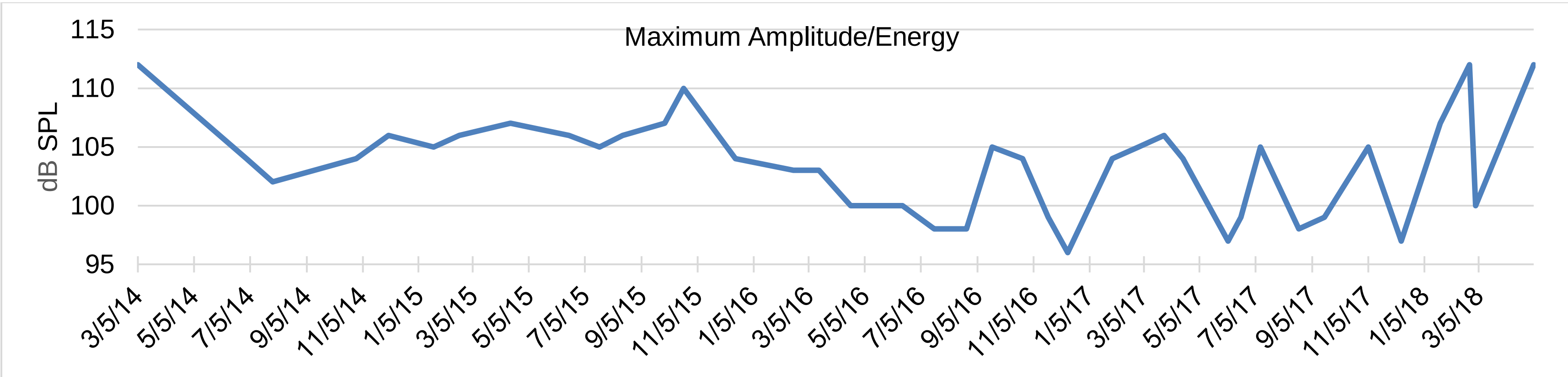

Figure 4
PA's maximum amplitude at each session, measured in dB SPL
Highest max amplitude 112 dB SPL; Lowest max amplitude 96 dB SPL

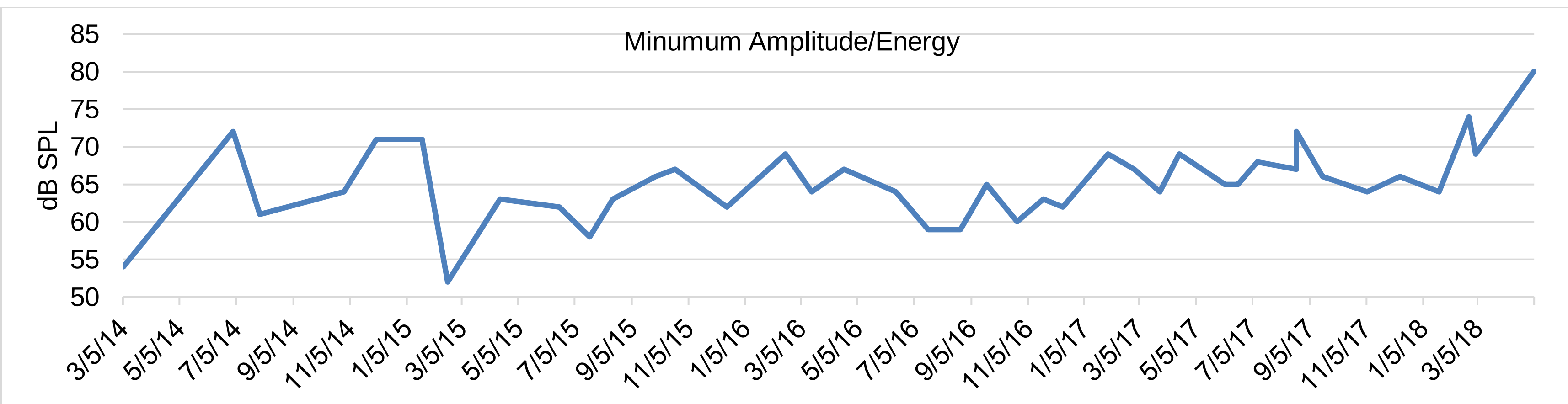

Figure 5
PA's minimum amplitude at each session, measured in dB SPL
Highest min amplitude: 80 dB SPL; Lowest min amplitude: 52 dB SPL

