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Voice Improvement in Parkinson's Disease: Vocal Pedagogy and Voice Therapy Combined

by

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Dedication

This thesis is dedicated to my grandmother Elsie Faison Mitchell Newland, my parents Doris Elsie Francis Newland Tanner and Byron Chester Tanner, and my sister Susan Tanner and her husband Irvin Waller, who all inspired me to keep learning.

Abstract

The objective of this study was to examine a group vocalization program consisting of vocal exercises and choral singing designed to improve the voices of people with idiopathic Parkinson's disease (IPD). A single group pretest-posttest research design was used. A total of 28 people with IPD participated in the study. Half (n=14) participated in an intervention program in the spring of 2010, and the other half participated in the fall of the same year. The intervention program was six weeks long. Two groups of 7 participants each attended one 90-minute session per week, and the two groups came together at the end of every week for another 90-minute session. Each session included vocal warm-up, vocal exercises, singing exercises, choral speech, and choral singing with piano accompaniment. Participants were provided with video and audio files of songs and exercises to facilitate daily vocal practice. Speech-Language Pathologists not involved with treatment gathered acoustic and perceptual data on participants' voices pre- and post-treatment, while another Speech-Language Pathologist with experience and training in both singing technique and voice therapy provided treatment.

Participants were tested for pre-/post-treatment changes in "vocal ability" (nine acoustic/timing measures and two SLP-rated perceptual measures) and "vocal quality of life" (two participant-rated measures) for a total of 13 dependent variables. Statistically significant changes at the

.004 level of significance (a correction for the number of variables employed) were found in two of the eleven measures of “vocal ability” (average frequency during an oral reading task and maximum intensity range) and in one of the two measures of “vocal quality of life” (the *Speech Intelligibility Inventory: Self Assessment Form*). Three of the eleven measures of “vocal ability” were found to be clinically relevant changes (maximum intensity range, maximum frequency range, and fundamental frequency variation during oral reading). Changes in scores on both questionnaires used to measure “vocal quality of life” were also found to be clinically relevant. In sum, three of thirteen measures showed statistically significant changes and five of the thirteen showed clinically relevant changes. While modest, these results indicate that participants experienced some improvement in their vocal ability and in vocal quality of life following participation in this group intervention. Measures that exhibited positive trends merit further investigation.

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Chapter I: Introduction to Parkinson's Disease and Its Associated Communication Disorders

A. Introduction to Parkinson's disease

Parkinson's disease (PD) is a progressive neurological disorder resulting from a dopamine deficiency in the substantia nigra of the basal ganglia (Hornykiewicz & Kish, 1986). It is usually diagnosed in individuals over the age of 50 and occurs with equal frequency in both genders in Alberta, Canada (Svenson, Platt, & Woodhead, 1993). Variable movement problems such as progressive tremor, akinesia (absence of movement or freezing), rigidity, bradykinesia (slowness of movement) and hypokinesia (reduced movement) (Marsden, 1996) occur all over the body in people with PD, including the oral, vocal and respiratory mechanisms. Life expectancy is reduced (greatest reduction occurs with young onset diagnosis) and the average time lived after diagnosis can range from 5 to 38 years (Ishihara, Cheesbrough, Brayne, & Schrag, 2007).

The prevalence of PD worldwide is 3,765,000 or 64.47/100,000 (WHO, 1997) and the incidence is 305,000 people per year or 5.2/100,000 (WHO, 1997). The prevalence in Alberta is 244/100,000 people (Svenson et al., 1993). This is 3.8 times the prevalence in the world as a whole. Idiopathic (of unknown cause) Parkinson's disease (IPD) is the most common type of PD, comprising 60 to 75% of cases. People with IPD generally have a good response to levodopa (drug used in the treatment of PD to increase dopamine concentration), and the disease progression

is slower and more predictable (Hughes, Daniel, Kilford, & Lees, 1992) than in other forms. It is because of these characteristics that most PD research is performed with IPD participants.

As the disease progresses, the movement problems listed above affect not only large muscles of the body such as those used for walking, but also the smaller muscles needed for such different aspects of communication as breathing, voicing, speaking, facial expression and swallowing. Swallowing is a specialty area in speech language pathology and is often included in the category of communication disorders.

B. Communication disorders in Parkinson's disease

Many individuals with PD and their families consider communication disorders to be one of their most difficult problems (Fox, Morrison, Ramig, & Sapir, 2002; Sapir et al., 2002). Those communication disorders encompass speech, voice and swallowing problems, as well as sensory-perceptual deficits (e.g., little or no awareness of their own quiet volume of voice; sensation of shouting when their voice volume is at normal loudness). Communication disorders also include flat affect (masked facies) due to loss of spontaneous facial expressions (Spielman, Borod, & Ramig, 2003), and are exacerbated by problems with posture and respiratory endurance that accompany the disease (Soloman & Hixon, 1993). In some individuals, associated Parkinson's dementia affects language, memory and cognition, and this in turn produces additional speech and communication symptoms (Brown & Marsden,

1984). The speech, voice and swallowing problems of people with PD are often left untreated. Up to 90% of those with IPD have speech and voice symptoms related to the disease (Duffy, 2005), but only a small number see a Speech Language Pathologist (SLP). The number of referrals to Speech Language Pathologists (SLPs) varies depending on the setting. In the United Kingdom referral rates have improved from 3.4% (Oxtoby, 1982) and 4.4% (Mutch, Strudwick, Roy, & Downie, 1986) in the 1980's to 20% (Yarrow, 1999) in 1999. Swedish referral rates were only 3% (Hartelius & Svenson, 1994) in 1994.

1. Speech and Voice Problems in PD

Because people with PD do not realize that their voices are quiet, they often complain about the large number of people around them with hearing problems (Fox & Ramig, 1997). Family and friends complain that people with PD are hard to understand. Reduced or poor speech intelligibility affects participation and activity levels with respect to communication ability, social engagement, psychological well-being and economic status (all part of the World Health Organization's International Classification of Functioning model). Economic factors are especially evident when the person with PD works in a field where he or she must use his or her voice. One third of all modern jobs require voice use as a primary tool (Vilkman, 2000). The economic costs of voice problems may be far greater and occur earlier in the disease progression than originally thought. According to Miller, Noble, Jones, & Burn (2006), "speech and

language changes in PD impact upon individual and family life long before frank impairment of intelligibility is apparent" (p. 235).

The voice and speech disorders associated with PD are numerous and the most prominent features distinguish PD from other neurological voice and speech disorders. These include dysphonia (harsh and/or breathy voice quality), reduced prosody (monopitch, monoloudness, reduced stress), lower speaking pitch, imprecise articulation (slurred speech), illogical pauses, variable rates of speech, and short phrases (short rushes of speech), all of which are grouped under the term hypokinetic dysarthria (Darley, Aronson, & Brown, 1969a; 1969b). There is also reduced overall loudness or hypophonia (Darley et al., 1975). The symptoms of PD as they occur throughout the body are similar to effects on motor movement involved in voice and speech. The slowness of movement, problems initiating movement, reduced range of motion, rigidity of muscles, tremor, postural fixation and variability of symptoms are all evident in voice and speech movements.

In a study by Logemann, Fisher, Boshes and Blonsky (1978) 89% of people with PD (sample of 200) were judged by two expert listeners to have laryngeal dysfunction. Darley et al. (1975) mention the two extremes of dysphonia (sometimes harsh and sometimes breathy voice quality of people with PD), calling attention to the variety of laryngeal problems that may occur in these patients. The Hanson, Gerratt and Ward (1984)

cinelaryngoscopy study showed asymmetrical laryngeal phonatory positions, supraglottic contraction and incomplete closure of the vocal folds (glottic gap and vocal fold bowing), which were thought to be related to laryngeal muscle rigidity such as that found in the limb and trunk muscles. Lehiste (as cited in Murdoch, 1998) showed phonation problems (breathy phonation, inappropriate voiceless sounds and irregular vocal fold activity) on spectrograms. Ludlow and Bassich (1984) found abnormally high intensity perturbation, which they thought was related to bowed vocal folds creating greater airflow turbulence and breathiness.

Reduced prosody (monopitch, monoloudness, reduced stress) is also likely related to rigidity of laryngeal muscles. Monopitch is related to rigidity and to reduced range of motion in intrinsic and extrinsic muscles of the larynx (Aronson, 1990). During normal speech the extrinsic laryngeal muscles move the larynx up and down during pitch changes (Erikson, Baer, & Harris, 1983; Honda, 1995). Vertical movement of the larynx is also important in a healthy swallow (Perlman & Grayhack, 1991). These movements may be reduced in people with PD due to muscle rigidity, thus reducing pitch variability and perhaps limiting pitch range as well. A reduced maximum fundamental frequency range in people with IPD has been noted by Ludlow and Bassich (1984) and by King, Ramig, Lemke and Horii (1994). Ludlow and Bassich (1984) also found a significant correlation between those judged to exhibit monopitch and those with reduced pitch ranges.

A lower speaking pitch in people with PD is mentioned by Darley et al. (1969a; 1969b; 1975). They rated low pitch as the ninth prominent feature of hypokinetic dysarthria. However, Canter (1963) and Ludlow and Bassich (1984) found that people with PD had higher than normal habitual speaking pitch. A recent study on 10 males with PD found normal fundamental frequency with a tendency for raises in pitch associated with greater impairment (Metter & Hanson, 1986). Freed (2000) suggests that this lack of agreement in the research pertaining to habitual vocal frequency shows that significant interpersonal pitch variation occurs in hypokinetic dysarthria.

Reduced range of motion in the tongue, jaw and lips (which do not move as quickly or as accurately as before) may explain variable rates of speech and imprecise consonants (Aronson, 1990; Weismer, 1984b).

Darley et al. (1975) attributed the Illogical pauses, variable rates of speech and short phrases (short rushes of speech) to shallow breathing, inflexibility in breathing patterns and poor synchronization of exhalation and speech. These respiratory abnormalities have been attributed to rigidity in the respiratory muscles (Murdoch, Chenery, Bowler, & Ingram, 1989; Solomon & Hixon, 1993). The typical stooped posture common in people with the disease also interferes with adequate respiratory support (Yorkston, Beukelman, Strand, & Bell, 1999).

Reduced overall vocal volume has been observed perceptually and reported (Darley et al., 1975; Ludlow & Bassich, 1984), but research findings for acoustic correlates for vocal intensity on specific tasks tested do not support these observations (Canter, 1963; Ludlow & Bassich, 1984; Metter & Hanson, 1986). However, most sources do agree that intensity range is reduced in people with PD (Canter, 1965; Goberman, Coelho, & Robb, 2002).

Although speech and voice problems can vary widely in severity, most individuals with PD eventually develop communication problems as the disease progresses (Selby, 1986). The first sign of PD (Ramig, Bonitati, Lemke, & Horii 1994), and often the first change noted in the communication domain, is a slight reduction in loudness (Aronson, 1990; Aronson & Bless, 2009; Harel, Cannizzaro, Cohen, Reilly, & Snyder, 2004). Some individuals experience a change in vocal quality as well. The onset can be insidious and gradual, which may explain why many patients say, “I have always had a quiet voice.” In the early stages some people complain of having to make increased effort when talking even though no speech symptoms can be detected (Yorkston et al., 1999), while others are not even aware of voice and speech changes that can be noticed by trained listeners (Stewart et al., 1995). In summary, most people with PD have voice and speech problems at some point in their illness that affect their ability to socialize, work and participate fully in life.

2. Swallowing Difficulties in Persons with PD

In the PD population swallowing disorders are even more prevalent than voice and speech disorders (Logemann, Blonsky, & Boshes, 1975). Ninety-five percent of patients with PD have swallowing problems (Sharkawi et al., 2002) and these problems can have serious consequences. Life threatening aspiration pneumonia can develop if the airway is not adequately protected. This occurs when the vocal mechanism is unable to protect the airway by rising and closing during the swallow, or by coughing and throat clearing after the swallow. The health and conditioning of the larynx is instrumental in airway protection. During a normal swallow, the larynx elevates and the vocal folds close so that food and liquid do not go down the trachea and into the lungs. Coughing and throat clearing can remove unwanted substances from the entrance to the lungs after the swallow. Poor laryngeal elevation, delayed swallow (tongue movements impaired), weak cough or throat clearing, and poor laryngeal closure may all compromise airway protection and have serious health consequences.

3. Cognitive Changes in Persons with PD

Early mild cognitive changes in PD have been identified (Lees & Smith, 1983) and more extensive cognitive changes can also accompany the disease (Brown & Marsden, 1984), affecting language abilities and thus communication. Brown and Marsden conservatively estimate that 20% of people with Parkinson's disease have dementia.

Many researchers agree that people with PD have impaired expression of emotion due to flat affect and a lack of vocal inflection as a result of the disease (Borod, 2000; Caekebeke, Jennekens-Schinkel, van der Linden, Burruma, & Roos, 1991; Mobes, Joppich, Stiebritz, Dengler, & Schroder, 2008; Schroder et al., 2006), but there is disagreement on whether or not impaired reception or perceptual problems underlie the flat affect and monotone voice.

There has also been some discussion and preliminary research on another sensory and perceptual deficit in PD (Ramig & Verdolini, 1998) that explains the challenges clinicians experience while trying to assist individuals with PD to use louder voices, a process called re-calibration. Patients perceive that their voices are too loud even when the loudness level is normal (Ho, Bradshaw, & Iansek, 2000; Liotti et al., 2003). Essentially, people with PD need to be oriented (recalibrated) to the new effort level required to produce adequate speech loudness. The reduced respiratory abilities and less compliant rib cages in patients with PD (Solomon & Hixon, 1993), as well as the slow, gradual onset of these changes, may also help to explain this clinical challenge affecting long-term maintenance of new vocal skills. Recalibration may also be more difficult to accomplish if the progressive cognitive changes associated with dementia are present.

In summary, IPD is the most common type of PD and is 3.8 times more prevalent in Alberta than in the world as a whole. It is generally diagnosed later in life, occurs with equal frequency in both genders and shortens life expectancy. The disease is characterized by deficits in dopamine production in the substantia nigra and produces multiple movement symptoms all over the body, including mobility issues, and voice, speech, swallowing, cognitive and perceptual deficits. Although difficulties with voice and speech can cause serious social and economic problems for those diagnosed with PD, the number seen by speech and language services is still quite small. The next chapter explores the literature to find out what speech and voice treatments are available to people with PD.

Chapter II: Literature Review of Treatment for Voice and Speech Problems in Parkinson's Disease

A. Library Search Methods

A literature search was completed using the following key words: Parkinson disease, Parkinson's disease, singing, sing, song, choral, choir, vocal, voice, breath, breathing, breathing exercise, speech, speech intelligibility, speech production, phonation, vocalization, voice therapy, voice quality, music, music therapy, recreation therapy, speech therapy, voice training, speech disorders, speech acoustics, psychomusicology, measurement, and treatment outcomes. Databases searched were CINAHL, Psych Info, Ovid Medline, ComDisDome, Web of Science, Google basic and advanced, Cochrane Reviews and the International Index to Music Periodicals. The search results were limited to English and French languages, and to publications since 2005. In addition, articles published in the *Journal of Voice* and the *Journal of Singing* since 2005 were reviewed by hand. Several relevant articles including some earlier than 2005 were also identified from reference lists in articles and from previous literature searches. The literature review also included books relevant to the topics listed above.

B. Speech-Language Pathology Approaches

1. Introduction

Traditional speech language pathology (SLP) approaches to remediation of the voice and speech problems in PD involved one to two

sessions per week (low intensity) with focus on articulation, or the 'speech aspects', not the 'voice aspects', of the disorder (Yorkston, Beukelman, & Hakel,1996). Minimal progress resulted, carryover was nonexistent and communication skills still tended to deteriorate as the disease progressed (Allan, 1970; Sarno, 1968). At the end of her article, Sarno (1968) states, "It is our strong impression that the speech of these patients does not improve with treatment." (p. 274). She did not offer specific details concerning time periods of treatment or stage of disease of patients treated. Greene and Mathieson (1991) believe that this lack of success reduced referrals to Speech Language Pathologists from physicians. A change in treatment focus to a vocalization approach showed that improved vocal loudness automatically improved articulation (Scott & Caird, 1983). Once the focus of treatment changed to voice and phonation rather than speech and articulation, positive outcomes resulted. All the studies discussed below involve vocalization based therapy.

2. Cochrane Reviews

There are two Cochrane reviews (Deane, Whurr, Playford, Ben-Shlomo, & Clarke, 2010a; 2010b) available on speech and language treatment for dysarthria in PD. One Cochrane review (Deane et al., 2010b) examined three different randomized control trial studies (n = 63 patients) up to and including studies completed by February 2002 on speech and language therapy versus no intervention. Of the three studies chosen for inclusion in this Cochrane review, one was Ramig, Sapir, Fox and

Countryman's 2001 study on the Lee Silverman Voice Treatment® (LSVT® LOUD), an intensive phonation based (voice) therapy. The other two studies, both British, (Johnson & Pring, 1990; Robertson & Thomson, 1984) used vocalization with visual feedback. The Cochrane reviewers state that the therapies used in each trial were different and that the duration and intensity of the therapies varied. Female patients made up only 29% of the sample, while they represent 50% of the total PD population (Rajput, Offord, Beard, & Kurland, 1984). The two British studies included ratings of overall speech quality (*Frenchay Dysarthria Assessment* and *Dysarthria Profile*). Only Robertson and Thomson (1984) included measures relevant to the everyday life of the patient arrived at by consulting family and friends about patient intelligibility.

There were similarities between the three studies as well. All three studies were vocalization-based rather than articulation-based, so the therapy approaches were similar. The variations in duration and intensity mentioned by the Cochrane reviewers were minor since all were intensive and short term, lasting 2 to 4 weeks with a total of 10 to 25 hours of treatment. Treatment and control groups were similar in the Ramig, Sapir, Fox, et al. (2001) and Johnson and Pring (1990) studies. Outcomes included intensity and frequency measures.

The other Cochrane review (Deane et al., 2010a) examined studies that compared two types of speech and language treatment. It found two

randomized control studies comparing two different approaches to remediation of dysarthria in PD. One was conducted by Ramig, Countryman, Thompson and Horii (1995) and the other by Scott and Caird (1983), and in total involved 71 people with PD. Ramig et al. (1995) compared respiratory therapy and LSVT® LOUD, and Scott and Caird (1983) compared prosodic therapy with and without visual feedback (Vocalite - a light that responds to vocal loudness levels). The Cochrane review authors (Deane et al., 2010a) found significant methodological flaws in concealment of allocation of patients to groups in both studies. For example, Deane et al. (2010a) criticized Ramig et al. (1995) for using something Deane et al. (2010a) referred to as "alternate allocation." In the Ramig et al. (1995) work itself, they state that "subjects were randomly assigned to one of two treatment groups" (p. 38). However, Deane et al. (2010a) stated that "alternate allocation" is a poor method in that it is not truly random and that the allocation of patients to one group or another is not concealed from the therapist. Thus they concluded that selection bias could not be ruled out. Further, they noted concerns about the possibility of selection bias in the Scott and Caird (1983) study, too, given that the allocation of patients to groups was carried out by an investigator who had previously served as a physician to some of the participants. One of the goals of this Cochrane review was to compare novel with standard speech and language therapies. Unfortunately, what was considered novel and standard was not yet established in the literature. The treatments were

also so varied that a meta-analysis could not be completed. The outcomes of one therapy versus outcomes of the other therapy were not compared statistically in either study, so no conclusions as to which treatment was more efficacious could be drawn. Better outcome measurements in general were found in the Scott and Caird (1983) and Ramig et al. (1995) studies, than in the three studies (Johnson and Pring (1990), Ramig, Sapir, Fox, et al. (2001) and Robertson and Thomson (1984)), examined by the other Cochrane review. Scott and Caird (1983) measured intelligibility and Ramig et al. (1995) measured speech activities in daily living and caregiver's impressions of speech.

Both Cochrane reviews concluded that the randomized controlled trials were not sufficient to support or refute the efficacy of speech language therapy for dysarthria in PD. They also pointed out that, as not all studies used the same techniques, best practice for PD has not yet been established.

Six of the seven therapy techniques used in the studies examined by the two Cochrane reviews (not including a respiratory comparison technique) were actually very similar. All six studies utilized some form of vocalization program and reported positive changes to dysarthric speech. All six studies seemed to agree that the best therapy is a type of vocalization therapy, as opposed to the older technique of articulation or speech-based therapy.

