
**UNIVERSITI PUTRA MALAYSIA**

# *EFFECTS OF MUSIC-BASED VOICE INTERVENTION PROTOCOL ON VOCAL AMPLITUDE, PITCH RANGE, RESPIRATORY RATE, AND QUALITY OF LIFE OF PEOPLE WITH PARKINSON'S DISEASE*

**ANG MEI FOONG**

**FEM 2019 2**

# EFFECTS OF MUSIC-BASED VOICE INTERVENTION PROTOCOL ON VOCAL AMPLITUDE, PITCH RANGE, RESPIRATORY RATE, AND QUALITY OF LIFE OF PEOPLE WITH PARKINSON'S DISEASE

By

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**EFFECTS OF MUSIC-BASED VOICE INTERVENTION PROTOCOL ON VOCAL AMPLITUDE, PITCH RANGE, RESPIRATORY RATE, AND QUALITY OF LIFE OF PEOPLE WITH PARKINSON'S DISEASE**

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**March 2019**

**Chair : Indra Selvarajah, PhD**
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Parkinson's Disease (PD) is a chronic neurodegenerative disease in which the symptoms worsen over time. These symptoms are characterized by motor and non-motor problems marked by tremor at rest, muscular rigidity, and slow movements. In addition, people with Parkinson's Disease (PwP) are prone to develop voice impairment known as Parkinsonian Dysarthria where latest research suggested 90% of the PwP are affected. **Methods:** This study explored the effects of Music-based Voice Intervention Protocol (MusVIP) on three vocal parameters including vocal amplitude, respiratory rate, and pitch range, as well as quality of life (QOL) of PwP. 22 PwPs participated in this study and received 120-minutes singing sessions weekly for eight consecutive weeks. One-way repeated measures ANOVA was conducted to compare scores on the three vocal parameters at pre-, co- and post-intervention. QOL was measured through Voice Handicap Index (VHI) and Voice Related Quality of Life (VRQOL) questionnaires at pre- and post-intervention. Pre- and post-intervention interviews were conducted to find out the PwPs' perceptions on their vocal problems, music and song preferences and feedback on MusVIP. **Results:** Statistical tests revealed positive significant outcomes on vocal parameters ($p \leq 0.05$); paired sample t-test results of the questionnaires reported no significant changes to the QOL, however the mean scores revealed trends of improvements. Empirical data on PwPs' perceptions on their vocal problems, music and song preferences and feedback on MusVIP were documented. **Implications:** The findings of this study suggested that MusVIP is effective for voice rehabilitation of PwP and revealed potential benefits on QOL. This study had also gained empirical findings on the PwP's self-perceived vocal problems, their music preferences, as well as their feedback on the studied intervention protocol. The

evidence obtained from this study suggests that the MusVIP is a viable treatment option to aid voice rehabilitation of PwP.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
Sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**KEBERKESANAN PROTOKOL INTERVENSI SUARA BERDASARKAN MUSIK ATAS AMPLITUD VOKAL, PITCH RANGE, KADAR RESPIRASI, DAN KUALITI HIDUP DALAM PESAKIT PENYAKIT PARKINSON**

Oleh

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**Mac 2019**

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Penyakit Parkinson (PD) adalah penyakit kemerosotan saraf di mana gejala penyakit tersebut bertambah buruk dari semasa ke semasa. Gejala tersebut boleh dibahagikan kepada masalah motor dan bukan motor termasuklah gegaran ketika rehat, ketegaran otot, dan pergerakan perlahan. Di samping itu, pesakit Penyakit Parkinson (PwP) lebih cenderung untuk membentuk kecacatan suara yang dikenali sebagai Parkinsonian Dysarthria di mana penyelidikan terkini menunjukkan wujudnya kejejasan tersebut pada 90% PwP. **Kaedah:** Kajian ini meneroka kesan Protokol Intervensi Suara berasaskan Muzik (MusVIP) pada tiga parameter vokal iaitu amplitud vokal, kadar respirasi, dan julat pic, serta kualiti hidup (QOL) para PwP. 22 PwP telah mengambil bahagian dalam kajian ini dan telah menerima 120 minit sesi nyanyian mingguan selama lapan minggu berturut-turut. ANOVA sehala diukur berulang telah dijalankan untuk membandingkan tiga skor parameter vokal iaitu pada peringkat pra-, pertengahan dan pos-intervensi. QOL telah diukur melalui soal selidik Indeks Kecacatan Suara (VHI) dan Kualiti Hidup Berkaitan Suara (VRQOL) pada peringkat pra- dan pos-intervensi. Temu bual pra dan pos-intervensi telah dijalankan untuk mengetahui persepsi para PwP mengenai masalah vokal, pilihan muzik dan lagu mereka serta maklum balas mengenai MusVIP. **Hasil:** Ujian statistik telah mendedahkan hasil positif yang signifikan pada parameter-parameter vokal ($p \leq 0,05$); keputusan padanan-sampel ujian-t yang dipadankan dengan soal selidik tidak melaporkan sebarang perubahan ketara kepada QOL, namun skor purata menunjukkan kecenderungan terhadap penambahbaikan. Data empirikal mengenai persepsi PwP mengenai masalah vokal, muzik dan pilihan lagu mereka serta maklum balas mengenai MusVIP juga telah didokumentasikan. **Implikasi:** Penemuan kajian ini mencadangkan bahawa MusVIP berkesan untuk pemulihan suara PwP sekaligus mendedahkan faedah-faedah yang berpotensi untuk meningkatkan QOL. Kajian ini juga telah

memperoleh penemuan empirikal mengenai masalah vokal berdasarkan persepsi diri PwP, pilihan muzik, serta maklum balas mereka terhadap protokol intervensi yang dikaji. Bukti yang diperolehi daripada kajian ini menunjukkan bahawa MusVIP adalah rawatan yang berkesan untuk membantu pemulihan suara PwP.