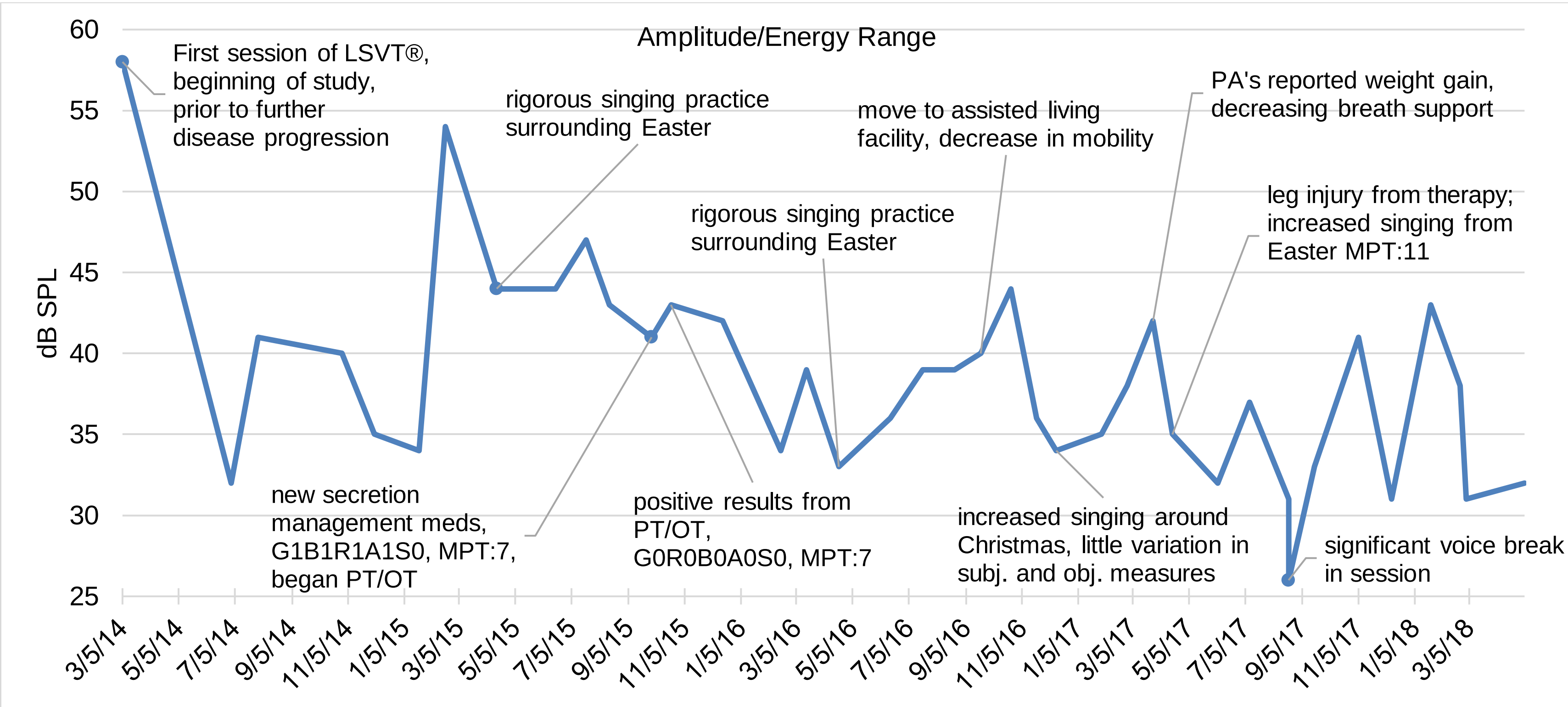

Figure 6

PA’s amplitude range at each session, measured in dB SPL.

Maximum range: 58 dB; Minimum range: 26 dB

Discussion

Although symptoms associated with Parkinson's disease vary between individuals, voice deficits are a consistent concern across the PD population (Miller, Noble, Jones, & Burn, 2006; Miller, Noble, Jones, Allcock, & Burn, 2008). Not only does PD affect voice, but those voice deficits lead into a decrease in quality of life (Shih et al. 2012). Voice therapy is the cornerstone of speech-pathologists' treatment for individuals with Parkinson's disease. Researchers have investigated therapeutic singing in lieu of LSVT®, aiming to identify a sustainable and enjoyable therapy due to the intensive nature of LSVT®. Because singing shares similar properties with LSVT®, including targeting vocal range and increased respiration and volume, therapeutic singing was not a far reach from LSVT®. However, prior research on therapeutic singing either included no measures of voice or intelligibility or they showed little gain beyond measures of respiration (Shih et al. 2010; Stegemöller et al. 2017). Prior to this study, what had not yet been considered was singing working in conjunction with LSVT® for therapeutic benefit.