3. Lee Silverman Voice Treatment® LOUD Studies

Physiotherapists have found that encouraging greater physical effort in persons with PD allows them to overcome some of their motor impairment deficits (McDowell, Lee, & Sweet, 1986). People with PD, unlike those with other degenerative neurological diseases such as multiple sclerosis and amyotrophic lateral sclerosis, tolerate exercise well, allowing substantial gains to be made in physical exercise programs (Reuter, Engelhardt, Stecker, & Baas, 1999). This has led Speech Language Pathologists to explore new, more physical and more rigorous treatment methods, including a phonation-based (vocalization) approach to PD. Ramig, Bonitati and others developed a “voice centered” approach in 1987 (Ramig et al., 1994) that is now called LSVT® (Lee Silverman Voice Treatment) LOUD. The main focus of treatment is to increase vocal loudness. Therapists use vocal loudness to improve the whole speech production system (respiratory support and articulation). Increased vocal effort is emphasized in an effort to increase vocal fold adduction, thereby reducing vocal fold bowing and glottic chinks and thus increasing loudness and decreasing breathiness. They also use pushing techniques, and increasingly louder vowel productions with good voice quality (pleasant and clear sounding voice). Improved intonation and laryngeal flexibility are achieved through pitch change exercises. Holding vowels to maximum duration with constant intensity and frequency is used to improve vocal fold stability, thus improving vocal quality. Another goal is calibration, the

process of adjusting to the newly required increased effort needed to produce a louder voice. Carryover is facilitated by establishing internal rather than external cues, so that the person acquires self-monitoring skills and is able to use the louder voice in everyday speech. The sessions are intensive (four times per week for four weeks).

Efficacy studies for LSVT® LOUD are ongoing, and a large clinical trial is presently being conducted through the National Institute on Deafness and Other Communication Disorders. Subjects receiving this type of therapy tend to be moderately affected by PD (mostly in stage III on the Hoehn and Yahr scale (1967)). LSVT® LOUD researchers have published many interesting and relevant articles on voice improvement and PET scan normalization changes in the brain (Liotti et al., 2003), improved vocal fold closure as assessed by laryngostroboscopy (Smith, Ramig, Dromey, Perez, & Samandari, 1995), improved swallowing as shown by modified barium swallow studies (Sharkawai et al., 2002), respiratory changes (Huber, Stathopoulos, Ramig, & Lancaster, 2003), reduction of flat affect (Spielman et al., 2003) and perceptual voice quality changes (Baumgartner, Sapir, & Ramig, 2001; Sapir et al., 2002).

Four studies have been conducted on the actual efficacy of LSVT® LOUD in remediating speech and voice disorders in PD (Ramig, 1992; Ramig et al., 1994; 1995**;** Ramig, Sapir, Fox, et al. 2001). The two earlier studies were valuable exploratory single group designs. The Ramig, Sapir,

Fox, et al., 2001 and Ramig et al., 1995 studies were randomized control studies that were considered rigorous enough to be included in the Cochrane reviews discussed earlier. Ramig, Countryman, O'Brien, Hoehn and Thompson (1996) have also conducted a 6 and 12-month follow-up, a 2-year follow-up (Ramig, Sapir, Countryman, et al., 2001) and a perceptual judgment of voices study (Sapir et al., 2002) using the data from and adding to the 1995 study. They have consistently shown statistically significant changes in objective measures of voice and speech (maximum phonation time, maximum phonation range, fundamental frequency, intelligibility and intensity). The LSVT® LOUD researchers have also shown that increased vocal loudness and phonatory effort improve voice characteristics, enhance articulation (Ramig, 1992; Ramig, Fox, & Sapir, 2004) and improve tongue-based swallowing disorders (Sharkawi et al., 2002). It is almost as though the motor system gets a kick-start and that all systems (respiratory, phonatory and articulatory) improve, resulting in enhancement of skills such as articulation and swallowing not specifically targeted in therapy (Ramig et al., 2004). Vocalization treatment may activate neuromuscular connections throughout the vocal and swallowing mechanisms. Preliminary PET scan studies support this theory (Liotti et al., 2003).

The well researched and effective LSVT® LOUD treatment with its extended vocalization exercises (maximum phonation durations and holding vowels at differing pitches) lends support to all vocalization

treatment for PD. In fact, the LSVT® LOUD community has created an enduring benchmark in speech language pathology approaches to PD and has had an effect on other therapy approaches within the Speech Language Pathology professions. Although the LSVT® LOUD researchers have demonstrated some positive results with long-term carryover at six-month (Ramig et al., 1996; Ramig, Sapir, Fox, et al., 2001), one-year (Ramig et al., 1996) and two-year (Ramig, Sapir, Countryman, et al., 2001) intervals following treatment, carryover is still a challenge (Fox et al., 2002) given the degenerative nature of PD (Ramig et al., 1994). Adams and Dykstra (2009) also question the ecological validity of those studies, because the LSVT® LOUD follow-up measures were all taken in clinic and not in everyday natural environments.

Other dosages of LSVT® LOUD may be effective. The LSVT® LOUD group advocate intensive therapy (four times per week for 4 weeks), but the recent LSVT® LOUD study by Spielman, Ramig, Mahler, Halpern, and Gavin, (2007) showed that twice a week for eight weeks had the same positive results as the prescribed standard LSVT® LOUD dosage (the Hoehn & Yahr (1967) stages of severity of PD in the participants were similar to that in previous studies). The sample size was small (n=3) but may mean that a less intensive dosage of LSVT® LOUD may also be effective. A successful alternative delivery of LSVT® LOUD treatment was explored by Howell, Tripoliti and Pring (2009) using a web cam for 75% of the sessions.

These different access methods to LSVT® LOUD treatment are important. People diagnosed with PD often live a long time with the diagnosis and must cope with many different stages of voice and speech change. The LSVT® LOUD researchers advocate intensive therapy (four times per week for 4 weeks). While LSVT® LOUD provides an excellent intervention for patients in the middle stages of the disease, where voice loss is apparent, it may not be suitable at earlier stages when people with PD in its early stages may not be as aware of vocal changes. As a result, those at earlier stages may be less interested in an intensive approach. In addition these early stage persons with PD may still be more involved with work and as such be unable to attend such frequent therapy. People with PD at its later stages may also find frequent therapy sessions (four times per week) difficult to manage due to transportation or fatigue problems.

4. Other Speech Language Pathology Approaches

Other speech language pathology researchers have produced good results with different types and dosages of vocalization therapy. The three non-LSVT® LOUD studies included in the two Cochrane reviews (Johnson & Pring, 1990; Robertson & Thomson, 1984; Scott & Caird, 1983) used general vocalization approaches with emphasis on not only loudness, but also on prosody, frequency and patient education, and produced positive improvements in the dysarthric speech of people with PD. Scott and Caird provided 10 hours of therapy over two weeks, Robertson and Thomson provided 35 to 40 hours over two weeks, and Johnson and Pring provided

10 hours over four weeks. Individual and group treatments were both examined in the Cochrane reviews. Ramig et al. (1995), Ramig, Sapir, Fox, et al. (2001), Robertson and Thomson (1984) and Scott and Caird (1983) provided individual therapy. The ability to address individual needs is the main advantage of this type of treatment. One other study included in the Cochrane reviews, Johnson and Pring (1990), used a group approach. With a group approach the therapist loses the ability to focus on the individual and tailor to his or her needs, but there are benefits. Group sessions contribute to carryover of skills, as they more closely resemble everyday speech situations (Ramig & Bennett, 1997). Peer pressure, competition, encouragement and support from other group members may make participants practice more diligently (Ramig & Bennett, 1997). A lack of SLP resources and large patient populations requiring service may also help to explain the growing number of recent studies focusing on group treatment (de Angelis et al., 1997; Gupta, Scholl, & Toynton, 2008; Johnson & Pring, 1990; Manor, Posen, Amir, Dori, & Giladi, 2005; Sullivan, Brune, & Beukelman, 1996). All of these group studies found positive outcomes from group voice therapy. A group of six people with PD received two sessions per week for 8 weeks in the Sullivan et al. (1996) study. Treatment was not well described but goals of intervention included breath support, rate control, increased pitch variation and vocal projection, as well as family education, carryover and articulation. The goals varied somewhat from person to person. Outcome measures

included a self-perception of communication questionnaire (Yorkston, Bombardier, & Hammen, 1992), intelligibility tests (Yorkston, Beukelman, & Traynor, 1984), a speech naturalness rating (Darley et al., 1975) and a five-point perceptual assessment scale administered by three Speech Language Pathologists. Five of the six participants improved their speech performance and maintained their improvement for 10 months following the program on at least some of the measures. De Angelis et al. (1997) treated 20 people with PD in 13 group sessions over four weeks and found increased maximum phonation times, a decrease in airflow (better glottal closure) and an increase in vocal intensity.

Manor et al. (2005) commented that following individual therapy "many patients do not practice treatments at home or apply the learned techniques in everyday situations" (p. 94). These researchers offered weekly 75 minute group sessions for eight weeks meant to improve home practice, maintenance and carryover of vocal skills for patients who had already had individual treatment. The treatment incorporated LSVT® LOUD-like exercises, external cueing and group interaction for communication skills practice. A Speech Language Pathologist and a social worker conducted the sessions. The study found statistically significant results on the *Speech Assessment Scale* (Johnson, 1975) and the *Pragmatic Protocol* (Prutting & Kirchner, 1987). *The Speech Assessment Scale* measured self-assessment of intelligibility (participants' judgments), while the *Pragmatic Protocol* was used by two SLPs to

identify participants' spontaneous initiation of speech and appropriate interactions with others, either as a speaker or listener, in a group situation.

Gupta et al. (2008) provided group voice therapy for 90 minutes once per week for 10 weeks. Their positive, statistically significant results included increased pitch range, habitual loudness and maximum phonation time. They concluded that weekly group voice therapy was adequate to produce a change in the voice and speech of people with PD.

In summary, the only clear conclusion from the speech and language literature is that the better type of treatment for the voice and speech problems related to PD is a vocalization approach as compared to an articulation or speech approach. The fact that increased vocal effort and vocal training tends to improve articulation as well as vocal production has made the older articulation based approaches less relevant.

The best vocalization protocol has not yet been established. The LSVT® LOUD researchers have a well-defined approach and train therapists around the world to replicate it as closely as possible. Other protocols vary and include many different voice therapy techniques.

Dosage has not yet been standardized. Frequency and length of sessions, for example, vary widely. Frequency of treatment ranges from once every week to 4 times per week for 2 to 8 weeks. Length of sessions varies from 45 minutes to 90 minutes. Dosage also depends on whether

therapy is offered individually or in groups. Due to budget cuts and large caseloads, Speech Language Pathologists have begun to consider group approaches in addition to individual therapy as a viable part of a treatment program for those with PD.

Some efficacy studies on LSVT® LOUD have been conducted, but only a few efficacy studies on other vocalization methods for persons with PD have been performed.

C. Neural Plasticity Research in Support of a Vocalization Approach for PD

The concept of neural plasticity, the ability of the brain to actually change both its physical structure (anatomy) and functional organization (physiology) as a result of thinking, learning and movement, first appeared in the literature on constraint-induced treatments for stroke survivors (Taub & Uswatte, 1999) and is now being applied to therapies for PD. A literature review of targeted exercise therapy for the voice and swallow problems associated with PD showed evidence for lasting changes in voice behaviour (Russell, Ciucci, Connor, & Schallert, 2010), suggesting that changes had taken place in the brain.

The five principles underlying neural plasticity are described in a chapter on voice and speech disorders in PD written by Fox et al. (2008). These principles - intensity of accurate practice (frequency, duration, amount of effort, number of repetitions), minimum usage (the minimum amount of activity required to maintain skills and increased use to improve

skills), saliency (performance of rewarding skills and associated positive feedback), complex movements (holistic rather than simple) and timing (early intervention prevents disease progression) - can all be found in the LSVT® LOUD approach to therapy.

Application of these principles can, in fact, improve almost any approach that trains motor function. Teaching singing, like other types of voice training involves refining neuromuscular control of the larynx and respiration (Stark, 1999). In the author's opinion, the neural plasticity principles can be applied to voice training in the singing studio and have actually been used in an intuitive way for centuries in the training of singing voices. For the purpose of this paper 'singing' is defined as the act of producing extended phonation with the human voice. Singing may be especially effective with respect to saliency (singing may be even more rewarding and pleasurable than vocal drill work), complexity (singing requires more sustained co-ordination of articulators, larynx and the respiratory system than many speech tasks) and intensity (singing requires greater vocal and respiratory effort than speech – Gregg, 1994). Articulation is present in singing. Richard Miller (1987, p.30) states that "one sings as one speaks (si canta come si parla)" and that "the physical and acoustic principles that contribute to ideal speech intelligibility must also be present in singing". Laryngeal function in both speech and song involves the vibrations of the vocal folds to adjust pitch (longitudinal

tension of vocal folds) and to open and close the folds for voicing, aspiration and voice quality (Kent, 1997).

Speech and singing are “special acts of respiration” that override the resting tidal respiration and make the whole respiratory system work harder (Hixon, 2006) than during rest breathing. The main difference is the length of the expiratory cycle. Expiration is longer in both speech and song than in normal rest breathing, but longer in singing than in spoken expiration (Gregg, 1994). As a person with PD becomes more and more de-conditioned they tend to move less and more slowly. The muscles gradually become less and less active to the point that even tidal resting breathing becomes effortful (Braun, 2000). By singing they can achieve greater muscle usage, allowing the muscles to be retrained for easier effort during speech. The greater respiratory system effort involved in singing, when compared to speech, is confirmed by several researchers (Hixon, Weismer, & Hoit, 2008; Kent & Ball, 2000; Watson & Hixon, 1987). They label classical singing as the most physically demanding of the singing styles and show that singing (especially classical singing) involves more movement (increased excursion and longer duration held) of the muscles of the abdomen (inward – less expanded than relaxed state of respiration with similar lung volumes) and the chest wall (up and out, a more expanded than relaxed state) for phonation on expiration (Watson & Hixon, 1987). The application of exercise physiology to vocal pedagogy and voice therapy described by Saxon and Schneider (1995) in the

training of the muscles involved in vocal production also supports the use of classical voice training techniques to condition voices.

Singing in a weekly community group could take place early in the disease without healthcare intervention (timing) and may help retention of vocal abilities (minimum use). The timing and minimum use principles can also be realized by adopting singing as a leisure activity.

Timing, including early intervention, has become more interesting to researchers because preliminary evidence shows that early intervention may enhance neural protection (Russell et al., 2010), thus perhaps slowing the disease progression. Earlier diagnosis of PD is needed to allow for such intervention. Early vocal symptoms themselves may be useful in making an earlier diagnosis of the disease itself (Harel et al., 2004) and speech samples obtained over the phone are already being used to monitor progression of the overall disease in people with PD (Tsanas, Little, McSharry, & Ramig, 2009).

D. Other Literature to Justify Clinical Practice

Singing exercises have been used for many years in voice therapy (Riley & Carroll, 1995); consequently inclusion of singing exercises in voice therapy for PD would not be unexpected. Carroll (2000), a Speech Language Pathologist, recommends singing exercises to treat voice problems and “elicit optimum vocal quality” (p. 1003). A review of music education, choral music, vocal pedagogy, theatre voice pedagogy,

psychology, music therapy, speech language pathology, nursing and medical literature was undertaken to examine whether there is evidence to support the therapeutic use of singing. Articles on the benefits of singing and a few more specific studies on the use of singing for people with PD are reviewed below.

1. Practical Application of Singing

From a pragmatic point of view singing has many advantages. Everyone is a singer and has the instrument within them. Singing is a primal part of humankind - babies sing before they talk (Chapman, 2006). There is evidence that the auditory-motor feedback loop in the brain is more intensely engaged by singing than by instrument playing (Bangert et al., 2006; Kleber, Veit, Birbaumer, Gruzelier, & Lotze, 2010) and that the auditory-motor networks in the brains of singers are more developed than those of instrumentalists (Loui, Wan, & Schlaug, 2010). The act of singing encourages greater excursion of the rib cage and the use of a higher percentage of vital capacity than speaking or rest breathing (Watson & Hixon, 1987) and thus can be employed to condition the respiratory mechanism for speech (Yan, Ruber, Hohmann, & Schlaug, 2010). Singing can be pleasurable and just as it enhances dry text and makes the repetition of words and texts more enticing (Smith & Sataloff, 2006) it makes the repetitive practice necessary in therapy more enjoyable. While singing can take place in individual sessions, group singing provides opportunities for successful experiences at differing levels of speech,

language and musical ability, and also builds group cohesiveness or social bonding through shared participation in a pleasurable and productive communal enterprise. Because it can be performed easily in groups and is readily available in most communities, singing as vocalization treatment may be accessible and economical. In addition, group singing is a normal activity involving socialization interaction, and may thus facilitate the maintenance of vocal skills over the long term (carryover).

2. General Support for Singing in Speech Language Therapy

The research into singing as a therapeutic intervention has been conducted on a variety of populations, from those with degenerative neurological diseases (e.g., dementia, PD) and neurological insults (e.g., stroke, brain injury), to ordinary citizens in choirs and trained vocal artists. Some of the research on the therapeutic effects of singing has been conducted in the field of music therapy (defined as the therapeutic use of music). Music therapy involves passive and active musical engagement with any musical instrument and may or may not include singing. In the area of stroke and brain injury, research suggests that music therapy involving singing improves social interaction (Nayak, Wheeler, Shiflett, & Agostinelli, 2000), mood, pitch range and pitch variation in speech (Baker, Wigram, & Gold, 2005), as well as speech intelligibility (Tamplin, 2008). In general, the studies are not very rigorous, but the number of studies in so many varied fields suggests that professionals are interested in the beneficial effects of singing. The establishment of organizations such as

the ‘Society of Arts in Healthcare’ and journals such as *Arts and Health* reflect a growing interest in the relation between the arts and health.

The benefits found to result from individual and choral singing can be physical and psycho-social. Physical benefits include increased respiratory muscle strength (Wiens, Reimer, & Guyn, 1999) that endures (Grape, Sandgrenm, Hansson, Ericson, & Theorell, 2003), better vocal control (Natke, Donath, & Kalveram, 2003), enhancement of the immune system (Beck, Cesario, Yousefi, & Enamoto, 2000; Kreutz, Bongard, Rohrmann, Hodapp, & Grebe, 2004), stress reduction (Beck et al., 2000; Wiens, Janzen, & Murray, 2001), fewer medical visits and reduced medication use (Cohen, 2009), better cardio-physiological fitness (Grape et al., 2003), improved oxygen saturation (Bechler-Karsch, 1993) and lowered heart rate/blood pressure (Bechler-Karsch, 1993). Psychological benefits include relaxation (Beck et al., 2000; Clift & Hancox, 2001), emotional release (Hamer, 1991), improved reality orientation (Shively & Henkin, 1986; Wolfe, 1983), improved mood (Bailey, 1985; Bechler-Karsch, 1993), improved self esteem (Bright, 1972), reduced agitation (Gerdner & Swanson, 1993; Lipe, 1991), reduced anxiety (Evans & Rubio, 1994; Smith-Marchese, 1994), increased attention span (Christie, 1992) and improved motivation (Purdie, 1997). Social benefits include improved communication (Selman, 1988), increased socialization and participation in therapeutic treatment programs (Pollack & Namazi, 1992; Purdie, 1997).

Glennie (2005) calls speech “a form of music which overflows with inflection, phrasing, dynamics, rhythm, punctuation, tempo, expression and emotion.” Singing is essentially a form of exaggerated speech and Glennie’s statement makes speech sound like song. Speech is embedded in song and shares the same physical mechanism, as well as some of the same neural mechanisms (Kleber et al., 2010). The universality and naturalness of singing make it an especially valuable tool for voice and speech remediation (Yan et al., 2010). Speech and song share diction (articulation), speed (rate), variation in frequency (pitch) and intensity (loudness), and rhythm (duration and prosody) (Cohen, 1994; Haneishi, 2001). Frequency (pitch) range demands are often much more extensive in singing than in speech. Singing naturally enhances speech production (Haneishi, 2001) because it extends the length of phonation, thereby elongating all articulatory movements and slowing speech rate. According to Richard Miller, a renowned vocal pedagogue, vocal projection is improved with increased respiratory and vocal endurance (Miller, 1986). Compared with speaking, singing uses a more sustained respiratory effort, better posture, larger facial movements, greater pitch variability and range, greater speech rate variation, more prolonged articulation and louder voice production (Haneishi, 2001). People with PD may benefit from the elongation of articulatory movements, slower rates, increased vocal projection, increased respiration and vocal endurance, better posture, larger facial movements and louder voice production, all mentioned as

benefits of singing. There is evidence that aspects of singing such as prolongation and exaggerated articulation have been effective in improving speech outcomes for people with PD. Prolongation can reduce speech rate and improve intelligibility (Dagenais, Southwood, & Lee, 1998), and exaggerated articulation has been found to improve the speech of individuals with PD (Goberman & Elmer, 2005).

The work of many researchers supports the therapeutic use of singing for improving speech and language abilities. Singing is used by music therapists to remediate speech and language skills in stroke and brain injured patients (Cohen, 1992), and helps to maintain speech and language skills and increase verbal output in Alzheimer's disease patients (Sambandham & Schirm, 1995). Speech Language Pathologists have also successfully used melody paired with phrases in "Melodic Intonation Therapy" for non-fluent aphasia (Sparks & Holland, 1976).

In summary, there appear to be many benefits from the use of singing, especially in the quality of life domain. The fact that speech and song share the same mechanisms has been explored by a number of Speech Language Pathologists with different populations, including people suffering from strokes, brain injuries and dementia, as well as the elderly.