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I certify that a Thesis Examination Committee has met on 29 March 2019 to conduct the final examination of Ang Mei Foong on her thesis entitled "Effects of Music-Based Voice Intervention Protocol on Vocal Amplitude, Pitch Range, Respiratory Rate and Quality of Life of People with Parkinson's Disease" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
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| | |
|---|---|
| PD | Parkinson's Disease |
| PwP | People with Parkinson's Disease |
| HD | Hypokinetic Dysarthria |
| VHI | Voice Handicap Index |
| VRQOL | Voice Related Quality of Life |
| HSM | Helping Skill Model |
| MusVIP | Music-related Voice Intervention Protocol |
| DBS | Deep Brain Stimulation |
| STN-DBS | Deep Brain Stimulation of the subthalamic nucleus |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background of the Study

Parkinson's disease (PD) is a chronic, progressive neurodegenerative disease that to date has no cure. The pathogenesis of PD remains unknown, what is known is that PD is caused by a reduction in the production of dopamine, a neurotransmitter that serves an important function to send signals among nerve cells. It is the main cause of motor problems in PD (S.-Y. Lim et al., 2012; Schulz & Grant, 2000).

The disease precipitates a range of motor and non-motor symptoms, as well as provokes mental health issues. Symptoms manifest differently in people with Parkinson's (PwP); and the order in which symptoms occur along the course of the disease emerges differently (Aarsland, Larsen, Karlsen, Lim, & Tandberg, 1999; Branchi et al., 2008; Jankovic, 2008; Meireles & Massano, 2012; Rutten et al., 2014).

The clinical diagnosis of PD relies on the identification of four core motor problems: tremor at rest, rigidity, bradykinesia (slowness), and postural instability. Other motor-symptoms such as freezing and dyskinesia are also observed among PwP at different stages of the disease (Dyduch & Załuska, 2014; Jankovic, 2008; S.-Y. Lim, Fox, & Lang, 2009; Politis et al., 2010).

Non-motor symptoms such as fatigue, depression, anxiety, constipation, pain, sleep disorders sometimes emerge before motor symptoms (S.-Y. Lim et al., 2009). The manifestation of non-motor symptoms is complex and can precede, occur concurrently, or follow motor symptoms (Wee et al., 2016). Other common non-motor symptoms include cognitive impairments, poor memory, slowness in psychological responses, problems of visuospatial functioning (Aarsland et al., 1999; Hyman, 1995; Meireles & Massano, 2012; Pagonabarraga, Kulisevsky, Strafella, & Krack, 2015), and sensory-motor integration impairments (Clark, Adams, Dykstra, Moodie, & Jog, 2014; Jankovic, 2008; Ramig, Fox, & Sapir, 2007; Richardson, Sussman, Stathopoulos, & Huber, 2014). In addition to that, PwP frequently suffers from neuropsychiatric symptoms, such as depression (Branchi et al., 2008), anxiety (Rutten et al., 2014), apathy (Pagonabarraga et al., 2015), hallucination/delusions (Meireles & Massano, 2012) and psychosis (Aarsland et al., 1999).

According to a systematic analysis on the global, regional, and national burden of Parkinson's disease within the years of 1990–2016, it is reported in this review that in 2016 there are 6.1 million individuals living with PD globally, strikingly increased as compared with 2.5 million reported in 1990, and the disease has caused 211,296 deaths in 2016. (Dorsey & Elbaz, 2018).

PD is the second most common neurodegenerative disease after Alzheimer's disease affecting almost 1-2% of people over the age of 60, or 0.3% in the general population, this is the commonly accepted prevalence rate so far (Massano & Bhatia, 2012). Even though PD is more common amongst older people, the onset of the disease can occur as early as in the adolescent years (S.-Y. Lim et al., 2012; Massano & Bhatia, 2012). Men are more likely to contract PD than women, with the male-female ratio at 3:2 noted in most studies (Alves, Forsaa, Pedersen, Dreetz Gjerstad, & Larsen, 2008; de Lau & Breteler, 2006).

A meta-analysis of epidemiological studies from 1985-2010, showed a rising prevalence of PD worldwide. Results of a meta-regression study show a rising prevalence of PD with age (Pringsheim, Jette, Frolkis, & Steeves, 2014). The disease is also expected to increase dramatically in the next few decades, particularly in developing countries as it is reported that many developing countries are experiencing an evitable demographic change, with a large proportion of the populations entering old age, the challenge of creating a sustainable healthcare service to the aged population is aggravated especially when PD affects predominantly older populations. This rising prevalence of PD and the duration of the disease also have a direct impact on the PwP and their immediate caregivers (Alves et al., 2008; de Lau & Breteler, 2006; Dorsey et al., 2007; Massano & Bhatia, 2012).