This study is a very preliminary look into a vocal profile of a trained singer with Parkinson's Disease and the relationship of how proper singing can supplement LSVT® by maintaining or even increasing vocal performance across a myriad of tasks. The primary research question for this project was to identify if frequent singing could help maintain gains following LSVT®. Prior to receiving therapy of any kind, PA's voice was subjectively assessed to be weak, unintelligible, and he reported a loss of vocal range and being short of breath. After completing his first round of LSVT®, performance on amplitude and pitch ranges increased slightly. Throughout the four years of data collection, though, peaks and dips occurred within both the amplitude and frequency ranges. As shown through LSVT® research, advances from the treatment program are generally lost after 24 months post-treatment (Ramig et al. 2001). It is important to note that even after this two-year period, PA continued to demonstrate increases in his frequency above baseline, implying that maintenance and even improvement was made at times. Though the extent of gains were not consistent, there was both subjective and objective evidence of vocal improvement surrounding the Easter and Christmas holidays due to increased frequency of singing.

Through comparison of PA's frequency and amplitude ranges to vocal norms established by Hallin et al. (2012), researchers found PA's performance to be poorer than controls. This was to be expected when paralleling a disordered voice to healthy individuals. The overall trend of both amplitude and frequency ranges included a slight decline toward the end of the project. Decline is also to be expected over a four-year period of someone with PD, but because there are no other subjects with Parkinson's disease to compare data, it cannot be determined that PA's decline is at the typical rate of individuals with PD.

When evaluating if frequency of singing affected pitch range, there were noteworthy increases throughout the study as shown in Table 2. PA demonstrated increased pitch range from baseline surrounding Easter when PA was singing more frequently in his church choir. Additional singing surrounding Christmas was not shown to be as effective in increasing pitch range to the same degree as the Easter holiday, however pitch range adjacent to Christmas still remained above baseline, signaling vocal maintenance.

Table 2
PA pitch range (in Hz) surrounding high singing frequency holidays

Baseline 3/5/14	Christmas 2014	Easter 2015	Christmas 2015	Easter 2016	Christmas 2016	Easter 2017	Christmas 2017	Easter 2018*
218.63	233.35	304.69	266.82	261.92	233.35	228.72	241.83	223.82

*April measures not recorded; this data point from 3/2/18

There were no identifiable trends for frequency of singing and amplitude range. The latter half of the project, intensity varied but overall decreased, and PA became less able to manipulate his voice to produce appropriate loud and quiet voicing in the respective conditions. Again, this decline is to be expected due to the nature of the disease. Because PA is a classically trained singer, it is important to note that this level of amplitude control could be attributed PA knowing his vocal limitations and not allowing himself to push his voice beyond its capacity. Another possible contributing factor for this variance in performance is the fact that with PD, the primary focus is increased vocal intensity. As this is a retrospective study, the approach at the time of data collection might have concentrated solely on increased vocal volume during tasks. Because of this, it is possible that the full amplitude range was not emphasized when collecting data and the subject not cued to complete his VRP using both quiet and loud voice.

The secondary goal of this study was to explore if other social or health variables would affect vocal performance either positively or negatively. While PA's vocal performance, as displayed through frequency and amplitude ranges, was not consistently affected by specific variables, there are salient points to note. When observing what health and social/environmental factors influence overall vocal performance as shown through intelligibility, audibility, and pitch range, researchers found varied results.

It is difficult to show how social or health variables could positively affect voice, as the predominant influences observed in this study were negative. When experiencing negative physiological changes, though, PA's vocal performance did appear to mirror that change, as seen when PA reported a decrease in mobility. When moving to an assisted living facility and PA noted a reduction in activity level, he demonstrated a decrease in pitch range. As noted in the results, the introduction of a new secretion management medication also diminished his frequency range. Maximum phonation time appeared to be significantly affected by periods of sickness and medication changes. Inversely, when beginning preemptive treatment of PT and OT, there was a slight increase in intelligibility as well as pitch range. At this time, there is not sufficient data to determine if PA's singing performance had predictive qualities and indicated disease progression before symptoms worsened versus singing performance simply reflecting symptom progression of PD. Concrete conclusions about direct influence of variables such as these cannot yet be made, however, this project does provide insight on potential variables that can affect speech and intelligibility.

This study is unique because of the complex interaction between PA's vocal performance and how that ties into, not only intelligibility in conversation, but also into his singing ability and quality of life. Though no quality of life scales were administered, PA would be perhaps more affected by a decrease in singing performance than intelligibility in conversation, due to his passion for singing. Also, from a technical standpoint, PA has a high level of awareness into how his voice appears in conversation and in singing and was very attuned to his performance and limitations. PA was the chosen subject to investigate because he had periods of vocal maintenance even up until 4 years past the treatment. Not only did he maintain, but he even made improvements in vocal performance and intelligibility at times. Thus, the connection was drawn between proper singing and vocal maintenance. Because he is highly motivated by singing, PA blends these social and physical components potentially more so than other individuals might, which provides an invaluable perspective on this topic.