3. Music Therapy for Parkinson's Disease

Music therapy has been useful in changing motor activity in PD (Thaut & McIntosh, 1999). Rhythm helps to organize motor movement

(Tomaino, 2000), and mental singing helps PD patients to initiate movement and prevent or solve freezing problems (Satoh & Kuzuhara, 2008). Vocalization, chanting, speaking and singing have often been included with physical movement as part of what music therapists term "active music therapy" (the patient participates in some way) as opposed to "passive music therapy" (the patient listens). This pairing of physical movement and voice in active music therapy has advantages that were noticed by the LSVT BIG® and LSVT LOUD® programs, which now combine voice/speech and physiotherapy (Fox et al., 2008). In music therapy there are options for participation, one of which is vocalization. A study that used choral singing, voice exercise and physical movement as part of a music therapy approach found improvement in mood, physical movement and socialization in persons with PD (Pacchetti et al., 2000). Unfortunately, the general outcome measures used (*Unified Parkinson's Disease Rating Scale* - Fahn & Elton, 1987*, Parkinson's Disease Quality of Life Questionnaire* - de Boer, Wijker, Speelman and Haes, 1996 and the *Happiness Measure* – Fordyce, 1988) did not assess separate voice and speech changes.

The use of the voice on its own (without instruments or activities) is relatively new in music therapy (Rider, Mickey, Weldin, & Hawkinson, 2003). Some studies that use only singing have produced successful outcomes with stroke patients (Cohen, 1995; Cohen & Masse, 1993). The review of music therapy literature revealed only one small study with no

control group (n=4) on the use of singing alone to treat voice and speech problems in PD. One music therapist (Haneishi, 2001), inspired by Cohen's work and the efficacy studies on the LSVT® LOUD, conducted a small study on four patients with PD. She used singing and vocalization ("music therapy voice protocol") as a treatment for speech intelligibility and vocal intensity. Intensive individual 60-minute sessions took place three times per week for at least four weeks. The frequency of sessions was similar to that in the LSVT® LOUD protocol. The results were impressive, with caregiver-rated speech intelligibility and vocal intensity both showing statistically significant improvement. Haneishi (2001) succeeded in choosing outcome measures that were relevant to patients and caregivers, and an acoustic measure (vocal intensity) that was able to show actual change. The positive results of this small novel study suggest that singing for people with PD has vocal benefits and that further studies should be conducted to explore the benefits of the singing form of vocalization as a treatment for voice problems in PD.

In summary, the review of music therapy literature revealed only one small study (n=4), with no control group, on the use of singing alone to treat voice and speech problems in PD. Singing has been beneficial in other related disorders, and may have beneficial psychological, social and vocal effects on people with PD.

4. Cross Disciplinary Research on Singing as Therapy for PD

A pilot project (Tanner-Semple, Wiens, & Campbell, 2005) was conducted to examine the effectiveness of a short period of intensive individual voice lessons on both speech intelligibility and vocal characteristics of people with PD as assessed by the *Phonetic and Sentence Intelligibility Tests*, the *Speech Intelligibility Inventory: Self Assessment Form* (Kent, 1994 - see appendix B), and acoustic/timing correlates of vocal health (pitch and loudness range, habitual pitch and loudness, maximum phonation time). A voice teacher (Harold Wiens) who follows a physiologically based German approach provided individual singing lessons to seven people (five male, two female) with PD three times per week over a four to six week period. Sessions were from 45 minutes to one hour long. This intensity of treatment (3 times per week) was the same as that used by Haneishi (2001) and is comparable to the LSVT® LOUD intensity of four times per week. The teacher had minimal knowledge of the LSVT® LOUD. He did not use a strict sequenced protocol with each participant, but followed an individualized approach that made use of a toolbox of techniques developed over many years in the training of healthy projected voices. Statistically significant improvements were seen in pitch range measured in semitones. No significant change in maximum phonation time, self-assessed intelligibility, intensity (habitual loudness) or intensity (loudness) range was found, and the formal speech intelligibility measures were not responsive enough to show changes in patients earlier in the disease progression (they scored in the normal

range prior to treatment). Small clinical changes were seen in maximum phonation time and self-assessed intelligibility that could be explored in a larger study. Although formal interviews were not conducted, participants provided anecdotal reports of reduced stuttering (one of the participants was a stutterer), improved coughing and swallowing, improved facial expression and increased participation in conversations socially. Two participants re-joined choirs and found that it helped to maintain their better quality voice. Naïve and untrained listeners, when asked if a voice was better or the same, noticed an improvement in voices when they heard before and after tapes.

There is also some value in the fact that this was a field study in which everyday voice teaching as found in the community was tested on people with PD. It shows what may happen if someone with PD attends voice lessons, just as anyone might in their daily life. The voice treatment given was not prescribed, controlled or adapted specifically for PD. Essentially, this pilot study tested the effect that an experienced, fully qualified singing teacher could have on the voices of people with PD, and as such may also inform the development of a larger study. A larger sample size would be needed as well as a more defined protocol and controls for intervening variables.

Other Speech–Language Pathologists have recognized the clinical value of singing in PD treatment. Two recent group studies on singing (di

Benedetto et al., 2009; Evans, Canavan, Foy, Langford, & Proctor, 2011) involving musicians and speech language pathologists have recently appeared in the literature. The di Benedetto et al. (2009) study combined separate sessions of group speech/voice therapy and choral singing. The therapist, trained in both speech language pathology and choral singing, offered two one-hour sessions of speech/voice therapy and one two-hour session of choral singing per week for between 10 and 13 weeks. The researchers describe the speech/voice therapy as teaching the basic techniques necessary for choral singing. The study found statistically significant changes in three respiratory measures (functional residual capacity, maximal inspiratory pressure, maximal expiration pressure), in maximum phonation time and in two perceptual analyses (prosody and fatigue). The improved respiratory measures may have contributed to voice improvement, given that people with PD have respiratory problems (Darley et al., 1975) and that voice cannot be produced without adequate breathing force from the respiratory apparatus (Hixon et al., 2008). Four examiners blinded to the subjects and the time of testing (pre or post) made the judgments. Perception of prosody was measured using a visual analog scale, and the perception of the presence or absence of vocal fatigue was measured with a dichotomous scale (yes/no). There was no statistically significant change in perception of either prosody or presence of fatigue in conversation; however, changes in both were statistically significant in the reading task. It would appear that the new skills were

applied in the easier reading task, but not retained during the demands of spontaneous conversation. The silent pauses and breath holding associated with high cognitive linguistic demands (such as in conversation) mean that less speech is produced per breath (Hixon et al., 2008). Reading has been shown to be easier from a breathing point of view in normal adults and this ease may be related to the less demanding cognitive-linguistic load of reading (Wang, Green, Nip, Kent, & Kent, 2010).

In the study by Evans et al. (2011), a singing teacher provided choral singing sessions, with consultation and assessment support from two Speech Language Pathologists. Speech Language Pathologists conducted 6 to 8 sessions of individual speech and voice therapy sessions with each participant. A two-hour singing session took place once every two weeks for two years. Ten out of 17 people completed all assessments. The outcome measures showed small significant change in maximum phonation time, pitch range, elicited intensity (loudness range) and overall perceptual rating of speech measured on the *Frenchay Dysarthria Examination* (Enderby, 1983). A small clinically meaningful improvement (but not statistically significant change) was seen in communication on the quality of life measure (Parkinson Disease Questionnaire 39, Jenkinson, Fitzpatrick, Peto, Greenhall, & Hyman, 1997).

E. Summary

The review of speech language pathology, music therapy and vocal and choral pedagogy literature revealed many studies that support the benefits of singing and vocalization for the normal population and for those diagnosed with neurological diseases. These studies have drawn from exercise research in physiotherapy, motor learning research, and from research in their own respective disciplines. Singing has many practical applications in voice treatment, and the close and unique relationship between speech and singing can potentially be beneficial for people with PD.

Evidence of specific benefits from vocalization and singing for people with PD can be found in studies from music therapy and in speech pathology. Haneishi (2001), a music therapist, and a number of Speech Language Pathologists (Ramig, Sapir, Countryman, et al., 2001; Robertson & Thomson, 1984; Scott & Caird 1983; Tanner-Semple et al., 2005) tested individual treatment, while others tested group treatment (de Angelis et al., 1997; di Benedetto et al., 2009; Evans et al., 2011; Gupta et al., 2008; Manor et al., 2005; Pacchetti, Aglieri, Mancini, Martignoni, & Nappi, 1998; Pacchetti et al., 2000; Robertson & Thomson, 1984; Sullivan et al., 1996). Approaches appear to be developing that balance individual with group treatment, community with clinic based environments, and the intense repetitive practice needed with time constraints of therapists and patients.

To date, individual and group vocalization programs for people with PD have included LSVT® LOUD, other voice therapies, voice lessons, choral singing and combinations of the above. All have shown positive trends on a variety of parameters. Intensity has varied from once every two weeks to 4 times per week and programs lasted from 2 weeks to 2 years in length, while sessions have varied from 45 minutes to 2 hours in length.

The literature included in this section revealed that singing has been adopted and adapted by music therapy and speech language pathology professions because it provides a vigorous, yet coordinated conditioning of the vocal mechanism and an attractive and engaging use of speech within song. These features of singing and vocalization intervention, along with the long term and changing needs of persons with PD, explain the recent surge of Parkinson choral groups around the world and the new research studies on these groups, including one at Harvard funded by the Michael J. Fox Foundation (Tarsy, Shih, & Piel, 2009) An understanding of the benefits of group singing and vocalization for persons with PD forms the rationale for the study described in the following chapters of this thesis.

Chapter III: Description of Study on Vocalization Therapy for People with Idiopathic Parkinson's Disease

A. Research Question:

Does a "cross-disciplinary group vocalization treatment" increase the vocal ability and vocal quality of life of people with idiopathic Parkinson's disease?

B. Definitions

1. Cross-Disciplinary

"Cross-disciplinary" is used when two or more different professions or disciplines are involved. In this case, the two disciplines are voice therapy from the field of speech language pathology and individual singing and choral singing from vocal pedagogy.

2. Vocalization Treatment

The term vocalization has been used frequently in this paper to point out the commonality between the studies discussed and encompasses all the phonation activities and treatments reviewed in the previous chapter. Use of the term helps to unify all of the fields that may make a contribution to the vocal health and the well being of people with PD.

A vocalization therapy or treatment is any form of phonation-based training (phonation is produced by the vocal folds or cords as they come together and vibrate to produce sound as air is driven from the lungs). It

may include singing, chanting (sustained repeated vowel sounds), humming, vocal improvisation, toning (sounds on pitches with fewer consonants than singing), keening (group vocalization at Irish funerals), projected speech, vowel prolongation, LSVT® LOUD vocal function exercises, maximum phonation time drills and the various exercises used in vocal training. Vocalization is physically demanding. It requires the use of abdominal, rib cage wall and diaphragm muscles for respiration, laryngeal muscles for phonation and oral and facial muscles for articulation. Vocalization therapy takes place in acting training, singing training and the voice therapy practiced by Speech Language Pathologists. These three fields of voice training all use similar pitch changing exercises, loudness changing exercises, respiration and phonation exercises to improve voice quality, endurance, vocal range (pitch and loudness), projection, and overall vocal performance for singing or speaking.

3. Vocal Ability

"Vocal ability" is defined as vocal skills, including skills that show laryngeal health (such as the ability to cough, clear one's throat, prolong a consistent vowel), voice quality (how pleasant and clear the voice sounds) and intelligibility (how a poor voice may interfere with how easily one's speech is understood by others). The last two refer to how the voice is perceived. Most people recognize a poor or good voice quality, but it is difficult to define. Kent and Ball (2000) in the introduction to their book

entitled *Voice Quality Measurement*, say “Voice quality is a concept that is at once widely recognized but very difficult to define in a way that is universally satisfying” (p. ix). They do admit that it ranges from disordered to ideal (Kent & Ball, 2000). For this paper good voice quality is defined as an agreeable vocal sound, free of harshness, breathiness or noise and is associated with a healthy larynx.

“Voice quality aberrations of breathiness, roughness, hoarseness, tremulousness, reduced pitch range and a modal speaking pitch inappropriate to the patient’s age and sex” have been identified as laryngeal disorders in people with PD by Logemann et al., 1978, p. 49). There is also some evidence that levodopa related dyskinesias and hyperkinesias in the larynx contribute to harsh voice quality in some patients (Ludlow & Bassich, 1984). In the normal population vocal quality seems to improve as physical vocal skills (greater vocal clarity, greater pitch and loudness range, better vocal projection) and laryngeal health improve. According to Richard Miller (1986), a vocal teacher, voice quality in singing improves with increased frequency range, increased vocal fold closure time (measured with an electroglottogram) and increased steadiness of phonation. Hollien (2000), a voice scientist, suggests that a good voice has extensive variability in vocal intensity and fundamental frequency, does not exhibit noise, breathiness, or harshness, and is appropriate to the situation. With this in mind, acoustic/timing measures of “vocal ability” (MPT, frequency and intensity ranges and averages, and

fundamental frequency variation) and perceptual measures of voice quality (i.e., how the voice sounds) were selected for the present study.

4. Vocal Quality of Life

"Quality of life" is defined as general well being or life satisfaction, and vocal quality of life is defined as the communication aspects of well being and life satisfaction. In this study vocal quality of life was assessed using two measures from the participants' perspective, the *Speech Intelligibility Inventory: Self-Assessment Form* questionnaire (Kent, 1994 - see Appendix B) and the *Voice-Related Quality of Life* (V-RQOL) questionnaire (Hogikyan & Sethuraman, 1999 - see Appendix C). The *Speech Intelligibility Inventory: Self-Assessment Form* questionnaire (Kent, 1994), also used by Haneishi (2001), is an indirect measure of intelligibility. This questionnaire measures the patient's perception of how easily his/her own speech is understood by others. Intelligibility is an important component of two-way communication and encompasses speech and voice. Direct measurement of intelligibility has proven to be difficult in past studies since many participants fall into the normal range of most intelligibility tests during the earlier stages of PD. Thus, before/after treatment changes cannot be seen because scores are too high. The second instrument used was a quality of life measure developed specifically for voice disorders, the *Voice-Related Quality of Life* (V-RQOL) (see Appendix C). The participants completed both questionnaires before and after treatment.

5. Other definitions

a. The Choral Effect

The choral effect was first confirmed experimentally by Johnson and Rosen (1937). They found that stutterers read fluently in unison with another person. The choral effect occurs when two or more people are reciting, reading or singing a text together. People find it easier to recall a memorized text, to read aloud fluently and to form words in this situation (Saskatchewan Education, 1997). This phenomenon may make it easier for people to participate vocally, and thus encourage attendance and full participation. Speech Language Pathologists use this technique in the treatment of dysarthria (including Parkinsonian dysarthria), in apraxia therapy to facilitate articulation and normal rate and prosody, and in stuttering therapy to eliminate dysfluencies (Kalinowski & Saltuklarglu, 2003). In the treatment of the speech and voice problems associated with PD the technique may help to regulate rate, improve initiation of speech and improve articulation. The effect occurs in choral singing and might empower people with PD to use their voices more effectively, essentially making communication easier. The choral effect may act like an external cue/model and thus help with initiation of speech, fluency and word retrieval. Other external cues have been shown to be effective for people with PD. A verbal instruction to increase speech loudness improves volume regulation of speech (Ho, Bradshaw, Iansek, & Alfredson, 1999) and external musical cues can improve limb movements in PD (Satoh & Kuzuhara, 2008). In addition, the fact that people are vocalizing together

allows each person to be anonymous, thus encouraging greater and more wholehearted participation.

b. The Lombard Effect

The Lombard effect, sometimes called the 'cocktail party effect', occurs in a noisy environment. If someone cannot hear his own voice, as at a noisy party, he increases his effort and loudness level until he can hear the auditory feedback of the sound of his voice. In similarly loud surroundings, rock singers use monitors on stage to make sure they can hear their vocals, and thus do not over sing and hurt their voices. For people with PD, where the goal is to increase phonatory (laryngeal) and respiratory effort (larger inhalations and more sustained exhalations) this effect can be useful. When properly warmed up, with reminders to use appropriate vocal technique, PD patients singing in a choir can use the Lombard effect to their advantage, practicing at a higher effort level than would be possible on their own at home (Adams & Lang, 1992; Adams, Haralabous, Dyskstra, Abrams, & Jog, 2005; Adams et al., 2006). There is some evidence in an older study that this phenomenon may be less effective for people who have PD (Ho et al., 1999). Adams et al., however, refute these claims in their 2005 and 2006 studies, pointing out that Ho et al. (1999) used volume levels of background noise (below 50 dB) that were less than the normal decibel level of normal conversation (60dB), which may not have elicited the Lombard effect.

C. Neural Plasticity

In the present study the five neural plasticity principles of motor learning mentioned in the literature review (Fox et al., 2008) were addressed with group vocal exercises and choral singing. This holistic activity conditions respiratory, vocal and speech mechanisms, exploits the unique relationship between speech and song and, by the addition of melody, adds to the complexity of a still manageable task in an enriched environment (principle of complexity). Singing is enjoyable and rewarding (principle of saliency), so compliance, home practice and maintenance of skills may be enhanced. The study group met twice per week (minimum frequency of use principle) and engaged in the repetitive practice of accurate vocal skills with increased effort (principle of intensity). People early in the disease progression were also encouraged to join (principle of timing and early intervention).

Socialization before, after and during a break was encouraged to reduce isolation (Nayak et al., 2000; Pacchetti et al., 2000; Pollack & Namzi, 1992; Purdie, 1997), increase natural vocal practice and promote the formation of support systems for the participants. Choral singing creates the opportunity for enhancement of mood (Bailey, 1985; Baker et al., 2005; Pacchetti et al., 2000; Tamplin, 2008) through creative vocal expression (Clift & Hancox, 2001), and for meaningful and successful contributions to a group, which may help improve self-esteem (Bright, 1972).

Given the potential acoustic benefits of the choral and Lombard effects, the motor learning neural plasticity principles, and the reduction in social activity experienced by many people with PD, a group program was selected. A group treatment that integrated and adapted three vocalization methods (voice therapy, vocal pedagogy and choral singing) was designed and tested.

D. Methods

1. Research Design

The pretest/posttest, within-subject research design was chosen to answer the research question. This design controls for variability between subjects since they act as their own controls. This is very important when studying the PD population, which is known for variability within subjects and between subjects on clinical tasks (Weismer, 1984b). The design cuts down on assembly or susceptibility bias, providing more power to detect a difference if one exists. The intra-subject variability common in PD was controlled for with dual testing before and after treatment (four test sessions).

A single-subject experimental design was not used because the cost of continuous or frequent measurement by impartial Speech Language Pathologists not involved in treatment was beyond the financial resources of the project. A control group is often preferred but was ruled out for this study because of the small number of participants available at one time in the test region, the costs associated with a larger group and

the ethical problem raised by denying treatment to interested participants. The need for a control group was less pressing given that PD is a progressive disease (deterioration or no change in skills is likely in those not receiving treatment rather than improvement due to factors other than treatment) and given that there are considerable challenges involved in matching subjects between groups.

This design also allowed for flexibility in acquiring subjects since matching of subjects was not needed and one treatment group could be started once eight people were available to attend. Each participant participated in two pre-tests and two post-tests (four test sessions) on acoustic/timing measures to minimize the variability of measurements known to exist when people with PD perform clinical tasks (Weismer, 1984b). The clinicians' and the patients' perceptions were included in the evaluation. Vocal ability was measured by assessment of acoustic/timing variables and through perceptual judgments by trained listeners. Vocal quality of life was measured using two questionnaires completed by the participants once before and once after the treatment period. Two six-week sessions with 14 participants each took place, one in the spring and one in the fall of 2010. They met in two groups of seven once a week and then formed a larger combined group of 14 for another session per week. Participants attended twice per week but could attend the other group session to make up for missed sessions, thus facilitating better attendance as well as compliance with scheduled medical appointments. Subjects

were recruited through notices in newsletters sent to community groups involved in supportive activities for people with PD in Edmonton such as the Movement Disorders Clinic and the Parkinson's Society of Alberta. The Movement Disorders Clinic made leaflets available that invited participation.

2. Subjects: Inclusion Criteria

Participants were eligible if they had received a diagnosis of IPD from a neurologist, had, in their physician's judgment, adequate vision for reading words, reading music and following visual directions, had sufficient hearing and cognitive skills to participate and understand the consent form, were no later than stage 3 on the Hoehn and Yahr scale (1967), were not participating in other concurrent speech language therapy, could sit or stand for a 60-90 minute session, were interested in voice improvement, could attend twice a week sessions and could sign the informed consent form. It was anticipated that a fairly even number of males and females would enroll, thus matching the equal numbers in the general PD population. This was important because pitch variables might be affected by gender. To rule out other causes of vocal changes all but one participant completed an otolaryngology assessment before treatment took place.