In view of the rising numbers of aged populations in Malaysia, the population aged 65 and above has increased from 3.9% in 2000 to 5.1% in 2010 based on the Population and Housing Census being conducted in 2010, and according to the latest publication on Current Population Estimates reported by the Department of Statistics Malaysia where they presented mid-year population estimations for the period of 2017 and 2018 based on the Census 2010, it is reported that the current estimation for the Malaysian population aged 65 and above has already increased to 2 million (6.3%) in 2017, and 2.1 million (6.5%) in 2018.

Based on the projected prevalence rate worldwide, it may be assumed that in Malaysia, there will be approximately 84,900 new PD cases yearly based on the Census 2010, or 97,200 cases yearly based on the population estimates 2018, that this drastic increment of PD may raise issues to health care system at the societal level and the national level on the annual medical costs, public healthcare systems and infrastructures, especially when the cost of care escalate over year (Boland & Stacy, 2012; Pringsheim et al., 2014). Therefore, an effective, sustainable and cost feasible treatment or rehabilitation is of critical importance.

In addition to motor symptoms, PwP is prone to develop Hypokinetic Dysarthria (HD) also known as Parkinsonian dysarthria (speech production problems due to PD). Hypokinetic Dysarthria affects the well-being of PwP which often results in the withdrawal from social activities and an increased risk of developing psychological disorders such as anxiety and depression; It also leads to secondary co-morbidities in the form of mental health issues which leaves a serious negative impact on both patients and their caregivers, increasing levels of frustration and distress (Aarsland et al., 1999; Miller, Deane, Jones, Noble, & Gibb, 2011; Miller, Noble, Jones, & Burn, 2006; Ramig et al., 2007). Even though speech impairments does not plague all PwP, early studies in the 1980s indicated that approximately 50% of PwP developed communication difficulties (Scott & Caird, 1983); By 2006, the deficit in speech among the PwP was charted as closer to 80% (Miller et al., 2006); The most recent studies by Ramig and Fox (2007) predicted that nearly 9 out of 10 PwP recorded a voice disorder (Ramig et al., 2007), indicating a rapidly escalating trend in the development of voice impairments in PwP.

## 1.2 Statement of the Problem

At present there is no cure nor prevention for PD, PD is a chronic disease that gradually worsens over time. Present treatments mainly rely on medication to control motor symptoms (S. Y. Lim, Puvanarajah, & Ibrahim, 2011). As for non-motor problems, particularly speech impairments in PD, various studies have reported that treatments are unsatisfactory; pharmacological treatment alone does not assert a significant improvement on voice and speech functioning in PD patients across various studies (Pinto, Ozsancak, Tripoliti, Thobois, Limousin-Dowsey, et al., 2004; Schulz & Grant, 2000); Moreover, surgical treatment such as STN-DBS (DBS of the subthalamic nucleus) reported speech intelligibility deterioration (Wertheimer et al., 2014).

As compared to pharmacological and surgical treatment, behavioral treatments such as speech therapy and music therapy which aimed at conscious and repeated training to strengthen vocal muscles appear to be a more effective way to treat parkinsonian dysarthria (Atkinson-Clement, Sadat, & Pinto, 2015; Pinto, Ozsancak, Tripoliti, Thobois, Limousin-Dowsey, et al., 2004; Schulz & Grant, 2000). Wide literature documented efficacy of behavioral treatments, including speech therapy, Lee Silverman Voice Treatment® (LSVT), and music therapy (Atkinson-Clement et al., 2015; Elefant, Baker, Lotan, Lagesen, & Skeie, 2012; Fogg-Rogers et al., 2015; Haneishi, 2001; Ramig & Fox, 2007).

Despite extensive research has been carried out on testing the efficacy of behavioural treatments in the foreign countries, there are currently no studies that report the efficacy of behavioural treatments, including music-based interventions on Parkinsonian Dysarthria in Malaysia, leading to limited evidence to support music-based vocal rehabilitation activities in the Malaysian context. Moreover, Malaysia is a multicultural society in which each ethnic group has different language, musical culture and beliefs, it is important to identify the song

preference among the PwP in Malaysia while developing a feasible and effective voice-rehab protocol, as Woolsey (2004) had implied in her study that client-preferred music is more effective in inducing change when achieving therapeutic objectives (Furman, 2000; Woolsey, 2004), it is therefore equally important to identify what are the preferred music and songs in the multicultural Malaysian context, to structure these song choices into a solid rehab protocol design and to test the efficacy through evidence-based research methods. It could then provide evidence to the more feasible music-based voice rehab programs for PwP in Malaysia.

There is vast literature that documented the efficacy of group singing and voice training, in the context of neurorehabilitation, motor movements, mood and quality of life using music-based intervention. However, the previous studies tend to focus solely on the intervention and its efficacy but lack of theories. Baker and Roth (2004) argued that despite increasing empirical evidence of neuroplasticity theory was documented in the medical field, there was still a paucity of literature in music therapy within the same area. This research incorporated knowledge of both medical and sociological theories as theoretical scaffolding when structuring the intervention protocol and to report outcomes of the intervention derived from it, the theories include the theory of neuroplasticity and theories in Helping Skills Model (HSM), a counselling module which is used in the music therapy approaches when handling clients.