Limitations

As with any project, there are limitations to note. First, the primary limitation is that this project is a case study (level III on levels of evidence scale). While it provides longitudinal data on a gentleman with Parkinson's Disease, it still remains only one individual. Had there been a larger sample size, data could have been compared and contrasted to evaluate degree of change or significance in measures. Also as previously stated, there is much variability in PD symptoms. This study maintaining its level of evidence, paired with the variability within PD, cannot be determined to generalize to other individuals of the Parkinson's community.

Secondly, it is a retrospective study and therefore, there was only access to the variables collected at that time. When analyzing data, researchers were not able to include other potential variables of interest. There were inconsistencies when tracking subjective measures, such as intelligibility in conversation and the GRBAS scale, as well as inconsistencies within patient report. Had this been a prospective study, structured guidelines for data collection would have been in place, ensuring a higher quality and more effective data pool. With more concrete and standardized variables, PA's progress would have been more easily tracked over time and effects potentially more substantial.

Finally, while voice range profile (VRP) measures are beneficial for providing concrete data, one must consider patient performance on structured tasks within a clinic and how these tasks relate to the ultimate goal of intelligibility. These types of structured tasks are not in a naturalistic environment or necessarily generalizable to such. Individuals also tend to perform better on tasks when they know they are being measured and VRP is a very isolated measure. VRP was the primary data collected this project was based on but is not necessarily generalizable to precision of speech in conversation.

Future Research

This study being a retrospective, longitudinal case study represents a research pool in its infancy, leaving much room to grow within this topic. Although consistent gains were not shown from increased singing practice, vocal gains and increased performance were observed surrounding times of frequent practice. Other social and environmental factors also affected performance on speech and singing tasks and these results may shape and inform further studies.

First, it is important on all future Parkinson's and voice research to include measures of intelligibility. Increased intelligibility is the ultimate treatment goal of voice therapy for individuals with Parkinson's disease. Without assessing intelligibility, it cannot be determined that the tested intervention was effective for improving the subjects' speech. While this study had periodic reports of intelligibility, it was not consistent. Vocal volume and pitch are shown to affect one's intelligibility, but without structured measures, it cannot be determined that simply by improving vocal volume or pitch alone increases an individual's ability to be understood by others.

Secondly, increasing the number of participants beyond the level of a case study is critical when evaluating how and what variables specifically affect voice. By conducting structured and controlled clinical trials with more participants, researchers would be able to better grasp the vocal profile of individuals with PD and how various environmental and social factors affect subjects differently with tested interventions. With more participants, further assessing therapeutic singing in conjunction with LSVT® would lend way to explore whether or not proper, regular singing could delay the need of the next round of voice therapy. As shown in PA, gains were maintained above baseline much longer than is typical following LSVT®. Without added research, it cannot be determined if this approach could generalize to other individuals with Parkinson's disorder.

Finally, if resources allow, future research utilizing a longitudinal model would provide a more robust understanding of vocal progression of individuals with PD. The increased sample size paired with the longitudinal format would show variance within the PD population. Researchers could then attempt to isolate if vocal performance on speech or singing tasks has any predictive qualities and determine whether or not singing tasks have the potential to signal disease progression more quickly or accurately than a decline in intelligibility. The longitudinal design would also shed light on how voice progresses and declines in individuals with PD. Also, including more frequent measures, rather than simply pre- and post-test, would provide a more accurate vocal profile, rather than a broad picture of vocal performance. With a disease that ebbs and flows as it does, this component is especially necessary to allow for variance without over or under-estimating disease progression and the effects of such.

Summary

This study was a retrospective, longitudinal case study that measured vocal performance in a single subject with Parkinson's Disease across four years. The subject participated in LSVT® and was a classically trained singer who frequently performed in social groups. Subjective and objective data, including voice range profile, maximum phonation time, intelligibility in conversation, and subject report of change in health or social/environmental status was collected and analyzed. Researchers first attempted to determine if there was any influence of frequency of proper singing on vocal performance shown through amplitude or frequency ranges. Secondly, researchers attempted to highlight if changes in health or social/environmental variables affected vocal performance and how. Researchers found that more frequent singing maintained and actually improved vocal performance on pitch range. Negative changes in health or social factors were shown to have decreased vocal performance and intelligibility.

In conclusion, increased frequency of singing has a positive effect on intelligibility and vocal performance in an individual with Parkinson's disease. If further investigated, therapeutic singing could be an effective maintenance tool to supplement a more structured, standardized form of treatment. It has the potential to delay the need for follow-up sessions of a structured voice program. Secondly, as to be expected, changes in health status impact one's voice both positively and negatively. Any change in medication or decrease in mobility or activity was shown to decrease vocal performance. While the results of this study are very preliminary, there is still much to be gleaned and investigated from this topic. Examining the influence different variables have on the voice of one with Parkinson’s disease will one day further inform treatment.

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