3. Subjects: Recruitment

Recruitment was successful and 16 people were enrolled in each session for a total of 32. No volunteers were excluded, although four

dropped out: one before testing began, one between the two initial tests, one before the first treatment session and one just after the first session. These four were not included in the results. One participant stopped attending after 3 weeks of treatment due to work commitments but returned for post testing and was included in the results because he felt that the 3 weeks of therapy had changed his voice. Twenty-eight people were included in the final sample, with 14 people in the spring session and 14 in the fall session. Twenty-six of the 28 people were diagnosed with IPD and one with a Parkinson related disorder. The person with the Parkinson related disorder was accepted into the study originally with a diagnosis of IPD. Her diagnosis was changed later, during the course of treatment, to a Parkinson's Plus disorder. Another participant was admitted with a tentative IPD diagnosis by a physiatrist at the Glenrose Rehabilitation Hospital but did not have that diagnosis confirmed by a neurologist during the course of the study. The average length of time since diagnosis was 6.3 years. Half of the participants were women, representative of the gender distribution in the PD population as a whole (Rajput et al., 1984).

4. Data Collection

In most cases measurements were taken at the same time of day (each person was scheduled around the same time on all test days) and at the same point in medication schedules, to control for on-off effects in the drug cycle. Usually participants attended a testing session two days in

a row at the same time of day. On-off effects from medication such as sudden, unpredictable changes in movement and alternation between normal movements and Parkinsonian movements were not found to be a problem during testing. The time of last medication taken, last meal consumed and previous exercise that day were recorded at the beginning of each testing session.

Measurements (acoustic/timing measures and questionnaires) were collected by four registered Speech Language Pathologists (SLPs) using a scripted protocol (see Appendix F). A time commitment of two half-hour sessions on different days before and after the treatment period was required from participants. The participants spoke and sang into microphones attached to a digital recorder, a digital video camera and a computer equipped with software that provided acoustic analysis. The positions of equipment were kept consistent with tape markings on the floor and tables. Vowel prolongation, oral reading, conversation and singing tasks were sampled. In addition, participants were required to complete two questionnaires.

a. Measurement instruments

i. Instruments for Acoustic/timing Measures of Vocal Ability

Maximum phonation time (or MPT) was timed using a Micronta LCD Quartz stopwatch. Acoustic measures were taken with a digital sound level meter from Radio Shack (for top of intensity range - weighted scale - setting A and fast rate) and the Real-Time Pitch module from the

Kay Elemetrics Computerized Speech Lab (CSL) 4500 (hereafter called Visipitch®) with a Shure SM48 microphone attached (for frequency and intensity measures). The Visipitch® is widely used in clinical acoustic measurement. Sound recordings were made using a digital recorder with a 44 kHz frequency response (Marantz professional solid state recorder PMD671 and head mounted Shure WH20 microphone) and a digital video camera (Canon FS200 and with AKG C1000S condenser microphone attached). Computers used included a Dell Precision 380 equipped with the CSL software for acoustic analysis and a desktop Macintosh Power Mac G5. An iTunes file on the Mac G5 was used to play the accompaniment to Silent Night in B flat major through Bose Quiet Comfort Headphones 2: Acoustic Noise Cancelling Headphones. All microphones were placed 5 cm (2 inches) from the mouth opening.

ii. Instruments for Perceptual Measures of Vocal Ability

Once the treatment portion of the study was completed, randomized sets of before/after voice samples of oral reading, conversation and singing were created. The method of collecting the original samples is shown in the testing protocol in Appendix F. *Consensus Auditory Perceptual Evaluation of Voice* (CAPE-V) scale (Appendix A). Speech stimuli and one verse of Silent Night were taken from the digital recordings of the first pre and first post sessions, paired, but with pre-post order randomized (coin flip), and played to blinded SLPs trained to rate the voices on the CAPE-V scale (Appendix A). The CAPE-V

was developed by a group of voice professionals to promote a standard approach to evaluating voice quality when making auditory-perceptual judgments (ASHA, 2006).

iii. Instruments for Perceptual Measures of Vocal QOL

The *Speech Intelligibility Inventory: Self-Assessment Form* (SII) (Appendix B) and the *Voice-Related Quality of Life* (V-RQOL) (Appendix C) were completed by all participants once before and once after treatment and provided information from the participants' perspective. The SII was used by Haneishi (2001) to test people with PD who received vocal music therapy. It has 21 items and a 5 point scale, with a possible score of 105 representing the worst intelligibility. The V-RQOL was chosen from nine voice quality of life measures available. The reliability, validity, responsiveness and low burden of this measure were established in a study by Hogikyan and Sethuraman (1999). Franic, Bramlett and Bothe (2005) concluded that the V-RQOL was more responsive than the *Voice Handicap Index* (Jacobson et al., 1997) and better for use with groups of patients. The scale has 10 items with a 5 point Likert scale. A scoring algorithm to translate the total raw score into a standard score was used for analysis (Hogikyan & Sethuraman, 1999). The scoring algorithm changes the values so that a higher score represents a better voice related quality of life rating.

Table 1

V-RQOL General Scoring Algorithm

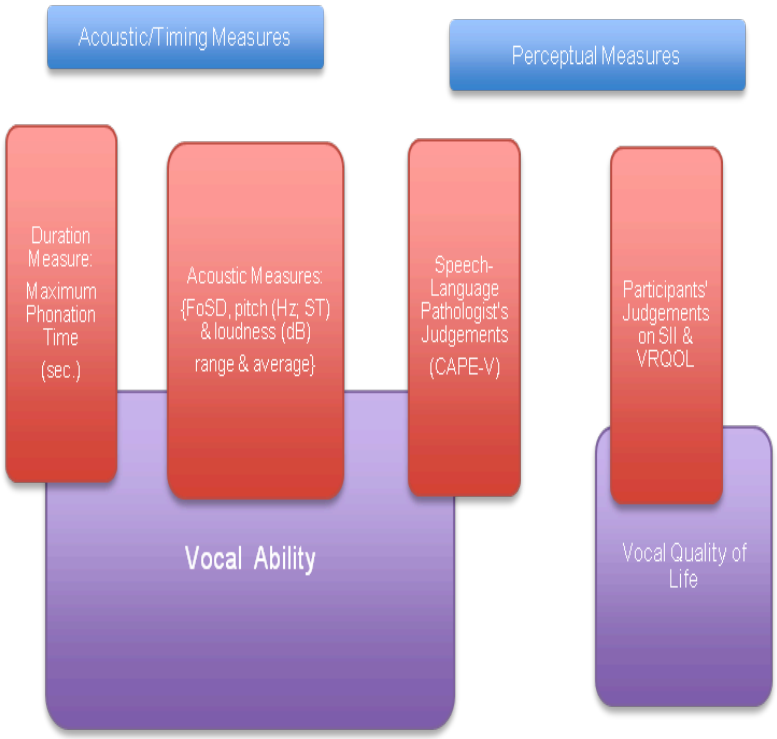
$$\text{Standard Score} = \frac{100 - (\text{Raw Score} - \#\text{ items total}) \times 100}{(\text{Highest Possible Raw Score} - \#\text{ items})}$$

5. Measurement

Since voice is a multidimensional phenomenon, adequate and relevant assessment of voice must include both objective and subjective measures (Piccirillo, Painter, Haiduk, Fuller, & Fredrickson, 1988). Voice change measurement is difficult and no standard measure or group of measures is available (Bhuta, Patrick, & Garnett, 2004). Clinicians usually take a comprehensive approach that makes use of both acoustic/timing and perceptual tools. Measurements in this study were selected to cover both objective and subjective aspects of vocal ability following treatment. Vocal ability was assessed with a measure of maximum phonation time, several acoustic measures and perceptual information from outside SLP professionals using the CAPE-V scale. Vocal quality of life was measured using self perceptual information (two questionnaires – the V-RQOL and the SII) completed by participants. Thus both clinician and participant perspectives were included. Acoustic/timing measures and the SLP perceptual information together measured vocal skills, while participants' perceptual judgments measured vocal quality of life and self rated intelligibility (see Figure 1 below).

Figure 1 *Measurement of Two Constructs:*

Vocal Ability and Vocal Quality of Life



a. Acoustic/Timing Measures

The acoustic/timing measures chosen include elicited maximum frequency range, elicited maximum intensity range, average frequency (habitual pitch), average intensity (habitual loudness) and fundamental frequency variability (standard deviation) during reading and conversation, and maximum phonation time (MPT). These are all common clinical tools used for measuring voice change. MPT is a simple and useful way to estimate glottal efficiency and respiratory efficiency during phonation (Kent

& Ball, 2000; Neiman & Edeson, 1981; Prater & Swift, 1984). Glottal efficiency according to Titze (2000, p. 269) is “the efficiency of conversion of sub-glottal aerodynamic power into acoustic power radiated from the mouth.” Because a known symptom of the PD population is bowed vocal folds (Hanson et al., 1984), for this study glottal efficiency is defined as the ability to close the glottis with adequate force to resist sub-glottal pressure. and respiratory efficiency is the ability to control the forces of expiration (Prater & Swift, 1984) during phonation. Frequency and intensity ranges were chosen because they are used in speech–language pathology and in voice teaching as a measure of vocal development. Maximum frequency range was also measured because it is often reduced in people with PD as compared with the normal population (Bunton, Kent, Kent, & Duffy, 2001; Canter, 1965; Gamboa et al., 1997; Ludlow & Bassich, 1984). Habitual frequency and intensity were chosen because most people with PD speak at an unusually low fundamental frequency (King et al., 1994; Ludlow & Bassich, 1984) and at a reduced intensity level (hypophonia) (Darley et al., 1975). Fundamental frequency variability (standard deviation) is significantly reduced in people with PD (Canter, 1963; Flint, Black, Campbell-Taylor, Gailey, & Levinton, 1992; Gamboa et al., 1997; Goberman & Elmer, 2005; Metter & Hanson, 1986; Skodda, Gronheit, & Schlegel, 2011) and is often measured in the LSVT® LOUD studies.

i. Maximum Phonation Time

Maximum phonation time (MPT) was taken during vowel production

(see Appendix F – Testing Protocol). MPT was chosen because it is the most common measure used in clinical voice evaluation (Hirano, 1989), it is considered an objective acoustic/timing measure of glottal and/or respiratory efficiency (Cielo & Cappellari, 2008; Neiman & Edeson, 1981) and provides information about respiratory function and laryngeal control (Colton & Casper, 1996). If the maximum phonation time is short compared to norms, it indicates that there is either a problem with vocal fold closure (control of the airflow) or with insufficient respiration (reduction of air available). As a before and after measure it could reflect improvements in laryngeal and/or respiratory control and function. MPT is the length of time the "ah" vowel can be held. It was recorded three times in a row and the best time of the three was taken from each of the four testing sessions (as recommended by Soman, 1997). The two pre values for each of the two pre sessions were averaged to provide the pre MPT value and to increase overall reliability (Speyer et al., 2010) they were obtained on two different days. Speyer et al. (p. 284) showed that "measuring maximum phonation time on two different days instead of on a single day resulted in an increased reliability, respectively, of 0.911 compared with 0.836." The same procedure was used to obtain the post MPT values.

ii. Acoustic Measures

Acoustic measures included elicitation of maximum intensity range, maximum frequency range, and habitual (average or normally used) pitch

and loudness during oral reading (Grandfather Passage, Hall & Mueller, 1988) and speaking (an interview question to elicit a monologue). These measures were chosen because they are typical acoustic indicators used in the university laboratory and because they are often used to determine the normality, health or development of the voice. The widely accepted Visipitch® was used for the acoustic measurements. Care was taken to have a consistent microphone distance and consistent levels, especially of the frequency and intensity range limits in the software settings. Because the Visipitch® only measures up to 90 dB, the top of the elicited loudness range was measured with a sound level meter with the microphone at the same distance from the participants' mouths as other microphones (5 cm or 2 inches).

a. Intensity Range

An elicited intensity range (subjects were asked to produce their loudest and quietest voice) was also measured using a sound level meter for the loudest sound and the Visipitch® for the quietest sound. Participants were asked to yell "Hey get out of here" as loud as they could to elicit their loudest effort and say "I don't want anyone to hear this" as quietly as possible without whispering to elicit their quietest voice. The present version of the Visipitch® software has a 90dB upper limit imposed on the range of intensity it will record. However, it has a 30 dB lower limit. The sound level meter's upper range is 126 dBSPL and the lower range is limited to 50 dBSPL. The upper intensity range measurement was taken

from the sound level meter and the lower end of the range from the Visipitch®. This is the method used by Dr. Melanie Campbell when testing normal voices such as those of Bachelor of Fine Arts Drama students. The method was used because it would accurately assess the vocal abilities of all the participants, including the abilities of the approximately 50% of participants in the study who were at the early stages of PD. Those in the early stages could have had loudness ranges that exceeded the limitations of the Visipitch®.

b. Habitual Intensity

To provide an estimate of habitually used loudness, the average loudness during reading and conversation was recorded using the Visipitch®. Zraick, Marshall, Smith-Olinde and Montague (2004) suggest that more than one task should be used to determine habitual intensity as there may be variability from task to task. For this reason, habitual intensity was taken during oral reading (Grandfather Passage) and spontaneous speech (“Tell me where you were born”) tasks.

c. Frequency Range

An elicited frequency range (asked to produce their highest and lowest notes) was measured with the Visipitch®. Measurements were taken in Hertz, as is usually done in voice science, and also in semitones. Hertz and semitones have a logarithmic relationship. Semitones provide a more accurate measure of frequency range since the number of Hertz within a semitone varies at different degrees of the musical scale (Baken & Orlikoff, 2000). The number of Hertz per semitone is larger at high pitch

than at low pitch (i.e., the number of Hertz per semitone increases as frequency rises).

d. Habitual Frequency

The average frequency during reading and conversation was recorded using the Visipitch® as a measure of the frequency used habitually during speech tasks. Both reading and conversation were examined as variability in habitual frequency between task types has been found in normal adult females (Zraick, Skaggs, & Montague, 2000).

e. Fundamental Frequency Variability

The fundamental frequency variability, an estimate of long term variability, was measured by examining the standard deviation of the fundamental frequency on the complete reading and conversation tasks as measured by the Visipitch®. As with all the acoustic/timing measures, an average of the two pre and the two post measures was used.

b. Perceptual Measures

i. Speech Language Pathologists' Perceptual Judgments

In published studies the clinician point of view often involves both acoustic/timing and perceptual measures. The *Dysarthria Profile* (Robertson, 1982) and the *Frenchay Dysarthria Assessment* (Enderby, 1983), established clinical measures for all dysarthrias, were used by other researchers, but are a mixture of clinical judgment and acoustic/timing measures. Use of such measures in this study would have made the results more complex and harder to interpret. A variety of perceptual measures were used in other studies, many of them developed

specifically for the study. Scott and Caird (1983) created two scales to judge intelligibility and another for an overall rating of the voice. Sullivan et al. (1996) developed a 7 point naturalness scale and a 5 point overall voice rating scale. Ramig et al. (1995) created a 5 point voice severity rating scale. Di Benedetto et al. (2009) developed a visual analog scale to rate perception of prosody and a yes/no scale for the perception of presence of fatigue. Gupta et al. (2008) adapted the *Parkinson's Disease Disability Rating Scale* (Yorkston et al., 1992) from a self rating into an SLP rating of voice severity.

The perceptual measures from the SLP clinician's perspective for this study included judgments using the Consensus Auditory Perceptual Evaluation of Voice (CAPE-V). The CAPE-V was recently developed by a group of established voice professionals in the American Speech-Language-Hearing Association as a standard auditory-perceptual scale to be used for perceptual judgments on all voice disorders, and was therefore thought to be an appropriate choice.

Two Speech Language Pathologists with experience in voice completed the *Consensus Auditory Perceptual Evaluation of Voice* (CAPE-V) perceptual judging form (see Appendix A), after listening to a randomized list of recordings made during pre and post testing. Two different sets of stimuli were judged. One set involved the speech stimuli recommended by the CAPE-V developers (prolonged vowels, reading and

conversation; stimuli shown in Appendix A and instructions in Appendix F) and the other was the singing task (one verse of Silent Night sung to an accompaniment in B flat major heard by participants through headphones). Silent Night was chosen because it is well known by most people and has more than the one octave range of most folk songs, allowing changes in pitch range to be more easily reflected in the sung performance. Both speech and singing samples were rated to find out whether changes could be heard in one or in both tasks. Pre and post recordings were taken from the first pre session and the first post session. Recordings were presented to one SLP at a time, but the order of pre and post samples (two sets for each of the 28 participants – one singing and one with speech stimuli) was randomized. The therapists did not know the participants and had not been involved in treatment. The same digital recorder used to record the samples was used for the perceptual listening tasks. The score was the number out of 100 on the CAPE-V overall severity category. Eight samples were judged twice by different evaluators to check inter-rater reliability. As the score range was from 1 to 100 on the CAPE-V, each point difference between scores by different listeners was calculated as 1%. Because inter-tester and intra-tester reliability was high (always over 90%) the point difference was always less than 10 or 10%. Inter-rater reliability was 93% for the speech stimuli and 94% for the singing excerpts. Intra-tester reliability was determined by having each

listener rate samples twice amongst other samples. Inter-tester reliability was established by having both listeners rate the same samples.

ii. Participants' Perceptual Judgments

The participant's viewpoint was examined because a change observed by clinician scientists following treatment does not necessarily indicate an awareness of change by the patient. It is important to collect this type of information to ensure that a treatment is not assumed to be beneficial just because clinical measures are statistically significant. Most vocalization studies for PD have gathered information on the patient's perspective (Evans et al., 2011; Haneishi, 2001; Manor et al., 2005; Pachettii et al., 1998; 2000; Ramig et al., 1995; Robertson & Thomson, 1984; Sullivan et al., 1996; Tanner-Semple et al., 2005). Tests fall into two general categories: Quality of Life (QOL) measures and self rating scales on various voice aspects. For this study the *Voice-Related Quality of Life* (V-RQOL) was chosen to assess the QOL and the *Speech Intelligibility Inventory: Self-Assessment Form* (SII) was used as the self rating scale.

QOL measures were introduced to determine whether treatments improved patients' well being. Most studies involving people with PD make use of a general self assessment QOL measure such as the Parkinson's Disease Quality of Life Questionnaire (PDQL), developed by de Boer et al. (1996). Many general QOL measures can be successfully used in PD research and these were employed in the Evans et al. (2011) and the Pacchetti et al. studies (1998; 2000). In order to measure only vocal ability

(not walking and other life activities) quality of life measures specific to voice were examined.

There are nine voice QOL measures in existence and the most popular is the Voice Handicap Index (Jacobson et al., 1997). The V-RQOL was chosen here for its sensitivity, because it is specific to voice disorders, and because it is able to measure the impact of voice change on daily life. The review of the literature did not find evidence of the use of this measure with the PD population but it is deemed to be the most sensitive for research purposes by Franic et al. (2005).

The other group of self rating scales focuses on actual vocal skills. One, the *Speech Assessment Scale* (SAS) was developed by Johnson (1975) and used by Manor et al. (2005). It focuses on self perception of speech clarity. The *Visual Analogue Perceptual Rating Scale* (VAPRS – Schiffman, Reynolds, & Young, 1981), also used by Manor et al. (2005), focuses on vocal skills (such as loudness and intelligibility). The *Parkinson's Disease Disability Rating Scale* (Yorkston et al., 1992) was used by Sullivan et al. (1996) and assesses self perception of communication effectiveness. Manor et al. (2005) also looked at pragmatic language with the *Pragmatic Protocol* (Prutting & Kirchner, 1987). Others have noted patients' comments (de Angelis et al., 1997).

The *Speech Intelligibility Inventory: Self-Assessment Form* (SII) was developed by Kent (1994) for use with all dysarthrias. The SII was

used in the Haneishi (2001) study and the Tanner-Semple et al. (2005) study. It was adopted in the present study as well because of its use in other PD studies involving singing, and also because of its focus on intelligibility. For detection of changes early in the disease an intelligibility measure from the patient's perspective may be more useful than clinician administered measures. Many clinician-given measures (such as the *Phonetic Intelligibility Test* and the *Sentence Intelligibility Test*), both developed by Yorkston et al. (1996), are not sensitive enough to detect subtle, early changes.

The *Speech Intelligibility Inventory: Self-Assessment Form* (SII, Appendix B) and quality of life (V-RQOL, Appendix C) questionnaires completed once before and once after treatment, provided data from the participants' perspective. Each questionnaire had a five point scale. It is interesting to note that on the two questionnaires the direction of the scales was opposite to each other. In one the improved voice values were to the left and in the other they were to the right. The total raw score for the SII questionnaire was calculated and compared pre and post testing. For the V-RQOL the total score algorithm (Hogikyan & Sethuraman, 1999) was used to convert to standard scores for comparison pre and post testing.

6. Data Analysis

Data analysis involved a repeated measures (MANOVA) for thirteen variables. Eleven variables measured vocal ability and two

variables measured vocal quality of life. The SPSS software was used to record and analyze the quantitative data. Using the mean difference and the standard deviation results of the dependent variable on the *Speech Intelligibility Inventory: Self-Assessment Form* from a pilot study on individual voice lessons for people with PD (Tanner-Semple et al., 2005) approximate sample sizes were calculated to verify that the sample size of 28 was adequate. Two constructs, vocal ability (MPT, acoustic measures and SLP judgments) and vocal quality of life from the participant's perspective (*Voice-Related Quality of Life* and *Speech Intelligibility Inventory: Self-Assessment Form* questionnaires), were measured. The independent variable was the "whole" intervention program. All *p* values less than 0.004 were considered significant for the dependent variables measured. This strict Bonferroni correction (0.05/13= *p* value) was completed to correct for multiple variables in addition to the correction made by SPSS for multiple variables.