Although there were many past research about benefits of singing as a form of voice rehabilitation for PwP yield positive significant outcomes in vocal productions, however many of these studies were conducted with a rather small number of respondents. For instance, in the study conducted by Haneishi (2001) to examine Music Therapy Voice Protocol (MTVP) on speech intelligibility, vocal acoustics and mood of the PwP, statistical improvements were found, but the number of the respondents was only 4 (Haneishi, 2001); In another study which examines Choral Singing Therapy for PwP and Stroke patients (Fogg-Rogers et al., 2015), a number of 8 stroke patients and 6 PwP were recruited, even though positive outcomes were yield but the small number of respondents made it difficult to generalize the finding to a wider population. Other studies done by the previous researches were also conducted with a smaller number of respondents, for instance, 10 PwP in Elefant's study (Elefant et al., 2012) and 13 PwP in Shih's study respectively (Shih et al., 2012).

This research is to address the gaps stated above, and furthermore, interview sessions were conducted with the PwP in Malaysia prior to the construction of the intervention protocol, to identify song choices and music preferences from the Malaysian PwP. The music preferences and song choices were then carefully designed into the core content of the intervention which incorporates theory of neuroplasticity and theories in HSM; and to achieve a stronger statistical power, a total number of 22 respondents were finally recruited to test the efficacy of the intervention protocol.

## 1.3 Theoretical Background

The research theoretical framework of this study is based on the theory of neuroplasticity and theories incorporated in Helping Skills Model (HSM), as the scaffold and basis in design and developing the intervention.

### 1.3.1 Theory of neuroplasticity

Theory of neuroplasticity emerged only around 120 years ago, despite its emergence was considered quite new but it is a very important discovery in neuroscience, there has been a huge evolution in the view of human's brain ever since (Demarin, Morovic, & Bene, 2014). William James presented this theory in his work *Principles of Psychology*, arguing that human brain is capable of functional changes. Later, Hughlings Jacksons contributed important findings of neuroplasticity in the brain in 1870 suggested that the slower the development of lesion in the brain can provide enough time for the brain to reorganize itself as to prepare for gradual loss of functions (York & Steinberg, 2011). In 1948, Jerzy Konorski further defined the term "neuroplasticity" in neuroscience context (Demarin et al., 2014).

Neuroplasticity is defined as the brain's ability to remodel, change, or reorganize for the purpose of better ability to adapt to new situations. It suggests that neural networks in our brain are not static, however, it can change dynamically according to our experiences (Demarin et al., 2014; Goh & Park, 2009).

Kolb and Whishaw (1985) suggested that brain reorganization occurs at the synaptic level, particularly the changes in the structure of glial cells. They further explained that when neuron cells lose synapses, retraction of dendritic arborisation will occur. This led to a logical assumption that if dendritic grew, functional recovery could occur. Later, from the examination through positron emission tomography (PET) and functional magnetic resonance imaging (fMRI) confirmed changes of cerebral reorganization which is observed through application of treatments (Kolb & Whishaw, 1985). Another research studied changes of size and number of glia cells, neurones and synapses in animals, and found out that animals in an enriched environment (a complex environment filled with tasks for them, for instance, playing toys) gained increment in both the size and number of glia cells (cited in Bryan & Robbin, 2011).

Several other studies provided a number of evidences that cognitive stimulations as well as experiences evinced more neurogenesis (the growth and development of nervous tissues). As summarized in Goh and Park's article (2009), a study conducted by Pereira et al. in 2007 illustrated that physical exercises increase neurogenesis and cerebral blood in mice dentate gyrus, suggesting improvements in cognitive functions.

Kempermann et al. (2004) further explained that physical exercise can increase proliferation of neural precursor cells, whereas the survival of these new precursor cells can only be obtained through novel and complex cognitive stimulation. Or else, the new precursor cells may fail to develop into mature neurons and possibly die (Kempermann, 2008; Kempermann et al., 2004). In another word, this is as much known by the "use it or lose it" principle. The growing evidence in neuroplasticity added much hopes to the ageing brain, as well as injured brain for recovery (Demarin et al., 2014; Goh & Park, 2009).

Goh and Park (2009) further confirmed that individuals are able to improve their abilities and develop new neural circuitry, when they are being put in an enriched and enhanced environment to maintain high level of participation in novel activities which include participating in new training, engage in exercise, or doing a task that is sufficiently complex. However, tasks that only involve repetitive movements but in the absence of new motor skill acquisition, will not stimulate reorganization (Baker & Roth, 2004).

In a research done by Park et al. (2014) with healthy aged people where they performed a controlled experimental trial to test the efficacy of engaging novel activities on cognitive behavioural performance in the aged subjects and relating them to neural structure and function, they found significant increase in episodic memory in all three experimental groups, in which demanding and novel new skills are introduced for at least 15 hour per week over 3 months, when compared to the two control groups, namely the social control group where participants only engage in social activities such as field trips and game playing but do not acquire new skills; and the placebo control group where the participants engage only with home or indoor activities such as listening to music and playing computer games. Thus, they concluded that a novel new skill or a productive engagement can effectively propagate continued learning and stimulate intellect.

Ungerleider et al. (2002) suggested a model that explains brain plasticity during motor skill learning. Their research result from fMRI (functioning magnetic resonance imaging) provided evidence that motor learning stimulates cerebral functional plasticity within the striatum and cerebellum. They also found that there is a shift of motor representations from associative to sensorimotor territories of the striatum during explicit learning of motor sequences, provided more evidence on the storage of motor skills in the basal ganglia. Moreover, they also observed there's a transfer of activity from cerebellar cortex to the dentate nucleus during the acquisition of implicit knowledge. Thus, they summarized and concluded that during the first phase of motor learning (the fast learning stage), there is functional and physiological change at both the inter- and intra-system levels and that this plasticity is necessary for building a motor routine which will be consolidated following an additional practice. However, it is important to note that the plasticity above explained the conditions of new spatiotemporal motor sequences or modification of an internal motor representation necessary to adapt to environment manipulations, and further hypothesized that motor learning which is more cognitive and associative base undergo different cerebral

network which will experience different patterns of cerebral plasticity (Doyon & Benali, 2005; Ungerleider et al., 2002).