Cohen's *d* effects sizes were calculated using the mean and standard deviation of the pre-test and post-test conditions and the correlation between them for each variable was measured with an online effect size calculator that corrected for dependence between means using Morris and DeShon's equation 8 (2002). Clinical significance was also calculated on all variables (Armijo-Olivo, 2011). A variable was clinically significant when it had an effect size larger than 0.4 and the mean

difference was above the minimal important difference (calculated with a small effect size of 0.2 times the pooled variance).

7. Facilities

Individual testing was done using equipment in a laboratory in Corbett Hall, Faculty of Rehabilitation Medicine at the University of Alberta in Edmonton. Group singing intervention occurred in a room located at the Glenrose Rehabilitation Hospital. This room had a piano, chairs and space for movement.

8. Treatment Protocol

Participants received two 90-minute group voice treatments each week for a six-week period. This intensity and length of treatment was chosen based on successful past studies using group voice therapy (de Angelis et al., 1997; Gupta et al., 2008; Johnson & Pring, 1990) and group music therapy (Pacchetti et al., 1998; 2000) for people with PD. Qualified Speech Language Pathologists provided treatment and testing. The four Speech Language Pathologists who performed the testing were not involved in treatment and did not have knowledge of the treatment protocols. A Speech Language Pathologist/Singer (the writer) provided treatment sessions. A pianist played live music accompaniment for all of the sessions. The focus of the voice therapy was on:

a. Vocal intensity and variation in dynamics (intensity range, average intensity)

b. Frequency range and pitch awareness (frequency range, average frequency, fundamental frequency variation)

c. Respiratory effort/use of breath support (MPT, intensity range, average intensity, frequency range)

d. Vocal effort (MPT, intensity range, average intensity)

e. Movement of the face, jaw and tongue (intensity and frequency range)

f. Posture and relaxed body stance (intensity and frequency range, average frequency and intensity)

g. Resonance (frontal focus) and vocal quality (MPT, frequency and intensity ranges).

A warm-up sequence and melodies to be learned were provided on a compact disc and on YouTube for home practice. Informal periodic interviews revealed that compliance was poor - very few people used the YouTube site, though some did occasional home practice with the CDs. During group sessions led by a Speech Language Pathologist/Singer, participants performed a series of exercises while standing, sitting or walking. The activities in these sessions included:

a. Socialization before and after the sessions and during the 10-minute break.

b. Warm-up and movement with easy vocalization to encourage the posture and muscle relaxation conducive to optimal vocalization. Some of these were adapted from Feldenkrais® (Feldenkrais, 1977) exercises. They also included accent method (Kotby, 1995) and other breath support exercises performed standing or sitting, depending upon the person's capabilities. Five note scale patterns were sung in combination with arm and leg movements. Most of these movements were adapted from Alexander® (Alexander, 2002) exercises. The range of pitches were from C3 up to A5, always starting at C4 and going up or down by semitone with men singing an octave lower.

c. Ten sustained, loud productions of vowel sounds at various pitches and ten pitch glides up and ten down holding the highest and lowest notes for 5 seconds were completed in an exercise similar to one used by the LSVT® LOUD program (Ramig & Fox, 2004). Ten quiet, sustained productions of the vowel "oh" with frontal resonance in the passaggio region (B3 to A4 for women and an octave lower for men) were followed by 10 pitch glides up and down on "no" going down and "whoop" going up. These were adapted from vocal function exercises (Sabol, Lee, & Stemple, 1995; Stemple, 2000).

d. This was followed by repetition of common phrases in a loud voice and song texts in a speaking voice.

e. Finally, the participants moved on to vocal music, first performing voiced sounds such as /r/, /z/, /zh/ and tongue or lip trills, then vowels and then an actual text with melody and song singing. These were mixed with exercises and movements to encourage breath support, facial movement and creative expression.

9. Ethical Considerations

The study was approved by the Health Research Ethics Board Panel B at the University of Alberta. Participants were contacted through the Movement Disorders Clinic, through newsletters and through Parkinson's Society publicity. All treatment was explained fully before the consent form was presented. Participants signed the consent forms themselves. Confidentiality of information was maintained and participants' names will not be used in any information disseminated by the researchers. Only the researchers involved have access to the documents. (See Appendix D for Information sheet and Appendix E for Informed Consent Form).

Chapter: IV Results

Two six week sessions were held in 2010, one in the spring and one in the fall. Treatment took place three times per week in 90 minute periods. Each participant attended twice per week, once in a small group (n=7), and again in the larger combined group (n=14). Testing occurred twice before and twice after the treatment. The results are categorized below as acoustic/timing measures and perceptual measures. Acoustic/timing results include MPT, average and elicited ranges in frequency and intensity, and fundamental frequency variation. The perceptual results come from two sources: the Speech Language Pathologists' judgments (using the CAPE-V scale) and questionnaires (SII and V-RQOL) completed by participants. A repeated measures MANOVA was completed using the SPSS software and the results are given in Tables 2 to 8 below.

Table 2

Vocal Ability: Descriptive Statistics

Variable *(n=28)*		Mean (SD)
Maximum Phonation Time (seconds)	Pre	14.02 (5.74)
	Post	15.09 (5.12)
Intensity Range (dB)	Pre	45.75 (10.16)
	Post	52.88 (7.04)
Average Intensity (dB)	Reading Pre	60.43 (3.56)
	Reading Post	59.39 (4.76)
	Conversation Pre	59.57 (3.98)
	Conversation Post	58.64 (4.89)
Frequency Range (Semitones)	Pre	22.14 (5.21)
	Post	25.19 (6.08)
Average Frequency (Hertz)	Reading Pre	155.55 (31.95)
	Reading Post	160.34 (32.39)
	Conversation Pre	48.95 (29.88)
	Conversation Post	151.80 (31.62)
Fundamental Frequency Variability Standard Deviation (Hertz)	Reading Pre	24.28 (10.49)
	Reading Post	28.80 (10.79)
	Conversation Pre	28.09 (12.95)
	Conversation Post	32.02 (13.40)
Speech Judged on CAPE-V (Raw Score)	Pre	23.54 (15.21)
	Post	20.18 (13.71)
Singing Judged on CAPE-V (Raw Score)	Pre	25.11 (15.43)
	Post	21.43 (15.60)

Table 3

Vocal Quality of Life: Descriptive Statistics

Variable (n=28)		Mean (SD)
Voice-Related Quality of Life (Standard Score)	Pre	67.77 (25.92
	Post	76.16 (19.82)
Self Assessment of Intelligibility (Raw Score)	Pre	56.93 (15.45)
	Post	49.18 (16.78)

Table 4

Vocal Ability: Repeated Measures MANOVA

Variable		Mean Difference (SEM)	95% CI LL	95% CI UL	F (df)	*p*-value	effect size
Maximum Phonation Time (seconds)		1.08 (.82)	-.61	2.76	1.72 (1)	.20	0.25
Intensity Range (dB)		7.13** (1.89)	3.25	11.01	14.23(1)	.001	0.65
Average Intensity (dB)	Reading	-1.04 (.58)	-2.23	0.15	3.21 (1)	.09	0.36
	Conversation	-0.93 (.63)	-2.22	0.35	2.23 (1)	.15	0.26
Frequency Range (Semitones)		3.05* (1.17)	.64	5.45	6.74 (1)	.015	0.49
Average Frequency (Hz)	Reading	4.80** (1.32)	2.10	7.50	13.29(1)	.001	0.70
	Conversation	2.85 (1.93)	-1.11	6.81	2.19 (1)	.15	0.28
Fundamental Frequency SD	Reading	4.51* (1.59)	1.25	7.78	8.04 (1)	.009	0.36
	Conversation	3.92 (2.59)	-1.38	9.23	2.31 (1)	.14	0.26
Speech CAPE-V		-3.36 (2.30)	-8.08	1.37	2.13 (1)	.16	0.28
Singing CAPE-V		-3.68 (2.45)	-8.70	1.34	2.26 (1)	.14	0.28

*p ≤ .05 **p ≤ .001

Table 5

Vocal Quality of Life: Repeated Measures MANOVA

Variable	Mean difference (SEM)	95% CI LL	95% CI UL	F (df)	*p*-value	effect size
Voice-Related QOL (SS)	8.39* (2.96)	2.33	14.46	8.07 (1)	.008	0.58
Self Assessment of Intelligibility (raw score)	7.75** (1.60)	4.46	11.04	23.39 (1)	.000	0.93

*p ≤ .05 **p ≤ .001

Table 6

Voice-Related Quality of Life Total Standard Score (Items 1-10)

Pre/Post Treatment	Mean	Standard deviation	Range of total standard scores
Pre	76.16	19.82	15.00 to 95.00
Post	67.77	25.92	27.50 to 97.50

Table 7

Statistical Significance and Clinical Relevance – Vocal Ability

Variable		Minimally Important Difference	Mean Difference	*p*-value	Effect Size	Clinically Relevant
Maximum Phonation Time (sec.)		1.09	1.08	.20	0.25	no
Intensity Range (dB)		1.75	7.13**	.001	0.65	yes
Average Intensity (dB)	Reading	.84	-1.04	.09	0.36	no
	Conversation	.89	-0.93	.15	0.26	no
Frequency Range (Semitones)		1.13	3.05*	.015	0.49	yes
Average Frequency (Hertz)	Reading	6.43	4.80**	.001	-0.70	possibly
	Conversation	6.15	2.85	.15	-0.28	no
Fundamental Frequency SD	Reading	2.13	4.51*	.009	0.36	yes
	Conversation	2.64	3.92	.14	0.26	no
Speech CAPE-V		2.90	-3.36	.16	0.28	no
Singing CAPE-V		3.10	-3.68	.14	0.28	no
*p ≤ .05	**p≤.001					

Table 8

Statistical Significance and Clinical Relevance – Vocal Quality of life

Variable	Minimally Important Difference	Mean Difference	*p*-value	Effect Size	Clinically Relevant
Voice-Related Quality of Life (SS)	4.62	8.39*	.008	0.58	yes
Self Assessment of Intelligibility (raw score)	3.23	7.75**	.000	0.93	yes
*p ≤ .05	**p≤.001				

A. Results from Acoustic/timing Measures

1. Maximum Phonation Time Results

As shown in 4 and 7 above the change in maximum phonation time (MPT) from before treatment to after treatment was not statistically significant or clinically relevant. The raw data showed that, of the twenty-eight participants, seven people had essentially the same MPT (less than one second difference), 12 improved and nine had a shorter MPT. If an average of the means of four norms for the elderly population for MPT (Kent, Kent, & Rosenbeck, 1987) is calculated for men (14.68 seconds) and women (13.55 seconds) and compared with the raw MPTs, 9/14 men

and 7/14 women are below the average before and 8/14 men and 7/14 women are below after. This shows that at least half of the group had poor MPTs before and after treatment and that very little change took place.

2. Acoustic Results

a. Intensity (Loudness) Results

i. Intensity Range Results

The elicited intensity range in decibels (participant was asked to produce the loudest and the quietest voice possible while voicing a speech phrase) was statistically significant and clinically relevant with a *p* value of .001 and a medium effect size (.65).

ii. Habitual Intensity Results

Measures of habitual intensity in decibels (relative intensity, not SPL) were taken during reading and conversation using the average intensity measure on the Visipitch®. All values fell between 50 and 69 dB relative intensity, with some below normal conversational loudness (60 dB). Average intensity change from before to after treatment was not statistically significant or clinically relevant in reading or in conversation.

b. Frequency (Pitch) Results

i. Frequency Range Results

The elicited frequency range (participants were asked to produce the highest and lowest tones possible) result in semitones was clinically relevant with a medium effect size (.49). It was statistically significant at the .05 level but not at the .004 level of significance. Despite the usual use of Hertz in speech language pathology, the semitone range is thought to be most representative of actual frequency range (Baken & Orlikoff, 2000).

Examination of the raw data showed that following treatment frequency range tended to expand upward but less downward to lower tones in most subjects, showing that they had regained upper register notes.

ii. Habitual Frequency (Pitch) Results

The average frequency was measured in Hertz with the Visipitch® to determine habitual frequency during the reading and conversation tasks. Participants were not evaluated by age and sex for individual appropriateness for of habitual fundamental frequency. All values fell within the normal range of habitual frequency. Before treatment the fundamental frequency from all participants on raw data on both reading and conversation combined was between 79.95 and 159.59 Hz with a mean of 128.45 Hz for men, and between 142.34 and 214.09 Hz with a mean of 179.05 Hz for women. Afterwards the range of fundamental frequency for men was 81.56 to 168.74 Hz with a mean of 130.62 Hz and the range for women was 150.44 to 211.63 Hz with a mean of 181.28 Hz. This raw data shows a small upward trend, and it shows that the values stayed within normal range limits for both men and women.

The changes in average frequency during conversation from before to after treatment were not statistically significant or clinically relevant. The average frequency during reading was statistically significant at both levels of significance with a medium effect size (.70), but did not surpass the minimal important difference. This finding may be potentially relevant clinically and is worth examining in a larger, more powerful study.

The raw data shows that habitual frequency increased for 20 participants in reading and for 17 during conversation. It is interesting to note that the habitual frequency level in conversation was usually lower than the habitual frequency level in reading in both pre and post tests. A comparison of the post average frequency in reading and the post average frequency in conversation revealed that 23 of the 28 participants spoke at a lower frequency in conversation than during reading, that two stayed the same and that three spoke at a higher frequency. Similar numbers were found in the pre data as well, with 20 of the 28 speaking at a lower frequency in conversation at the outset. The mean average frequency therefore was usually lower in conversation than in reading in all conditions. Britto and Doyle (1990) found habitual frequency levels to be lowest in conversation, followed by reading, and highest in isolated vowel measures. Another study (Abu-Al-makarem & Petrosino, 2007) found that average fundamental frequency was always higher in reading than in spontaneous speech in young Arabic men speaking in English and in Arabic. Hollien, Hollien, and de Jong (1997) found similar results in native English speakers.

iii. Fundamental Frequency Variability Results

Fundamental frequency variability (standard deviation) improved in reading tasks but not in conversation, which was similar to the findings for habitual frequency. This change was clinically relevant with a medium effect size (.54) and a mean difference that exceeded the minimal

important difference. It was statistically significant at the .05 level but not at the .004 level of significance. The improvement in this measure shows that the variation in intonation during the reading task increased after treatment, but this result must be interpreted with caution because of the small sample size and the multiple dependent variables.

B. Results from Perceptual Measures

The results for the perceptual measures are given in Tables 4 and 5 above. The assessments conducted by speech language pathologists (bottom of Table 4) measured vocal ability and the participant questionnaires measured vocal quality of life (Table 5).

1. Perceptual Results from Speech Language Pathologists

Perceptual voice judgments were made by Speech Language Pathologists from audio digital tapes of participants speaking and singing, recorded before and after treatment. The therapists did not know the participants and inter-rater and intra-rater reliability was over 90%. A clinical judgment of overall severity was used for analysis. No significant differences or clinical relevance (Tables 7 & 8) were found in either task, which means that a change in voice quality was not noticed by the SLP judges.

2. Questionnaire Results - Participant Perspective

Participants completed two questionnaires before and after treatment that assessed the participants' perspective on the effect of treatment on their vocal ability. One questionnaire was developed to

measure quality of life in communication situations that involve use of the voice (*Voice-Related Quality of Life* – V-RQOL) and the other measures participants' impressions of how well others understand their speech (*Speech Intelligibility Inventory: Self-Assessment Form* or SII). Results from both questionnaires were considered clinically relevant with good effect sizes (.93 for the SII and .58 for V-RQOL) with mean differences above the minimal important difference. The opposite directions of the scales on the two questionnaires may have been a confounding variable given the mild cognitive impairment suffered by many people with PD. The Speech Language Pathologists conducting the testing made sure to mention the difference in the direction between the two scales in an attempt to minimize this problem. Despite the extra cognitive load of completing two questionnaires with opposite scales, both showed significant improvements post intervention at the .05 level of significance.

C. Summary of Results

The above tables clearly illustrate the results from the study. If a less conservative approach, with a .05 level of significance, was used on both measures of vocal QOL (V-RQOL and SII) and three measures of vocal ability (intensity range in dB, frequency range in semitones, and average frequency in Hz during reading), the results would be considered significant.

Only three variables were statistically significant at the .004 level (correction for multiple dependent variables): two measures of vocal ability

(average frequency (Hz) in reading and maximum intensity range (dB)) and one measure of vocal QOL (the *Speech Intelligibility Inventory: Self-Assessment Form)*.

From clinical relevance calculations, the average frequency in reading is potentially clinically relevant, and may warrant investigation in a larger study (with greater power). The intensity range, frequency range, fundamental frequency variation in reading, and the results from the two questionnaires completed by participants were all considered clinically relevant.

Maximum phonation time, average pitch and fundamental frequency variation in conversation, and the CAPE-V judgments by Speech Language Pathologists of speech and singing samples were neither statistically significant nor clinically relevant.

Chapter V: Discussion

A. Comparison of Present Study to Similar Studies in the Literature

Many studies have focused on the effectiveness of voice treatment. Several specific efficacy studies support individual voice treatment for people with PD, one in music therapy (Haneishi, 2001) and several in speech language pathology (Scott & Caird, 1983; Johnson & Pring, 1990; Tanner-Semple et al., 2005), as well as the many studies on the LSVT® LOUD "vocalization" approach (Ramig, 1992; Ramig et al., 1994; 1995; Ramig, Sapir, Fox et al., 2001). In addition, nine other studies have found group voice therapy for PD to be effective, six in the speech language pathology literature and two in music therapy sources (de Angelis et al., 1997; di Benedetto et al., 2009; Evans et al., 2011; Gupta et al., 2008; Manor et al., 2005; Pacchetti et al., 1998; 2000; Robertson & Thomson, 1984; Sullivan et al., 1996). Group treatment was chosen for the study described in this paper.

The present study is similar to and different from the studies mentioned above in frequency of sessions, duration of sessions, number of sessions, length of treatment period, type of vocalization performed, number of people in the study, outcome measures and study design. Although not all studies gave complete details, the information gleaned from the literature is presented below.

Frequency of sessions varied from every two weeks (Evans et al., 2011), once per week (Gupta et al., 2008; Manor et al., 2005; Pacchetti et al., 1998; 2000), twice per week (Gupta et al., 2008; Johnson & Pring, 1990; Sullivan et al., 1996), three times per week (de Angelis et al., 1997; di Benedetto et al., 2009; Haneishi, 2001; Johnson & Pring, 1990; Tanner-Semple et al., 2005), four times per week (most LSVT® LOUD studies – Ramig, 1992; Ramig et al., 1994; 1995; Ramig, Sapir, Fox et al., 2001) to five times per week (Robertson & Thomson, 1984; Scott & Caird, 1983). The frequency of sessions was twice per week in the study outlined here.

Duration of sessions in this study was 90 minutes. This was the same as in the Gupta et al. (2008) group study. Two individual treatment programs Haneishi (2001) and the LSVT® LOUD studies (Ramig, 1992; Ramig et al., 1994; 1995; Ramig, Sapir, Fox et al., 2001) had one hour long sessions. Other programs varied from 30 to 45 minutes (de Angelis et al., 1997; Tanner-Semple et al., 2005) to one to two hours in length (di Benedetto et al., 2009; Evans et al., 2011; Johnson & Pring, 1990; Manor et al., 2005; Pacchetti et al., 1998; 2000; Scott & Caird, 1983). Robertson & Thomson (1984) held the longest sessions - subjects were involved for four hours daily in a combination of individual and group therapy.

The number of sessions in the study described here was 12. De Angelis et al. (1997), Pacchetti et al. (1998; 2000) and Haneishi (2001) were close to this number with 12 to 14, and Johnson and Pring (1990)

provided 12 sessions in one part of their study. In the LSVT® LOUD studies (Ramig, 1992; Ramig et al., 1994; 1995; Ramig, Sapir, Fox et al., 2001) 16 sessions were given. The Evans et al. (2011) study probably offered the most sessions since it was 2 years long and choral sessions took place once every 2 weeks, but the exact number is not mentioned. The smallest number of sessions in total was eight (Gupta et al., 2008; Johnson & Pring, 1990; Manor et al., 2005; Sullivan et al., 1996). Many offered 10 sessions (Robertson & Thomson, 1984; Scott & Caird, 1983) or up to 15 sessions (another part of the Scott & Caird (1983) study).

The longest treatment period was two years (Evans et al., 2011) and the shortest was 2 weeks (Robertson & Thomson, 1984; Scott & Caird, 1983). Most were one month long (de Angelis et al., 1997; Haneishi, 2001; Johnson & Pring, 1990; Sullivan et al., 1996). The Manor et al. study (2005) was 2 months in length, as was one of the Gupta et al.'s groups, while another Gupta et al. group was 8 months long. The Pacchetti et al. studies (1998; 2000) lasted three months. The treatment discussed in this paper was 6 weeks long.

The number of people in the study described here was 28, but treatment group size alternated between 7 and 14 people. Sixteen people participated in each of the Pacchetti et al. studies (1998; 2000) and were treated in groups of 8. The Johnson and Pring study (1990) had 12 people with PD, but only 6 received treatment. Twenty people were involved in

the de Angelis et al. (1997) study, treated in groups of 5. Manor et al. (2005) and Sullivan et al. (1996) had only 8 and 6 people respectively in their study and treatment groups. Robertson and Thomson (1984) offered a combination of individual and group treatment to 12 individuals with PD out of 22 participants (10 in control group). The numbers in the studies that provided individual treatment and that made use of pre-post designs varied from four (Haneishi, 2001) and seven (Ramig, 1992) to 40 (Ramig et al., 1994). In the random control trials the total number of participants was greater and the number receiving individual voice treatment was 13 (Scott & Caird, 1983), 14 (Ramig, Sapir, Fox et al., 2001) and 26 (Ramig et al., 1995).

A pre-post design was used in the study discussed in this paper. Most of the studies reviewed also followed this type of design. The Ramig et al. (1995), Ramig, Sapir, Fox et al. (2001), Johnson and Pring (1990), Scott and Caird (1983) and Robertson and Thomson (1984) were all random control studies.

The type of vocalization treatment varied but most focused on high effort phonation and loudness with pitch change exercises (De Angelis et al., 1997; Gupta et al., 2008; Manor et al., 2005; Ramig, 1992; Ramig et al., 1994; 1995; Ramig, Sapir, Fox et al., 2001). Six studies involved singing (di Benedetto et al., 2009; Haneishi, 2001; Evans et al., 2011; Tanner-Semple et al., 2005; Pacchetti et al., 1998; 2000). The older

studies tended to have a wider focus including prosody (Johnson & Pring, 1990; Robertson & Thomson, 1984; Scott & Caird, 1983; Sullivan et al., 1996). The study described in this paper involved high effort phonation and pitch change exercises, as well as choral singing.

Outcome measures used in the present study were acoustic/timing (maximum phonation time, pitch range, loudness range, average pitch, average loudness, fundamental frequency variation) and perceptual from the clinicians' and participants' point of view. Clinicians used the *Consensus Auditory Perceptual Examination of Voice* (Appendix A) to measure the impairment level (International Classification of Functioning (ICF) model) and participants completed the *Speech Intelligibility Inventory: Self Assessment Form* and the *Voice-Related Quality of Life* (Appendix B and C) in an assessment of quality of life and patient satisfaction.

All studies examined some objective acoustic/timing measures of the voice with the exception of the two Pacchetti et al. studies (1998; 2000), which used the *Unified Parkinson's Disease Rating Scale,* an overall measure of function for people with PD. General dysarthria tests with a mix of objective and clinician perceptual judgments such as the *Frenchay Dysarthria Assessment* (Johnson & Pring, 1990) and the *Dysarthria Profile* (Evans et al., 2011; Robertson & Thomson, 1984) were utilized in British studies. Other studies used perceptual judgments by

clinicians on rating scales they developed themselves (di Benedetto et al., 2009; Evans et al., 2011; Gupta et al., 2008; Scott & Caird, 1983; Sullivan et al., 1996;) and interviews (de Angelis et al., 1997; Manor et al., 2005).

Perceptual measures from the participant's point of view were less frequent, but several studies made use of the *Speech Intelligibilty Inventory: Self Assessment Form* or SII (Haneshi, 2001; Tanner-Semple et al., 2005), the same form used in this paper. The *Self Assessment Scale* and *Visual Analog Perceptual Rating Scale* (Manor et al., 2005), participant interviews (Sullivan et al., 1996), the *Happiness Measure* (Pacchetti et al., 1998; 2000), and two mood measurement scales (Haneishi, 2001) were also found in the literature.

The study in this paper used the *Voice-Related Quality of Life*. No other studies involving people with PD were found that used this measure. Other quality of life measures such as the *Parkinson's Disease Questionnaire - 39* (Evans et al., 2011) and the *Parkinson's Disease Quality of Life Questionnaire* (Pacchetti et al., 1998; 2000) were used in some studies.

Perceptual ratings by or interviews with family members and friends (Haneishi, 2001; Robertson & Thomson, 1984; Scott & Caird, 1983) were also included in a few studies. This was an area not covered by this study.

With promising scientific support, it appears that a vocalization approach of some kind might be a useful alternative treatment for the

voice and speech problems associated with PD. Nevertheless, the LSVT® LOUD program stands out as the most successful therapy to date. It has the most extensive efficacy studies, the best-defined and most reproducible protocol and a training program in which the writer herself has been certified. Despite the achievements of LSVT® LOUD, other less intensive vocalization programs are still being created and tested. An Australian research group (Gupta et al., 2008), states that it is not always possible to implement LSVT® LOUD due to the intensive time requirements of the program. The Speech Language Pathologist providing treatment may be unable to devote the necessary time (one hour 4 times per week for 4 weeks) to each individual who could benefit. Also, patients and caregivers often have transportation issues and commitments that interfere with the required schedule.

Patient comments about cost of treatment, access to treatment, maintenance of skills acquired in treatment and lack of programs for people early in the disease process have been reported anecdotally to this writer. An intensive program such as LSVT® LOUD might not be possible in inpatient and outpatient settings if the caseload is too large and the number of therapists too few to allow for 16 sessions in 4 weeks for one patient. Moreover, many people might not be able to manage 4 appointments per week due to fatigue, expense of transportation or lack of transportation more than once per week, or because they may not be able to leave work or may not be able to drive in darkness. Access may also be

a problem in any area lacking SLP services or in rural areas with poor transportation services. A preliminary study of LSVT® LOUD treatment using a partial webcam has been successful with 3 people and this method may contribute to patient access, but face to face sessions are still needed to set intensity level measurements and check on progress (Howell et al., 2009). Moreover, this approach may not work for all severities of PD.

Maintenance of skills after LSVT® LOUD can be problematic. Some studies show long term carryover of results (Ramig et al., 1996; Ramig, Sapir, Countryman et al., 2001; Ramig, Sapir, Fox et al., 2001) of up to 2 years, but Fox et al. (2002) acknowledge problems, given that PD is a progressive disease. The ecological validity of the LSVT® LOUD results is questioned by Adams and Dykstra (2009) since testing took place in a clinical setting rather than in natural speaking environments. Wohlert (2004) found that maintenance of changes post-LSVT® LOUD deteriorated over time. Participants retained some but not all of the original gains made in loudness. Maintenance problems may be due to the disease itself: slow gradual onset, cognitive changes, initiation of movement problems, less compliant rib cages and respiratory problems, and perception problems in self monitoring of loudness (Ramig & Verdolini, 1998) all inhibit vocal improvement. Measurements of skills in a clinic can also be biased because the clinician becomes an external cue for loudness. Therapists who follow people with PD have reported

anecdotally to this writer that they often have LSVT® LOUD participants returning for further therapy at a later date. They also report anecdotally that they have noticed that some people who graduate from the LSVT® LOUD program with vibrant voices lose these abilities over time even though they are vocally active. It may be that the internal cueing training starts to fade as the disease progresses.

Maintenance may also be affected by poor compliance in the daily practice needed to keep the voice in shape following the intensive program. Some patients complained anecdotally to this writer that it is hard to keep up the suggested daily practice because the exercises are so repetitive. Those newly diagnosed with PD or who are in the early stages might not feel sufficiently motivated to undertake an intensive approach and would prefer something less frequent that will help them maintain their voices. In this study participants did not consistently use the CDs or YouTube home exercises provided, so maintaining motivation may be a universal problem for all treatment approaches.

Researchers have also noticed that the social lives of many people with PD are less active than before the onset of the disease (Oxtoby, 1982). Many simply may not have sufficient energy to work fulltime and also maintain a social life. Others might have social difficulties because they have trouble making themselves heard in group situations due to low vocal volume and poor voice quality. Other people might be uninterested

in socializing with people with PD because people who have the disease show less emotion and animation on their faces (masked facies) and thus appear less interested in social interaction. According to Fridlund (1994) facial expression affects social interaction. This reduction in social activities might exacerbate the decline of voice and speech as individuals find less opportunity to use these skills.

In this study a comprehensive approach to measuring vocal ability and vocal quality of life was undertaken using both acoustic/timing and perceptual measures. Both professional and participant viewpoints were included. Vocal ability was assessed using laryngeal and acoustic measures, and perceptual judgments by Speech Language Pathologists, while vocal quality of life was evaluated by means of questionnaires completed by the participants.

B. Vocal Ability

1. Maximum Phonation Time

This measure did not show statistically significant change. A recent study (Speyer et al., 2010) shows maximum phonation time (MPT), sometimes called maximum phonation duration, to be a very cost effective, reliable measure of the efficiency of the respiratory mechanism during phonation. However, Speyer et al. excluded anyone with a neuromuscular disease (including those with PD) from their results, probably due to the variability within these populations. Moreover, a study by Weismer (1984b) found that people with PD tend to have variable voice

and speech in clinical testing situations, especially when the task under examination involved physical effort. Because performance on MPT tests depends on glottal closure as well as on respiratory support, it is hard to determine what is being tested. A study by Solomon, Milbrath and Garlitz (2000) question the value of MPT when assessing speech breathing and vocal function. Their study showed that MPT was not associated with vital capacity in the 12 normal subjects they tested even though each subject used most of their vital capacity to perform the task. In the case of dysarthric speakers, problems with MPT may be due to difficulty generating sufficient sub-glottal air, inability to control exhalation, inability to coordinate exhalation with the initiation of phonation or inability to close vocal folds to valve expiration (Yorkston, Beukelman, & Bell, 1988). MPT may be a quick and easy to administer measure but unfortunately the information one receives may not be easily interpreted because so many factors may influence the MPT. Intensity, frequency, flow rate, sub-glottal pressure and vocal fold vibratory patterns may all contribute to or influence MPT. A shorter MPT might be caused by many problems or combinations of problems or even vocal improvement (Rammage, personal communication). The motor problems of PD could affect any movement in the respiratory (affecting sub-glottal pressure and flow) or laryngeal (intrinsic and extrinsic) muscles (affecting glottal closure, frequency, initiation of sound, vocal fold vibratory patterns). The threshold pressure for vocal fold vibration is defined as the amount of pressure

needed to start the vocal folds oscillating. According to Plant (2005) more threshold pressure is needed as intensity and pitch rise. Titze (2000) suggests that when taking pre-post measures of glottal efficiency, pitch and loudness should be kept constant. This is not done systematically when eliciting MPT. A shorter MPT was thought to be a negative outcome in this study, but it may also be a result of reduced hyperfunction (less harshness or laryngeal tension) and result in improved voice quality (Rammage, personal communication).

A study by Wohlert (2004) measured MPT in 11 people with PD who received LSVT® LOUD therapy from graduate students supervised by an LSVT® LOUD certified therapist. Seven of the 11 patients had decreased MPTs following treatment. Interestingly, they also found that 9 out of the 11 increased their intensity level while performing MPT tests. Using a louder voice can translate into a shorter MPT. Shorter but louder MPT productions may also explain the lack of significance of the MPT results in the present study. Unfortunately, this cannot be confirmed, as the intensity during MPT was not measured here.

It is evident that the treatment in this study was not associated with an improvement of the participants' MPT ability to prolong a vowel (MPT). One third (32%) of the participants' ability deteriorated, perhaps due to the disease progression or the strain of producing louder phonation. A quarter (25%) stayed the same and 42% improved. This means that in total 67%

did not deteriorate. Change in MPT may show the presence of a disorder or a change in disease progression, but it may not be a useful measure of change in vocal ability in people with PD as a result of a behavioural treatment.

In summary, the non-significant result in the MPT measure is not surprising given the variability shown by people with PD in performance of clinical tasks, the probable louder (thus shorter) productions, the possible presence of co-ordination or other problems resulting from PD, and the shorter MPTs following treatment reported in other studies (Wohlert, 2004).

2. Acoustic Results

a. Intensity (Loudness)

i. Intensity Range

The statistically significant (at the .05 and .005 levels of significance) and clinically relevant improvement in maximum intensity range of over 7 decibels shows that the treatment had a positive effect on participants' overall ability to increase vocal effort (in terms of sub-glottal pressure and vocal fold closure) and ability to vary intensity. This result was expected since an important focus of treatment was on breath support and increased vocal effort. It is likely that the larger intensity range is a result of one or more of the following: improved breath support, better vocal fold closure and better awareness of loudness levels (improved internal calibration). The Lombard effect may have contributed to

participants' ability to practice at higher intensity levels, which in turn may have expanded the intensity range.

ii. Habitual Intensity

Average intensity results before and after treatment during reading and conversation tasks showed that habitual intensity change was not statistically significant or clinically relevant. However, the increase in elicited maximum intensity range discussed above, suggests that the ability to produce greater intensity did improve. The new ability to produce a louder voice was not evident in the speech contexts tested. Group practice (and perhaps along with the Lombard effect benefits) did not therefore translate into greater habitual intensity when speaking in solo clinical speech tasks. The intensity or the length of the treatment may not have been adequate to generalize this skill to solo speech in the clinic context (oral reading and conversation). Learning to speak more loudly is complicated by the problems people with PD have with loudness perception (Ho et al., 2000; Liotti et al., 2003). If their loudness level has not diminished to the point where they receive negative feedback about their voices, they generally will not make an effort to speak more loudly. An individual may have increased his or her loudness range but may not yet use their increased skill automatically in all speech contexts. Clinically this means that a carryover plan is needed, when dealing with a progressive condition such as PD. It is interesting to note that anecdotal reports suggest that some of the participants were projecting their voices

better outside group situations. Either they actually used a louder voice or their improved voice quality allowed for better projection. This of course was not tested objectively and may not have occurred in all participants. The group situation, as well as the Lombard and choral effects, may have played a role here since the support group context was closer to the treatment group setting than to the clinic testing situation.

b. Frequency

i. Frequency Range

Maximum frequency range in people with PD is often reduced in comparison with the normal population (Bunton et al., 2001; Canter, 1965; Gamboa et al., 1997; Ludlow & Bassich, 1984). Two units of measurement – Hertz and semitones - can be used when measuring frequency range. As explained earlier, semitones provide a more accurate representation of frequency range. The change in elicited maximum frequency range in semitones was statistically significant at the .05 level but not at the .005 level of significance. This shows that the treatment did expand the frequency range of the participants, but because of the multiple measures used and the small sample size in this preliminary study, the result cannot be fully generalized. However, the change of just over three semitones was considered clinically relevant and means that participants would likely notice that their range had expanded. This would not be surprising since pitch slides and variation in frequency were an integral part of the treatment protocol and the choral singing portion of the treatment.

The extension of frequency range indicates that more muscular activity took place post treatment, in the larynx and the entire vocal tract during the performance of vocal tasks. Reduced maximum fundamental frequency range (King et al., 1994; Ludlow & Bassich, 1984) and rigidity of the cricothyroid muscles in the larynx (Aronson, 1990; Weismer, 1984a) are observed in many people with PD. The therapy may have increased movement in extrinsic and intrinsic laryngeal muscles, resulting in the greater variations in frequency (Lindestad, Fritzell, & Persson, 1991; Roubeau, Chevrie-Muller, & Saint Guily, 1997), and this in turn may have reduced laryngeal stiffness and may also have had swallowing benefits as well. Nagaya, Kachi and Yamada's (2000) study suggests that improved laryngeal elevation may hasten the initiation of the swallow reflex. The better movement of the vocal folds and larynx may be related to self-perceived improvements in voices revealed by the positive self assessment questionnaire results. These two findings may have implications for greater frequency variation and expression in the participants' voices (and thus for a reduction in the monotone quality often heard in Parkinsonian speech), for greater clarity and focus (voice quality), which translates in to better speech intelligibility (their voices may be less distracting and may reduce the interactive effects of voice quality and speech intelligibility) even though voices are not significantly louder. However, to date research has not conclusively associated acoustic correlates with perceptual correlates (Kreiman & Gerratt, 2000).

ii. Habitual Frequency

The statistically significant improvement at the .004 level of significance (with a medium effect size) in average reading frequency may suggest that breath support was improved in this speech context. Higher fundamental frequency requires higher sub-glottal pressure (Sundberg, Andersson, & Hultqvist, 1999). In addition to the closure of the glottis, the muscles of inspiration slow the expiration of air to help produce sub-glottal pressure (Seikel, King, & Drumright, 2010). It follows that greater breath support and respiratory activity may be required to maintain a higher overall average frequency level. This is also an important finding for speech intelligibility. When one speaks below the range of healthy habitual frequency (below the bottom 8 to 10% of one's frequency range – Britto & Doyle, 1990; also thought to be below normal speech pitch – Miller, 1986) the voice becomes less clear and vocal fry (growl register) is often heard. Habitual use of this low pitched voice reduces resiliency, vocal projection, flexibility and durability of the voice; it is associated with decreased breath support and leads to vocal fatigue and reduced intelligibility (less understandable speech) (Greene & Mathieson, 1991; Miller, 1986; Spencer, 1988). Although this statistically significant change in average reading frequency was not found to be clinically relevant, it may be potentially relevant clinically and worth examining in a follow-up study.

iii. Fundamental Frequency (Pitch) Variability

Fundamental frequency variability increased significantly at the .05 level of significance in reading but not in conversation, which is similar to

the findings for habitual frequency. Unfortunately this result was not significant at the .004 level of significance, but was still found to be clinically relevant. As mentioned earlier, fundamental frequency variability tends to be reduced in people with PD (Canter, 1963; Flint et al., 1992; Gamboa et al., 1997; Goberman & Elmer, 2005; Metter & Hanson, 1986; Skodda et al., 2011). Although there is an assumed relationship between the monotone voice heard often in Parkinsonian voices and limited fundamental frequency variability, it has not yet been shown to be causal (Adams, Reyno-Briscoe, & Hutchinson, 1998; Ludlow & Bassich, 1984). This result shows that the participants were able to use their new frequency skills in the less cognitively demanding reading task, perhaps showing that skill acquisition had begun but was not yet habituated to all contexts.

3. Speech Language Pathologists' Perceptions

a. Speech Samples

No statistically significant changes or clinically relevant changes in the speech samples were noticed by the Speech Language Pathologists who listened to the before and after recordings. These results were surprising in light of the positive anecdotal comments to this investigator about changes in participants' voices from caregivers and from participants themselves. There may be several reasons for this. The speech stimuli were recorded exactly as suggested by the CAPE-V instructions (ASHA, 2006) and included vowel prolongations, reading of 6

sentences and conversation. The samples chosen for judgments may have been too long and complex (they included all the CAPE-V stimuli). Another study that used a simpler perceptual task (a dichotomous scale - yes/no) to detect perception of fatigue (with shorter reading samples) showed statistically significant results (di Benedetto et al., 2009). Judging degree of impairment with the CAPE-V may be a more difficult perceptual task. Some people with PD exhibit both breathiness and harshness, qualities that are placed at opposite ends of the voice quality scales (Darley et al., 1969b; 1975). This breathy-harsh continuum represents the physiologic status of the larynx and degree of vocal fold closure/opening. An overlapping of breathiness and harshness at the midpoint of the scale has been termed “hoarseness”, perhaps making auditory-perceptual judging especially difficult. Hoarseness can be characterized by increased levels of contribution by either breathiness and/or hoarseness, which allows for hoarseness to essentially form the midpoint of this continuum.

It is also possible that pre/post treatment samples had few perceptible differences to SLP judges because of the participants chosen for the study. Three of the participants developed colds just at the time of post testing, which may have obscured voice improvements, but delay of the test was not possible. All participants were living in the community and most were living independently. At least 50% were early in their disease progression. Individuals at this stage of PD are not widely studied, perhaps because changes due to the disease are not as dramatic or as

easy to measure as changes in later stage PD patients. Yorkston et al. (1999) mention that sometimes no speech symptoms are detected in people with PD who nevertheless complain of having to use increased effort to speak.

The CAPE-V was developed for all voice disorders, not specifically for voice problems in dysarthria, much less hypokinetic dysarthria, which is a complex combination of voice and speech problems. Many participants fell in the mildly deviant range or near normal range on the scale. A simpler disease specific scale that targets the particular problems in PD, perhaps building on Ludlow and Bassich's work (1984), may be more sensitive. A similar problem was reported in another study (Tanner-Semple et al., 2005) when the *Sentence Intelligibility Test* (Yorkston et al., 1996), a standard measure for all dysarthric speakers (not specific to PD), was used. The test was found not to be appropriate for those in the early stages of PD because they essentially had normal intelligibility at the outset (Tanner-Semple et al., 2005).

Clinicians recognize the importance of objective (acoustic) and subjective (perceptual) measures to capture all aspects of voice (Bhuta et al., 2004). Unfortunately, the lack of correlation between acoustic and perceptual measures has been a long time problem in voice science (Kreiman & Gerratt, 2000) and might have occurred here as well.

b. Singing Stimuli

The Speech Language Pathologists who listened to the before and after recordings did not perceive, at a statistically significant level, differences between the recorded singing samples. The CAPE-V perceptual scale was used for this task as well. This scale was not developed for judging singing samples; another scale specific to singing tasks may be more sensitive.