In a leading literature that discusses about incorporating theory of neuroplasticity in music therapy, Baker and Roth (2004) suggested that music therapy intervention can directly target on the restoration of deficit functions, which should be viewed as stimulating neuroplasticity; in oppose to developing a compensatory mechanism that is based on the spared function, which focused on compensatory skills or tools in aid of the impairments such as using walking sticks to aid walking, or to adopt diary-using-habit to ease memory, or to strengthen the unaffected limbs to compensate the impaired limbs and so forth, in which these behavioural compensation strategies were previously being used in vast music therapy interventions (Baker & Roth, 2004).

In consistent to the proposal by Baker and Roth (2004), there are more recent neuroscientific music-based interventions for functional treatments which sit on the techniques and protocols of Neurologic Music Therapy (NMT). NMT is based on a neuroscience model of music perception and production, and yield positive outcomes in speech/language, cognitive and sensorimotor domains in the PwP, stroke patients, multiple sclerosis, cerebral palsy, traumatic brain injury and other conditions. Research in neuroscience provided insights of musical therapeutic effects and allowed further understanding on how music is engaged in the brain which can be translated to therapeutic learning and training. To highlight an important discovery of the relationship of music with brain, according to Thaut and McIntosh (2014), a study in the mid-1990s reported an experience-dependent plasticity in the brain, suggesting that music is able to instigate complex cognitive, affective and sensorimotor processes, which can later be transferred to therapeutic applications (LaGasse & Thaut, 2013; M.H. Thaut & McIntosh, 2014; Michael H. Thaut, 2015; Michael H. Thaut et al., 2009).

### 1.3.2 Helping Skills Model (HSM)

Helping Skills Model is a counselling module to acquire immediate reflections and feedback on the efficacy of intervention over time, for a more holistic rehabilitation purpose. Although the benefits of group-singing often being discussed as to provide active social interaction, and to create opportunities for PwP to stay connected to society (Buetow, Talmage, McCann, Fogg, & Purdy, 2014), the “connectedness” that is being discussed in the literature of sociology addressing positive outcomes in improving mood among people with chronic disease. However, it appears very little attempts in associating counselling techniques in neuro-rehabilitative music-based interventions particularly for PwP.

Helping Skills Model is a three-stage model counselling practice for therapists. This three-stage approach consists of “exploration”, “insights”, and “action”.

The “exploration” stage is based on client-centred theory, intended to encourage thoughts and feelings and it emphasizes the strong relationship between helper and the individuals who receive help. The strong relationship serves as a good environment for the individuals to fully accept themselves, the three major goals to achieve in exploration stage are: 1) attending-observing-listening, 2) help to explore thoughts, 3) help to explore feelings.

The “insights” stage is based on psychodynamic theories aiming to help individuals to understand the reasons of their feelings and thoughts; while the “action” stage is based on behavioural theory, and its objectives are to help the individuals to understand their problems at a deep level and to gain a new way to see things.

Consequently, the “action” stage is, therefore, to help the individuals to make changes in their lives after they have understood the problems at a deeper level and desired to make a change. However, it is important to note that the helpers should not be instilling personal opinions for changes but to suggest one of the four action plans based on the need or desire of the individuals. The four types of actions are 1) relaxation, 2) behaviour change, 3) behaviour rehearsal and 4) decision making.

HSM emphasized themes which include empathy, collaboration throughout the therapy, cultural considerations, a constant focus on what is needed by an individual. Empathy highlighted on helpers’ empathy, in other word, being non-judgemental and to be actively listening to the individuals without judging them; this is relatively important to build good collaboration throughout the whole process. The end result of this model is to help the individuals to identify what is needed and how to address the needs; Cultural considerations is a reminder for helpers to take cultural differences into account when giving help and staying focus on the particular need an individual is facing.

Incorporating HSM into the intervention protocol can help the PwP to explore their thoughts and feelings, to accept and better comply with the intervention protocol, and to be more determined in making a change. On the other hand, it can also help the researcher to better understand the feelings of PwPs as well as their music preferences and thoughts, it does not only help in creating a bonding trust among researcher and PwP but also allowing the researcher to identify cultural issues and individual needs.