C. Vocal Quality of Life - Participants Viewpoint

The differences between results from the two questionnaires completed by participants before and after treatment to assess their vocal abilities were considered clinically relevant. It is important to find out whether people with PD receiving treatment find it beneficial, especially since there is little empirical evidence obtainable "concerning the individual's own perception of changes" (Miller, 2006, p. 235). One questionnaire was intended to judge participants' overall satisfaction with their QOL with respect to their voice, and the other assessed their perception of how others understood their speech (intelligibility). Participants reported that their quality of life in communication situations had improved and they also felt that others understood their speech better. Responses to both questionnaires were statistically significant from pre to post treatment. A study by Fox and Ramig (1997) found that people with PD had lower speech intensity levels than normal healthy control subjects and also tended to rate their voices as more severely impaired than normal healthy control subjects, thus showing that people with PD

have fairly accurate perceptions of their actual skills. The participants' change in perception of their intelligibility and their vocal quality of life in the present study may be due to actual skill changes, as it was in the Fox and Ramig's (1997) study, but it also may be due to other positive group or musical effects such as mood enhancement or improved self confidence. Listening to and participating in music is known to improve mood and social interaction (Nayak et al., 2000), which could enhance self-perception of communication skills. A positive group experience and talking with peers in a similar situation could also enhance overall communication and confidence, which may have created a placebo effect. In order to control for these variables one would have to test a comparison group that did not receive voice and singing intervention. It is interesting to note that the improvement in the voices of participants was noticed by others (who have PD but were not attending the treatment program) when participants attended other PD support groups (anecdotal reports to this investigator). One woman in such a support group noticed that those participating in the voice treatment group were projecting their voices more effectively and were better understood during meetings (Wood, personal communication). In any case, even if these positive results were due to factors other than the treatment, it suggests that a group approach might lead to benefits related to vocal QOL among people with PD.

The lack of agreement between the participants' perceptions and the SLPs' perceptions is interesting. This is similar to findings by Karnell et

al. (2006). Their clinician ratings of voice disorders on two clinician perceptual judgment scales, GRBAS (Grade, Roughness, Breathiness, Asthenia, Strain – Hirano, 1981) and the CAPE-V, were only weakly correlated with the patient ratings on the *Voice-Related Quality of Life* and the *Iowa Patient's Voice Index* (Smith et al., 1996). They concluded that professionals' and patients' experiences are quite different. Those experiencing the disease will naturally have a different perspective and experience than those observing effects of the disease from the outside. The findings of the present study confirm the poor correlation between the patient and clinician measures reported by Karnell et al. (2006) and the lack of agreement between clinician and PD patients' perceptions about voice reported by Yorkston et al. (1999 – no speech symptoms detected in some PD patients who complain of having to use increased effort to speak).

D. Limitations of the Study

The study results are limited by the type of PD patient who participated and may not be transferable to those that did not volunteer. Subjects were recruited on a voluntary basis (which may contribute to subject bias). The fact that the treatment provider has a unique cross-disciplinary background may also make it more difficult to transfer to other therapists. Reproduction of the treatment program would probably require the involvement of two professionals working together (one from the field of vocal pedagogy and one from speech language pathology).

Important information surfaced in the anecdotal reports from friends and family of the participants. They reported improved voice use in everyday situations outside the clinic (where skills were tested). Unfortunately this information was not measured objectively and so cannot be evaluated to see if this happened to all participants or only to a few.

E. Clinical Implications of the Results

The perceptual results showed some statistically significant (SII) and clinically relevant changes (SII and V-RQOL), which are likely related to the good compliance, participation and attendance in the treatment. Participants noticed these improvements in their everyday communication and were motivated to organize a weekly community continuation group made possible by funding from the Alberta Parkinson's Society. The treatment has thus moved into a naturalistic setting and participants have been empowered to self manage at least a part of their care.

The acoustic/timing results also showed statistically significant (average frequency in reading, maximum intensity range) and clinically relevant acoustic/timing improvements (average frequency in reading, maximum intensity range, frequency range, fundamental frequency variation in reading) following the treatment program. This means that some vocal skills were enhanced following a group treatment for people with a progressive disorder, and that this change has perhaps helped to slow deterioration. The fact that not all acoustic changes were transferred into all clinical contexts or tasks tested implies that the new skills were not

completely learned and that further maintenance or carryover treatment is required following the program so that participants retain and habituate the vocal quality of life they reported. Participants gain vocal skills, but they may not be able to use them all the time. A longer treatment period may be required to bring about complete skill acquisition and habituation, or perhaps individual treatment is still needed. As such, this intervention may serve as a maintenance group for skills developed in individual therapy, as a proactive way to prevent loss of vocal skills early in the disease, as a valuable education group prior to individual therapy, or as an alternative when no other resources are accessible. The treatments for PD at the Glenrose Rehabilitation Hospital have been expanded as a result of this study. A version of this program is now offered periodically throughout the year.

Given that this was a group treatment rather than an individual treatment program, the results are surprisingly positive. In light of the strong commitment to individual treatment by the successful and effective LSVT® LOUD program, it is surprising that such a group approach could be effective. A group approach has the added benefit of possible social network support for people with PD. The findings add to the growing literature on group approaches to voice and speech treatment for people with PD.

In summary, some of the results reported above support group clinical interventions in the treatment of voice problems found in Parkinson's disease.

F. Broader Implications of the Study

The improvement in acoustic/timing measures following treatment may have resulted from the participants' greater laryngeal and respiratory skills, which in turn may have enhanced speech/voice and swallowing, two areas of concern for people with PD and other neurological diseases, and also for those experiencing normal aging. Voice improvement may benefit deconditioned elderly or stroke victims, for example. Swallowing improvement as a side effect of vocalization treatment has been documented in one study (Sharkawi et al., 2002) and reported anecdotally in others (de Angelis et al., 1997; Tanner-Semple et al., 2005). If improved swallowing could be shown to result from vocalization therapy, the treatment may have implications for reduced hospital visits and may actually lengthen lives for people with PD and those with other neurological disorders. According to Svenson et al. (1993) the average hospital stay for people with PD is 104 days and hospitalization can be frequent.

G. Research Implications

Although there is some limited evidence that vocalization programs are beneficial to those with PD, larger and more rigorous studies such as

those suggested by the Cochrane reviews would improve the research data supporting these clinical programs. A study with a control group could be conducted. To avoid refusing treatment to interested participants, a joint Speech Language Pathologist/Voice Teacher program could perhaps be compared to a normal choral program or a non-vocal support group. The finding of consistently lower pitch during conversation as opposed to reading should also be explored. The participants' viewpoint is important, but the people who live with and around those with PD should also be consulted to explore the anecdotal evidence on louder voice use and better swallowing.

The reported improvements in swallowing mentioned above (de Angelis et al., 1997; Sharkawi et al., 2002; Tanner-Semple et al., 2005) suggest that benefits other than voice improvement may result from vocalization programs. A program that has a larger focus on the singing voice may in fact have different benefits than one focused solely on the speaking voice. Greater benefits in the swallowing domain may occur with a large singing focus as a result of the more extensive laryngeal excursion that comes from the observed expansion of frequency range. If such benefits are demonstrated, this and similar treatments could have a major impact on the health and quality of life for people with PD and for people with many other neurological diseases, and possibly lead to savings in health care dollars from reduced hospital stays.

Chapter VI: Conclusion

The purpose of this study was to determine whether a group treatment for people with PD that combines vocal pedagogy and speech-voice pathology approaches within sessions is effective in improving the vocal ability of participants and improving their vocal quality of life as it relates to communication. Evidence for the effectiveness of such an approach could facilitate coordination of SLP and singing resources available in the community and perhaps help to integrate therapeutic activities into normal everyday life. Such treatment would allow the wider voice training community to become involved in the overall speech/voice treatment for people with PD, with the aim of reducing costs, improving access, improving and maintaining community re-integration, providing a program to slow voice deterioration, and ensuring that resources for continued vocal health are in place. In short, this approach may contribute to the creation of a feasible, affordable, community resource-based treatment that encourages lifelong vocal health, self management of care and maximization of the vocal resources available to people with PD.

In this dissertation Parkinson's disease (PD) and its associated voice, speech, dysphagia and cognitive problems were introduced. A library search and a literature review were followed by the research question: Does a "cross-disciplinary group vocalization treatment" increase the vocal ability and vocal quality of life of people with idiopathic

Parkinson's disease? A description of the study followed and the dissertation concluded with the findings, discussion and an examination of the implications of the research.

PD is a progressive neurological disorder resulting from dopamine deficiency that causes movement problems across the body including the respiratory and vocal mechanisms. The voice and speech problems present in PD include dysphonia (poor voice quality), hypophonia (reduced loudness), reduced prosody (less frequency and loudness variation), variable rate of speech, reduced speech intelligibility, slurred speech, shallow breathing and problems initiating the voice. Poor vocal fold closure, problems with laryngeal elevation or delayed swallow due to reduced tongue mobility and co-ordination may contribute to swallowing difficulties. Cognitive problems may include poor awareness of an individual's own vocal loudness and a progressive dementia. The stooped posture that frequently develops interferes with respiration and the flat affect often seen hinders communication and socialization. This study focused on improvement of voice problems, which may overlap with speech, breathing, posture and swallowing problems.

The library and literature review included a survey of the development of voice and speech treatment for the PD population and began by mentioning that the early, articulation based therapies were not very effective. The first vocalization study was conducted by Scott and

Caird (1983). They showed that improved vocal intensity tended to improve articulation, a finding that had implications for the treatment of various speech and voice disorders. The effective and well researched LSVT® LOUD program was formally developed in 1987 (Ramig et al., 1994), and at about the same time Robertson and Thomson (1984) and Johnson and Pring (1990) showed positive outcomes for other vocalization approaches. Following the lead of the successful vocalization programs for PD created by the LSVT® LOUD group, music therapist Haneishi (2001) and Speech Language Pathologist Tanner-Semple et al. (2005) explored individual voice therapy that included singing. Many have followed Johnson and Pring's (1990) group approach. Successful voice therapy groups for PD were studied by Sullivan et al. (1996), de Angelis et al. (1997), Manor et al. (2005) and Gupta et al. (2008). Other researchers introduced singing into group music therapy (Pacchetti et al., 1998; 2000) and tested separate speech language pathology sessions and choral sessions for people with PD (di Benedetto et al., 2009; Evans et al., 2011).

The LSVT® LOUD program has the best efficacy results and the most standardized protocol, but may not address all the voice and speech treatment needs of people with PD. Maintenance of skills, ways to make repetitive practice more enjoyable, early intervention, less intensive treatment, and easier access to treatment all need to be addressed where and when LSVT® LOUD is not available or appropriate (such as early in

the disease). Many of the other studies mentioned have tested programs aimed at addressing these needs in one way or another.

The research question asked whether a “cross-disciplinary group vocalization approach” would increase the vocal ability and vocal quality of life of people with idiopathic Parkinson’s disease. The rationale for testing the effectiveness of a group vocalization program arose out of the literature summarized above, neural plasticity and motor learning studies, the existence of group acoustic effects (Lombard and choral effects) that enhance treatment goals, the need to address all the voice and speech needs of people with PD, research on the benefits of singing in general, and from the writer’s own clinical experience. There is limited but growing evidence in the literature that individual and/or group vocalization programs are helpful in the remediation of the communication problems experienced by persons with PD, and that a specific type of vocalization - singing - may add to these benefits. The treatment program involved vocal exercises and choral singing aimed at improvement of all aspects of vocal ability. Twenty-eight participants completed six weeks of twice weekly sessions in a within subjects pre and post research design. Attempts were made to control inter and intra subject variability and tester bias.

Participants’ vocal ability was tested with both acoustic/timing and perceptual measures. The statistically significant changes in expanded intensity ranges and the evidence of higher habitual frequency in reading

aloud post treatment showed that some acoustic/timing vocal improvement did take place despite the lack of individual attention (only group treatment provided) and the inevitable deterioration of voice that accompanies the disease.

Improved vocal ability most likely contributed to the statistically significant improvement in vocal quality of life reported by participants (*Speech Intelligibility Inventory*), but this may not have been the only cause. Other factors, such as a positive group experience, the pleasure of working towards a common group goal, social interaction with people in the same situation, and the creative expression and mood enhancement that results from singing and music making may all have had an effect. In any case, it is evident that the group treatment improved the vocal quality of life of the participants, so much so that they have formed a continuation group following the study led by the writer.

Other unexpected information came to light during the study. Possible positive effects on swallowing were mentioned by several participants, and the fact that habitual frequency was usually lower in conversation than in oral reading is also noteworthy. These observations could lead to research projects on the effect of task on measures of average fundamental frequency in people with PD and the effect of vocalization programs involving singing on swallowing in people with PD.

Future research should involve larger, more rigorous studies with control groups or comparison treatments in order to determine the best protocols and dosages for each stage of PD. Measurements should include not only clinician and participant viewpoints, but also judgments from people who communicate with the participants outside the clinic. Studies on task dependent frequency and intensity differences in people with and without PD may help as well to sort out measurement issues. Swallowing changes resulting from vocalization therapy is another area that requires further attention. The LSVT® LOUD researchers have created a well-defined vocalization program that can be replicated and researched systematically. This standardization and careful definition is necessary for singing treatments, so that future studies can reproduce and test the effects.

Based on the sample size, the statistically significant changes and the reasonable effect sizes one can conclude that this treatment program had positive effects on the vocal ability and vocal quality of life of participants. Specifically, with the most conservative approach to statistical significance, two measures of vocal ability and one measure of vocal quality of life improved. The average voice frequency of participants during reading rose significantly and they were able to produce louder and quieter sounds (greater loudness ranges). The *Speech Intelligibility Inventory: Self-Assessment* results showed that participants noticed vocal improvement.

This study has tested a unique cross-disciplinary group approach that combines voice/speech pathology and vocal/choral pedagogy into a meaningful, enjoyable, community based activity. It appears to be relatively easy to access, appropriate at many stages of voice problems, does not require prior musical training, maximizes the acoustic effects on loudness, vocal effort and initiation of voice, makes use of the anonymity of vocalizing in a group and provides social opportunities. The progressive nature of PD necessitates long-term therapy that addresses differing needs at various stages of the disease. Given the detrimental effects of voice loss on psycho-social-economic well being, the low uptake of speech language pathology services and the limited accessibility to treatment in many areas, it is clear that there is room to improve service for people with PD. The results reported in this study showed that this group vocalization approach has the potential to provide a valuable service that can enhance the lives of people with PD.

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Appendix A: Consensus Auditory-Perceptual Evaluation of Voice

Name:_____

Date:_____

The following parameters of voice quality will be rated upon completion of the following tasks:

1. Sustained vowels, /a/ and /i/ for 3-5 seconds duration each.

2. Sentence production:

a. The blue spot is on the key again.
b. How hard did he hit him?
c. We were away a year ago.
d. We eat eggs every Easter.
e. My mama makes lemon muffins.
f. Peter will keep at the peak.

3. Spontaneous speech in response to: "Tell me about your voice problem" or "Tell me how your voice is functioning."

Legend: C= Consistent	I= Intermittent
MI= Mildly Deviant	MO= Moderately Deviant

Overall Severity _____ **C I** ___/100

MI MO SE

Roughness _____**C I** ___/100

MI MO SE

Breathiness _____ **C I** ___/100

MI MO SE

Strain _____**C I** ___/100

MI MO SE

Pitch **(Indicate the nature of the abnormality):**_____

_____**C I** ___/100

MI MO SE

Loudness **(Indicate the nature of the abnormality):**_____

MI MO SE

_____ _____ **C I** ___/100

MI MO SE

COMMENTS ABOUT RESONANCE: NORMAL OTHER

Description:_____

_____

ADDITIONAL FEATURES (for example, diplophonia, fry, falsetto, asthenia, pitch instability, tremor, wet/gurgly, or other relevant terms):_____

Clinician:_____

Appendix B: Speech Intelligibility Inventory: Self-Assessment Form

Name of person completing form:_____

If not client, relationship to client:_____**Date:**_____
Diagnosis:_____

People find it hard to understand my (his/her) speech:

1. In noisy places	**[ ] always**	**[ ] often**	**[ ] sometimes**	**[ ] seldom**	**[ ] never**	**[ ] does not apply**
2. In most public places	**[ ] always**	**[ ] often**	**[ ] sometimes**	**[ ] seldom**	**[ ] never**	**[ ] does not apply**
3. In a group of people talking	**[ ] always**	**[ ] often**	**[ ] sometimes**	**[ ] seldom**	**[ ] never**	**[ ] does not apply**
4. In the morning	**[ ] always**	**[ ] often**	**[ ] sometimes**	**[ ] seldom**	**[ ] never**	**[ ] does not apply**
5. In the afternoon	**[ ] always**	**[ ] often**	**[ ] sometimes**	**[ ] seldom**	**[ ] never**	**[ ] does not apply**
6. In the evening	**[ ] always**	**[ ] often**	**[ ] sometimes**	**[ ] seldom**	**[ ] never**	**[ ] does not apply**
7. If I haven't had my medications	**[ ] always**	**[ ] often**	**[ ] sometimes**	**[ ] seldom**	**[ ] never**	**[ ] does not apply**
8. If people are too far away	**[ ] always**	**[ ] often**	**[ ] sometimes**	**[ ] seldom**	**[ ] never**	**[ ] does not apply**
9. Over the telephone	**[ ] always**	**[ ] often**	**[ ] sometimes**	**[ ] seldom**	**[ ] never**	**[ ] does not apply**
10. When it is dark	**[ ] always**	**[ ] often**	**[ ] sometimes**	**[ ] seldom**	**[ ] never**	**[ ] does not apply**
11. When the listeners are strangers	**[ ] always**	**[ ] often**	**[ ] sometimes**	**[ ] seldom**	**[ ] never**	**[ ] does not apply**
12. When I talk too fast	**[ ] always**	**[ ] often**	**[ ] sometimes**	**[ ] seldom**	**[ ] never**	**[ ] does not apply**
13. When I talk too slow	**[ ] always**	**[ ] often**	**[ ] sometimes**	**[ ] seldom**	**[ ] never**	**[ ] does not apply**
14. When I talk too softly	**[ ] always**	**[ ] often**	**[ ] sometimes**	**[ ] seldom**	**[ ] never**	**[ ] does not apply**
15. When I talk too loudly	**[ ] always**	**[ ] often**	**[ ] sometimes**	**[ ] seldom**	**[ ] never**	**[ ] does not apply**
16. When I am tired	**[ ] always**	**[ ] often**	**[ ] sometimes**	**[ ] seldom**	**[ ] never**	**[ ] does not apply**
17. When I am standing	**[ ] always**	**[ ] often**	**[ ] sometimes**	**[ ] seldom**	**[ ] never**	**[ ] does not apply**
18. When I am sitting	**[ ] always**	**[ ] often**	**[ ] sometimes**	**[ ] seldom**	**[ ] never**	**[ ] does not apply**
19. When I am walking	**[ ] always**	**[ ] often**	**[ ] sometimes**	**[ ] seldom**	**[ ] never**	**[ ] does not apply**
20. Unless I try to hard to make myself understood	**[ ] always**	**[ ] often**	**[ ] sometimes**	**[ ] seldom**	**[ ] never**	**[ ] does not apply**

On the whole, people find it hard to understand my speech
[ ] all of the time [ ] most of the time [ ] sometimes [ ] seldom [ ] never

What do you do to improve your speech?_____

Appendix C: Voice-Related Quality of Life

Name:_____

Date:_____

We are trying to learn more about how a voice problem can interfere with your day to day activities. On this paper, you will find a list of possible voice related problems. Please answer all questions based upon what your voice has been like over the past two weeks. There are no "right" or "wrong" answers.

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

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

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

Appendix D: Information Sheet

Office of the Dean, Faculty of Rehabilitation Medicine

UNIVERSITY OF ALBERTA

3-48 Corbett Hall

Edmonton, Alberta, Canada T6G 2G4

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INFORMATION SHEET

Vocalization Project for People with Idiopathic Parkinson's Disease (IPD)

Principal Investigator:

Merrill Tanner, BSc, MBA, MMus, R. SLP, PhD Candidate, University of Alberta

Supervisory Committee:

Drs. Lili Liu, Melanie Campbell, Leonard Ratzlaff, and Sharon Warren

Background: Over 75% of people with Parkinson's disease have speech and voice symptoms. Symptoms include reduced loudness, slurred speech and difficulty starting speech. Vocalization therapy includes singing, chanting, humming and voice exercises. Speech therapists can provide therapy and measure voice improvement. However, less than 20% of people with Parkinson's disease receive speech therapy in a clinic. These therapies tend to focus on voice exercises rather than a meaningful activity. It has been suggested that

voice therapy in combination with singing can help improve voice and speech for people with Parkinson's disease. Singing could offer an enjoyable way for people to exercise their voices outside of a clinic.

Purpose: You are invited to participate in a research study that looks at the usefulness of vocalization therapy to improve the voices of people with Parkinson's disease.

Procedures:

a) You will be tested twice before the study and twice after the study. Each test will be one-hour long. Testing involves questionnaires and measurements of voice and speech by computer, and tape and video recorder. You may still participate if you do not wish to be recorded by video, and agree to be audio recorded.

b) You would attendance 2 sessions each week for 6 weeks. Each session is 60 to 90 minutes. You will be put into a group of 8 people that receive one treatment session per week, and into a larger group for another session per week (total 12 treatment sessions). In these sessions you will do vocal warm-ups with body movements and vocal exercises such as prolonging vowels, loud talking, singing as well as projected speech.

c) You will receive a DVD or CD for daily practice.

Your age, sex, year of birth, stage of Parkinson's and previous speech or voice therapy will be obtained from your medical record for use in analyzing the data.

Possible Benefits: The possible benefits to you from taking part in this study are improvement in your voice and which may help you participate in community vocal and social activities.

Possible Risks: There are no known risks in participating in this study.

Confidentiality: Personal health records relating to this study will be kept confidential. Any research data collected about you during this study will not identify you by name, only by coded number. Your name will not be disclosed outside the research clinic. Any report published as a result of this study will not identify you by name.

The researchers may request past medical history and test results from your personal health records in order to understand your test results in this study. If you agree, they may also contact your family physician and your other health care providers to obtain additional medical information. The Health Research Ethics Board may have access to your personal health records to monitor the research and verify the accuracy of study data.

By signing the consent form you give permission to the study staff to access any personally identifiable health information, which is under the custody of other health professionals as deemed necessary for the conduct of the research. The study data will be stored in a locked filing cabinet in the Glenrose Rehabilitation Hospital in the locked office of Merrill Tanner.

Voluntary Participation: You are free to withdraw from the research study at any time, and your continuing medical care will not be affected in any way. If the study is not undertaken or if it is discontinued at any time, the quality of your medical care will not be affected. If any knowledge gained from this or any other study becomes available that could influence your decision to continue in the study, you will be promptly informed.

Reimbursement of Expenses: You will be provided with parking passes at each visit.

Contact Names and Telephone Numbers: If you have concerns about your rights as a study participant, you may contact Joanne Volden, Associate Dean of Graduate Studies and Research in the: Faculty of Rehabilitation Medicine
3-48, Corbett Hall, Edmonton, Alberta, Canada, T6G 2G4
Office 780-492-0651, 780-492-9674; or Email: joanne.volden@ualberta.ca.

Please contact these individuals if you have any questions:

Merrill Tanner, R.SLP, PhD Candidate: (780) 436-6553 or (780) 735-7999

Lili Liu, PhD, Study Supervisor: 780-492-5108

Appendix E: Consent Form

UNIVERSITY OF ALBERTA

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www.rehabmed.ualberta.ca

Consent Form

Part 1 (to be completed by the Principal Investigator):

Title of Project: Vocalization Therapy for People with idiopathic Parkinson's disease

Principal Investigator: Merrill Tanner (780) 436-6553

Study Supervisor: Dr. Liili Liu (780) 492-5108

Part 2 (to be completed by the research subject):

Do you understand that you have been asked to participate in a research study?

Yes ☐ No ☐

Have you read and received a copy of the attached Information Sheet?

Yes ☐ No ☐

Do you understand the benefits and risks involved in taking part in this research study Yes ☐ No ☐

Have you had an opportunity to ask questions and discuss this study Yes ☐ No ☐

Do you understand that you are free to withdraw from the study at any time without having to give a reason and without affecting your future medical care?

Yes ☐ No ☐

Has the issue of confidentiality been explained to you?

Yes ☐ No ☐

Do you understand who will have access to your records, including health information that will identify you personally?

Yes ☐ No ☐

Do you want the investigator(s) to inform your family doctor that you are participating in this research study?

Yes ☐ No ☐

If so, give his/her name _____

Do you give permission to be videotaped?

Yes ☐ No ☐

Do you give permission to be audiotaped?

Yes ☐ No ☐

Do you give permission for the use of videos obtained during this study in future research and education sessions about the results of the project?

Yes ☐ No ☐

Who explained this study to you?

_____

I agree to take part in this study:	YES ☐	NO ☐

Signature of Research Subject

_____

(Printed Name)

_____

Date:_____

Signature of Witness

_____

I believe that the person signing this form understands what is involved in the study and voluntarily agrees to participate.

Signature of Investigator or Designee_____ Date _____

THE INFORMATION SHEET MUST BE ATTACHED TO THIS CONSENT FORM AND A COPY GIVEN TO THE RESEARCH SUBJECT

Appendix F: Testing Protocol

EASY-TO-USE TESTING PROTOCOL INSTRUCTIONS

Lab door – lock to left and it will stay locked when you close it

SET UP: Turn on both computers, taperecorder, videorecorder and visipitch/CSL. Gather stopwatch, binder & sound level meter from drawer. Position client, microphones and video camera. Make sure two mics on stands do not touch – check video recording to see if buzz recording on video. Put disc in video camera turn it on after client is seated and placed at mic. Turn on taperecorder. State patient's iniytials and date with year before beginning testing for taperecorder and video.

Initials of client: _____Date_____, 2010 Time _____

Time of last meds _____Time of next meds_____

Remind client "Whenever you do speaking tasks please face the camera and speak into the microphone."

Visipitch/CSL and Taperecorder & Video – instructions all in binder

State patient's name and date before beginning for taperecorder and video.
Taperecorder-put mic in first (left) channel-recording level at 5 – controlled by outside-put in card with wire looking side in first – snap door shut - on/off slide black button over-to record slide red button over-stop record press black stop

1. **MPT – record on Visipitch/CSL**
   No Model allowed
   Instruction: Say "ah" for as long as I hold up my hand (5 sec) at a comfortable pitch and loudness when I say "Go"
   Click "Record" then say "Go"
   Name file with initials, gender, task code and date - Save file
   Print select parameter and analysis statistics (not numerical) label under institution with initials, gender, task code - print

   Also use stopwatch for 3 trials of ah- record no. of seconds-don't record on visipitch/CSL
   Instruction: Say "ah" for as long as you can at a comfortable pitch and loudness when I say "Go" Repeat 3x.
   _____ _____ _____ sec

2. **Counting**

   No model allowed
   Instruction: Count from 1 to 10 when I say “Go”
   Click “Record” then say “Go”
   Name file with initials, gender, task code and date - Save file
   Print select parameter and analysis statistics (not numerical) label under institution with initials, gender, task code - print

3. **Conversation**

   No model allowed
   Instruction: Tell me about the place you were born when I say “Go”
   Click “Record” then say “Go”
   Name file with initials, gender, task code and date - Save file
   Print select parameter and analysis statistics (not numerical) label under institution with initials, gender, task code - print

4. **Oral Reading (Grandfather Passage)**

   Instruction: Please read this passage out loud when I say “go”
   Hand them the passage
   Click “Record” then say “Go”
   Name file with initials, gender, task code and date - Save file
   Print select parameter and analysis statistics (not numerical) label under institution with initials, gender, task code - print

5. **Loudness Range – also use sound level meter set to fast rate, setting A and at the appropriate level of loudness – probably 80 for loud and 60 for quiet.**

   A. Model Allowed
   Instruction: Say as loudly as you can **“Hey get out of there!”** when I say “Go”
   Click “Record” then say “Go”
   Name file with initials, gender, task code and date - Save file
   Print select parameter and analysis statistics (not numerical) label under institution with initials, gender, task code - print.
   Write down highest dB level observed_____

   B. Model Allowed
   Instruction: Say as quietly as you can (without whispering) “**I don’t want anyone to hear this”** when I say “Go”
   Name file with initials, gender, task code and date - Save file
   Print select parameter and analysis statistics (not numerical) label under institution with initials, gender, task code - print.
   Write down lowest (max) dB level observed_____

6. **Pitch Range Task**
   Model allowed
   Instruction: Say “ah” at a comfortable pitch and then slide up as far as you can go. Then start again at a comfortable pitch and slide down as far as you can go.
   Model slide up and down.
   Click “Record” then say “Go”
   Name file with initials, gender, task code and date - Save file
   Print select parameter and analysis statistics (not numerical) label under institution with initials, gender, task code - prin.t.
   Later - check the range from recording on the keyboard to see if vivsipitch is accurate.
   Lowest note_____ Highest note_____

CAPE-V data – head mic should already be on and taperecorder should be running – no computer needed for this section

7. **Vowel Prolongation**
   A.
   No Model allowed. Instruction: Say “ah” for as long as I hold up my hand (5 sec) at a comfortable pitch and loudness Repeat 3x
   B.
   No Model allowed. Instruction: Say “ee” for as long as as I hold up my hand (5 sec) at a comfortable pitch and loudness Repeat 3x

8. **Sentences** No Model allowed.
   Instructions: Please read the following 6 sentences aloud:

   a. The blue spot is on the key again.

   b. How hard did he hit him?

   c. We were away a year ago.

   d. We eat eggs every Easter.

   e. My mama makes lemon muffins.

   f. Peter will keep at the peak.

9. **Spontaneous Speech**
   No Model allowed. Instruction: Please tell me how your voice is functioning

SINGING (the grand finale - all machines at once)

Using headphones attached to MAC computer playing "Silent Night" in ITunes and then recording on the CSL/Visipitch. (recording on tape recorder and on video camera are still going since beginning of session).

Check volume on MAC in upper right hand corner of screen – should be in middle. Song is in Itunes in the Parkinson's playlist.

10. Silent Night

Model allowed – two microphones-to sing into -one head mounted and one on a stand.

Instructions: Sing "Silent Night". You will hear an introduction and then the tune begins - when you hear the tune- start to sing the song.

Put headphones on client. Press start on start "Silent Night" on Itunes on MAC.

Click "Record" on CSL/visipitch. After they sing one verse, stop visipitch.

Name file with initials, gender, task code and date - Save file

Print select parameter and analysis statistics (not numerical) label under institution with initials, gender, task code - print.

Turnoff song, take off headphones.

Please check that taperecorder, video and Visipitch recordings are there and that the quality is reasonable at the end of each session. Thanks.

Task Codes:

or 1-10 for counting

Conv = conversation

MPT = maximum phonation time

Grand = grandfather passage excerpt

Loud = loudness range -add Quiet if has to be divided

Pitch = pitch range

Night = singing one verse of Silent Night

Appendix G: Data

Table A

Partici-pant	Male Female	Age	Time (years) since Dx	Group	Pre-MPT	Post-MPT	Pre-Maximum Intensity Range	Post-Maximum Intensity Range
1	M	64	7	Spring	13.31	13.29	56.33	57.00
2	M	60	2	Spring	6.11	9.09	27.60	63.48
3	M	68	15	Spring	17.30	11.99	47.75	49.09
4	M	46	8	Spring	12.53	13.36	56.24	75.88
5	M	68	6	Spring	17.90	16.81	32.47	46.11
6	F	69	3	Spring	6.47	11.59	39.54	52.91
7	M	61	1	Spring	12.45	10.78	42.32	50.69
8	F	46	10	Spring	14.00	12.58	40.36	44.74
9	F	63	19	Spring	17.98	17.91	46.40	56.15
10	M	70	3	Spring	8.67	17.88	44.07	51.56
11	F	67	14	Spring	19.33	15.37	59.51	49.41
12	F	67	2	Spring	7.86	8.01	38.43	54.14
13	F	60	1	Spring	5.36	4.35	32.84	48.05
14	F	74	6	Spring	9.00	11.48	22.96	47.53

The darker squares show positive change.

Table B

Partici-pant	Male Female	Age	Time (years) since Dx	Group	Pre-MPT	Post-MPT	Pre-Maximum Intensity Range	Post-Maximum Intensity Range
15	M	68	2	Fall	11.31	12.61	51.28	58.54
16	M	61	5	Fall	28.68	22.26	61.84	59.35
17	F	70	6	Fall	21.89	23.77	58.88	56.22
18	M	69	5	Fall	10.85	11.26	52.77	50.65
19	F	63	14	Fall	17.07	19.33	54.35	55.01
20	M	66	10	Fall	19.31	22.16	41.33	52.83
21	F	59	19	Fall	21.50	19.45	36.17	48.84
22	F	82	5	Fall	7.91	13.88	47.17	49.09
23	F	79	0	Fall	16.09	16.86	42.08	48.66
24	F	83	2	Fall	14.68	13.09	49.94	54.02
25	M	58	3	Fall	22.16	22.38	59.66	50.96
26	M	58	1	Fall	9.42	25.42	47.42	59.77
27	F	62	2	Fall	12.46	14.74	53.30	53.69
28	M	66	9	Fall	10.84	10.87	38.01	36.25

The darker squares show positive change.

Table C

Parti-ci-pant	Pre-Average Intensity Conver-sation	Post-Average Intensity Conversation	Pre-Average Intensity Reading	Post-Average Intensity Reading	Pre-Frequency Range	Post-Frequency Range
1	64.00	62.60	63.73	61.76	16.00	16.00
2	61.00	64.28	62.82	63.11	21.00	26.00
3	60.89	64.38	58.50	63.69	16.50	16.00
4	56.21	57.55	56.59	57.94	26.50	27.00
5	66.89	63.46	68.98	66.15	23.50	25.50
6	58.85	61.40	60.78	62.89	21.50	26.69
7	63.57	61.91	60.62	60.83	24.00	24.00
8	58.30	61.21	60.12	62.01	15.00	35.00
9	62.33	63.17	65.75	65.28	25.00	25.00
10	62.69	64.89	63.28	65.14	12.50	17.50
11	64.67	65.75	67.40	67.02	30.00	32.00
12	61.43	56.54	56.49	60.82	22.50	28.07
13	57.82	54.49	57.99	54.06	16.50	29.50
14	56.07	52.37	58.61	55.54	15.50	21.50

The darker squares show positive change.

Table D

Partici-pant	Pre-Average Intensity Conversation	Post-Average Intensity Conversation	Pre-Average Intensity Reading	Post-Average Intensity Reading	Pre-Frequency Range	Post-Frequency Range
15	53.62	52.56	57.46	55.83	25.50	23.00
16	56.31	57.62	58.91	58.75	30.00	31.50
17	51.44	54.38	53.75	53.19	31.50	29.00
18	65.48	58.79	64.03	62.75	25.50	32.50
19	57.64	53.14	56.95	53.77	21.00	29.50
20	58.14	59.94	60.05	59.68	14.50	18.50
21	58.87	57.05	58.89	53.78	29.00	27.00
22	57.71	49.32	60.05	50.52	22.00	20.50
23	53.55	53.64	56.86	53.17	25.00	9.00
24	64.62	61.68	59.77	59.55	20.00	25.00
25	58.51	55.52	61.35	57.39	22.50	29.00
26	60.82	57.45	61.40	58.47	26.00	26.50
27	54.20	50.62	56.91	53.43	25.00	34.00
28	62.43	66.18	63.99	66.45	16.50	20.50

The darker squares show positive change.

Table E

Parti ci-pant	Pre-Average Frequency Conver-sation	Post - Average Frequency Conver-sation	Pre-Average Frequency Reading	Post-Average Frequency Reading	Pre-Frequency Variability Conver-sation	Post-Frequency Variability Conver-sation
1	150.12	149.17	148.87	151.14	14.82	37.79
2	148.52	151.44	159.26	154.89	14.64	23.61
3	156.99	165.49	158.59	168.74	26.69	58.85
4	117.65	115.35	122.51	120.26	13.48	12.29
5	126.53	126.34	139.28	138.72	17.24	21.12
6	180.78	188.95	190.67	206.68	28.63	37.74
7	115.35	123.84	125.06	136.96	8.99	18.06
8	142.34	150.44	160.29	166.30	13.70	17.10
9	166.61	174.70	185.29	193.45	17.59	25.73
10	137.55	131.88	138.56	137.55	59.63	36.81
11	191.47	195.97	214.09	211.23	50.82	46.93
12	174.13	171.54	187.97	199.16	40.77	43.50
13	175.81	191.29	175.99	177.62	28.25	45.66
14	155.62	159.38	161.40	172.96	8.47	31.73

The darker squares show positive change.

Table F

Partici-pant	Pre-Average Frequency Conver-sation	Post - Average Frequency Conver-sation	Pre-Average Frequency Reading	Post-Average Frequency Reading	Pre-Frequency Variability Conver-sation	Post-Frequency Variability Conver-sation
15	79.95	81.56	94.72	102.70	25.81	24.90
16	147.71	120.70	135.00	121.20	30.39	24.01
17	154.35	156.19	162.12	165.87	38.17	29.78
18	128.87	137.43	129.64	136.44	31.20	29.81
19	184.06	181.93	195.06	201.61	23.93	20.86
20	96.18	108.92	95.70	111.80	40.56	11.21
21	182.80	211.63	185.11	190.05	34.98	57.71
22	193.16	181.97	200.12	209.46	23.57	19.83
23	171.14	181.90	165.50	173.00	21.14	20.27
24	148.35	141.85	154.11	152.83	27.98	34.39
25	121.12	119.30	138.32	144.71	53.28	53.28
26	100.72	114.86	103.31	117.66	28.93	35.71
27	177.33	179.49	193.77	195.34	27.59	50.58
28	145.35	136.88	135.02	131.30	35.40	27.34

The darker squares show positive change.

Table G

Participant	Pre-Frequency Variability Reading	Post-Frequency Variability Reading	Pre- SLP CAPE-V Rating Speech	Post- SLP CAPE-V Rating Speech	Pre-SLP CAPE-V Rating Singing	Post- SLP CAPE-V Rating Singing
1	12.92	20.88	18.00	38.00	17.00	25.00
2	20.75	23.28	32.00	22.00	7.00	7.00
3	28.44	46.89	52.00	54.00	47.00	64.00
4	10.55	17.98	11.00	3.00	23.00	17.00
5	21.27	29.92	18.00	17.00	29.00	40.00
6	21.52	28.54	9.00	28.00	22.00	14.00
7	9.85	24.90	17.00	16.00	18.00	16.00
8	15.05	16.45	27.00	5.00	24.00	15.00
9	32.21	45.13	4.00	5.00	8.00	7.00
10	15.47	16.36	32.00	18.00	30.00	33.00
11	57.19	49.90	18.00	18.00	8.00	2.00
12	29.25	38.56	25.00	4.00	35.00	12.00
13	13.15	24.19	50.00	30.00	25.00	16.00
14	18.44	16.66	73.00	48.00	51.00	38.00

The darker squares show positive change.

Table H

Par-tici-pant	Pre-Frequency Variability Reading	Post-Frequency Variability Reading	Pre-SLP CAPE-V Rating Speech	Post- SLP CAPE-V Rating Speech	Pre-SLP CAPE-V Rating Singing	Post- SLP CAPE-V Rating Singing
15	16.19	19.25	11.00	10.00	5.00	5.00
16	14.18	17.83	30.00	10.00	24.00	10.00
17	24.39	26.69	9.00	26.00	15.00	13.00
18	41.36	24.73	31.00	25.00	40.00	35.00
19	19.66	23.26	14.00	16.00	10.00	15.00
20	24.80	32.31	15.00	5.00	5.00	5.00
21	23.58	25.81	33.00	29.00	50.00	50.00
22	41.40	42.92	24.00	19.00	65.00	10.00
23	30.47	23.95	29.00	34.00	40.00	50.00
24	24.54	36.02	24.00	40.00	25.00	28.00
25	29.89	54.80	10.00	7.00	10.00	10.00
26	29.72	22.51	18.00	10.00	20.00	20.00
27	23.65	24.40	8.00	7.00	30.00	25.00
28	30.06	32.17	17.00	21.00	20.00	18.00

The darker squares show positive change.

Table I

Participant	Pre- SII:SAF	Post- SII:SAF	Pre- VRQL	Post- VRQL
1	64.00	58.00	65.00	75.00
2	70.00	52.00	87.50	85.00
3	86.00	89.00	17.50	27.50
4	45.00	26.00	95.00	97.50
5	64.00	62.00	65.00	75.00
6	59.00	59.00	77.50	62.50
7	31.00	31.00	87.50	90.00
8	57.00	46.00	75.00	92.50
9	45.00	34.00	85.00	92.50
10	55.00	35.00	82.50	90.00
11	48.00	36.00	87.50	92.55
12	65.00	32.00	77.50	95.00
13	72.00	65.00	15.00	32.50
14	89.00	80.00	32.50	45.00

The darker squares show positive change.

Table J

Participant	Pre- SII:SAF	Post- SII:SAF	Pre- VRQL	Post- VRQL
15	53.00	50.00	82.50	85.00
16	53.00	46.00	95.00	87.50
17	33.00	30.00	92.50	97.50
18	49.00	49.00	65.00	65.00
19	58.00	62.00	72.50	60.00
20	52.00	39.00	65.00	92.50
21	56.00	50.00	15.00	82.50
22	73.00	66.00	27.50	44.00
23	60.00	59.00	50.00	67.50
24	62.00	58.00	82.50	80.00
25	52.00	46.00	90.00	92.50
26	75.00	54.00	35.00	47.50
27	17.00	10.00	90.00	85.00
28	51.00	53.00	85.00	82.50

The darker squares show positive change.