## 1.4 Conceptual Framework

**Figure 1.1: Conceptual Framework of the Present Research.**

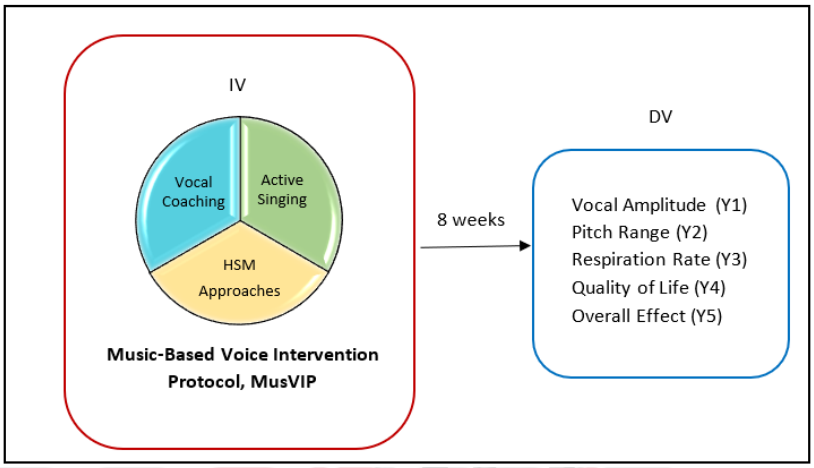


Figure 1.1 illustrated the conceptual framework of this study. It consists of one independent variable (X1), the Music-based Voice Intervention Protocol (MusVIP), which is the intervention model of the study. MusVIP consists of three main components: Vocal Coaching; Active Singing; and HSM approaches when handling PwP. The entire intervention took two-hours weekly for eight consecutive weeks.

Interviews were being carried out a week before intervention, to acquire demographic details and medical histories of each respondent, and to identify individual needs and problems as well as to collect individual's ideas and song preferences. Respondents were being asked to fill up two questionnaires namely the Voice Handicap Index (VHI), and Vocal Related Quality of Life (VRQOL) questionnaire, to serve as baseline data for quality of life measurement. A final interview was carried out at the end of the intervention, to find out individual's experiences, thoughts and feedbacks, the final interview session also aimed to inculcate continuous voice rehabilitation plans. VHI and VRQOL were administered again to collect post-intervention quality of life data.

Vocal coaching component consists of vocal warming up and vocal techniques sessions which were built through breathing exercises and vocalizing exercises, this component takes around half an hour every week before active component takes place; Active singing component consists of several singing activities which include, (i) Around 45 minutes of short song singing along with rhythmic movement session, aiming to stimulate internal cues. In this session, the songs were selected by the researcher/ instructor, at the end of the session, after many rounds of repetitions, PwP was able to memorize the song texts along with some basic upper body movements while being seated; (ii) Around 45 minutes of song

singing session aiming to expand vocal amplitude and instilling positive mood, while merging vocal techniques which were being taught at the beginning of every class, the songs being taught in this session were picked from the song list acquired through interview before intervention. Songtext enunciations were also being emphasized in this active singing component.

The outcomes of the intervention were measured by the five dependent variables illustrated in figure 1.1, which are marked as “vocal amplitude” (Y1), which aimed to measure vocal volume in a normal conversational setting, respondents were asked to read a short passage, while both maximum volume (loudest voice) and minimum volume (softest voice) were being collected with a sound level meter; “pitch range” (Y2), aimed to measure changes of maximum pitch (highest pitch) and minimum pitch (lowest pitch); “respiration” (Y3), aimed to measure respiratory changes; and “Quality of Life” (Y4), aimed to explore PwPs’ quality of life related to voice; and lastly, a combined overall effect (Y5) aimed to explore effects of MusVIP in a whole on the several above said dependent variables.

## 1.5 Research Objectives

The main objectives of this study are to evaluate the effects of MusVIP on vocal amplitude, pitch range, respiratory rate and quality of life related to voice in PwP. In addition to that, this study also seeks to better understand the vocal changes, song and music preferences, the perception of quality of life from the PwPs’ self-reported experiences, as well as the feedback on MusVIP from the PwPs.

The quantitative data gained from measuring amplitude, pitch range, and respiratory rate can help gauging better understanding on whether the singing protocol is effective to help improving voice and speech problems in the PwPs, whereas the qualitative data from this study supported the quantitative design in two ways: firstly is to help finalizing the intervention protocol through the investigation on the PwPs’ vocal problems and their music preferences, and secondly to gauge feedback on the studied protocol post-intervention to further identifying the strength and weaknesses of the protocol and laid preliminary foundation for future studies.

Understanding the vocal problems in the PwPs from their own perspectives is very important because there are limited references on the vocal problems with which the PwPs are facing, but these empirical data can serve as a guideline for voice rehabilitation practitioners to draft and continuously enhancing the voice intervention protocol. Music and song preferences, on the other hand, is essential for the voice rehabilitation practitioners to better understand which type of music can best suits this cohort in order to encourage better intervention compliances and yield better interventional outcomes, as denoted by Furman (2000) and Woolsey (2004) that clients’ preferred music often leads to more positive outcomes in a therapeutic setting, and through further music analysis on rhythm, pitch ranges, song-text suitability, voice rehabilitation practitioners can

then better develop the MusVIP curriculum and content. Lastly, the final interview on the feedback of MusVIP aimed to add detailed and critical information that can further enhance the quantitative findings in this study.

Following the rationales of the intentions depicted above, the specific objectives of this study are:

1. Evaluate the effects of MusVIP on Vocal Amplitude, Pitch Range, and Respiratory Rate.
2. Identify Malaysian PwPs' perspectives on vocal changes associated with PD, their song and music preferences, as well as their feedback on MusVIP.

## 1.6 Research Questions and Hypothesis

The research questions of this study are as follow:

1. Do measures of vocal amplitude, pitch range, and respiration rate change significantly pre-, co- and post-intervention?

2. Do measures of Voice Handicap Index (VHI) and Vocal Related Quality of Life (VRQOL) change significantly pre- and post-intervention?

3. How do the measurements change?

4. What are the preferences of songs and music among the Malaysian PwP?

5. What are the voice and quality of life related problems did PwPs encounter from their own perspectives?

6. How do the Malaysian PwPs perceive MusVIP?

The research hypotheses are as follow:

1. There are significant changes in the mean scores of min vocal amplitude (softest volume, in decibels) from pre-intervention ($T_1$) to 4 weeks after weekly-sessions ($T_{2)}$, and from $T_1$ to 8-weeks after weekly-sessions post-intervention ($T_{3)}$.

2. There are significant changes in mean scores of max vocal amplitude (loudest volume, in decibels) from pre-intervention ($T_1$) to 4 weeks after weekly-sessions ($T_{2)}$, and from $T_1$ to 8-weeks after weekly-sessions post-intervention ($T_{3)}$.

3. There are significant changes in mean min pitch (lowest frequency, Hz) in pitch range from pre-intervention ($T_1$) to 4 weeks after weekly-sessions ($T_{2)}$, and from $T_1$ to 8-weeks after weekly-sessions post-intervention ($T_{3)}$.

4. There are significant changes in mean max pitch (highest frequency, Hz) in pitch range from pre-intervention ($T_1$) to 4 weeks after weekly-sessions ($T_{2)}$, and from $T_1$ to 8-weeks after weekly-sessions post-intervention ($T_{3)}$.

5. There are significant changes in mean respiratory rate from pre-intervention ($T_1$) to 4 weeks after weekly-sessions ($T_{2)}$, and from $T_1$ to 8-weeks after weekly-sessions post-intervention ($T_{3)}$.

6. There are significant changes in respondents' perception of their Voice Handicap Index (VHI) from pre-intervention ($T_1$) to 8-weeks after weekly-sessions post-intervention ($T_{3)}$.

7. There will be significant change in respondents' perception of their voice-related quality of life (VRQOL) from pre-intervention ($T_1$) to 8-weeks after weekly-sessions post-intervention ($T_{3)}$.

## 1.7 Significance of the Study

This research will produce a voice rehabilitative intervention protocol for PwP which is based on the theoretical framework which it incorporates theories of both medical and social sciences, and that consists of three major components: (i) Vocal Coaching; (ii) Active Singing; and (iii) HSM Approaches; The uniqueness of this intervention also exists in the fact that the curriculum in this protocol not only comprises of songs selected by instructor-researcher but it also contains song selections from the Malaysian PwPs preferences list, taking account on multicultural and neuro nostalgia considerations for better rehabilitation outcomes. The accomplishment of this intervention protocol can be regarded as an additional inventory to the voice rehabilitative model locally, to the neighbouring regions and even worldwide.

Another uniqueness of this intervention is that it incorporates skills of counselling in handling the PwPs, through all the singing sessions as well as interview sessions. HSM helps to create a better bond between researcher and respondents, also helps to identify the problems PwPs were facing as well as to indicate methods and ways to solving problems. Other qualitative findings, particularly the perceptions of vocal problems among PwP were possessed to better understand the vocal problems and characteristics of the Malaysian PwP and to obviously capitalized as guidelines to future research in the field of vocal rehabilitation in PwP in Malaysia.

In summary, this study's contribution is to generate statistical findings of the efficacy of MusVIP on vocal amplitude, pitch range, respiratory rate, and quality of life related to voice in the PwP in Malaysia, the data filled the paucity in national data, as well as to have gathered data on perceptions of the Malaysian PwPs on their vocal problems, music and song preferences and their feedback about the studied-intervention. This study has enriched the local data of vocal rehabilitation for Malaysian PwP and the studied-intervention which was developed for the study could be perceived as an additional inventory to the voice rehabilitation model both locally and worldwide.

## 1.8 Limitations of the Study

There are a few caveats needed to be noted and clarified regarding the present study. The most important limitation lies in the research design itself in which it had been conducted in a one-group repeated measure design. This research design is selected because PD symptoms varied across all PwPs and it is almost impossible to standardize characteristics of the research respondents in different groups under good experimental control. Hence, the result of this study reports only changes within group pre-intervention, during the intervention, and post-intervention.

This study recruited only the PwP who are not undertaking other occupational therapies, including speech therapy and other singing lessons at the same time when MusVIP is administered, and this study has no intention to compare efficacies of different interventions from other means of therapies on the dependent variables measured in this study.

This research examined the efficacy of MusVIP on vocal amplitude, pitch range, respiratory rate and quality of life, mainly to focus on the effects of the voice training to speech intelligibility and the quality of life related to vocal changes; however, this study does not attempt to measure changes of vocal qualities such as hoarseness and vocal tremor which arise from HD in PD.

Mainly due to the constraints on medical condition of the research subjects, this study selected purposive sampling methods and was conducted as a single-centre-trial within Kuala Lumpur and Selangor district. The number of respondents in this study was sufficient to achieve statistical power, but the outcome derived from this study was still unable to be generalized or to represent the PD population in Malaysia, however it can still serve as an exploratory data for setting up future guidelines for music-based voice rehabilitation programs in Malaysia.

## 1.9 Definitions of Terminology

The terminology used in this study are operationally defined as follow, the definitions are taken from the web-based medical term dictionary and literatures (Benabid, Chabardes, Mitrofanis, & Pollak, 2009; de Lau & Breteler, 2006; Hely, Morris, Reid, & Trafficante, 2005; Jankovic, 2008; Krause et al., 2001; S.-Y. Lim et al., 2012; Massano & Bhatia, 2012; "MedTerms," n.d.; "Web-based Medical dictionary," n.d.):

1. Parkinson's Disease (PD): Parkinson's Disease is a neurodegenerative disease that affects 1-2% of the general population worldwide.

2. People with Parkinson's (PwP): refers to people diagnosed with Parkinson's Disease.

3. Hypokinetic Dysarthria (HD)/ Parkinsonian Dysarthria: Hypokinetic Dysarthria is a motor-speech disorder attributed to neurological injury, it happened because the motor movements of the muscles that help to produce speech are impaired. HD is characterized by poor articulation; other speech subsystems such as respiration, phonation, prosody and resonance could also be affected, resulting in impairments on audibility, naturalness, intelligibility and efficiency of vocal communication. It is different from aphasia, in which the latter refers to a disorder in the content of speech. HD also occurs due to the onset of Parkinson's Disease. Symptoms of HD in PD including hypophonia, dysprosody, inaccurate articulation(slurred), develop vocal tremor, and hoarse and breathy vocal quality.

4. Speech Intelligibility: refers to the quality of spoken language that is comprehensible, it is often associated with vocal loudness, clarity and intonation.

5. Hypophonia: refers to an abnormal weak voice due to incoordination of the muscles used for vocalization.

6. Dysprosody: refers to an inability to apply normal patterns of speech intonation (monotone).

7. Bradykinesia: refers to slowness in movement, it is one of the cardinal motor symptoms detecting PD.

8. Dyskinesia: refers to involuntary muscle movements or known as "wriggling". In PD context, dyskinesia is associated with levodopa consumption and usually occurs when PwP is "ON".

9. Dysphagia: refers to problems or difficulties in swallowing as a result of a disease. In this context, it refers specifically to the difficulty or discomfort in swallowing due to PD.

10. Dystonia: refers to abnormal muscle tone that results in muscular spasm, typically due to neurologic disease, or a side effect of certain drug therapy. In this context, dystonia refers specifically to the abnormal muscle tone due to PD.

11. "ON": refers to the period of time when levodopa is effective, and the PD symptoms are well-controlled.

12. "OFF": refers to the period of time when the symptoms of PD return after the "ON" period due to the effects of levodopa couldn't last long.

13. "Wearing-off" phenomenon: "wearing-off" is when PwP start to feel the improvements gained from levodopa medication started to fade before the next dose of levodopa takes place.

14. Dopamine: refers to a chemical substance found in the body which serves as a neurotransmitter to pass information from one neuron cell to the other. The onset of PD is when the destruction of dopamine in the area of substantia nigra happens.

15. Levodopa (L-dopa): is the main drug that is used to treat PD.

16. Apomorphine: is a dopamine agonist.

17. Apomorphine pump infusion: Infusion of apomorphine using a battery-driven pump.

18. Deep Brain Stimulation (DBS): is a surgical treatment for patients with a neurologic disorder, in this context, referring to DBS for PwP. DBS is introduced to PwP who are experiencing prolonged "OFF" period, and who continue to experience severe dyskinesia. A tiny electric shock is to install to either subthalamic nucleus (STN) or globus pallidus internus (GPi), aiming to stimulate the deep part of the brain to control PD symptoms.

19. Deep Brain Stimulation of the subthalamic nucleus (STN-DBS): is the DBS of the subthalamic nucleus.

20. Music-Based Voice Intervention Protocol (MusVIP): refers to a music-based intervention for voice rehabilitation in PwP with three major components: (1) Vocal Coaching; (2) Active Singing; (3) HSM Approaches.

21. Rhythm: refers to a strong and regular repeated pattern of movements or sound. In the context of this study, it is referring to the patterns of regular pulses (tempo) during the singing sessions.

22. Dynamics: refers to the volume of a sound produced by instruments or voice. In the context of this study, it is particularly referring to the degree of loudness during singing, for instance, very loud, loud, medium, soft, very soft.

23. Vocal Amplitude: refers to the volume measured from the position of equilibrium. In the context of this study, it is referring to both the maximum and minimum volume produced by PwP measured with the sound level meter in decibel (dB).

24. Pitch Range: refers to the range of pitch from the lowest to the highest of the same source of sound can produce. In the context of this study, it is referring to a range of voice, including the max pitch (highest pitch), and the min pitch (lowest pitch) that a PwP can produce and is measured by frequency in Hertz (Hz). In this study, pitch range is detected by the researcher with the aid of a music keyboard.

25. Respiratory Rate: refers to the number of breaths per minute or cycles of inspiration and expiration per unit time. Healthy adults' respiratory rate is ranged between 12-20. In the context of this study, Respiratory Rate in PwP is measured with mobile device application in the unit of breath-per-minute.

26. Quality of Life: refers to the general well-being of a person, it is defined in terms of contentment and comfort in life, health and happiness, regarded as an extent of life satisfaction rather than wealth. In the context of this study, quality of life is associated with vocal health and vocal problems. The vocal related quality of life in this study is measured through Voice Handicap Index (VHI) questionnaire and Voice-Related Quality of Life (VRQOL) questionnaire.

27. Voice Handicap Index (VHI): is a measurement scale comprising of 30 items self-administered questions, covering three main aspects related to voice disorders: (1) physical, (2) functional, and (3) emotional. In the context of this study, this scale is to be applied to PwP to further explore their own perception on the vocal functions, impairments, and effects of MusVIP.

28. Voice-Related Quality of Life (VRQOL): is two domains, 10 items measurement scale, used to measure quality of life related to voice.

29. Vocalise: The vocalise refers to structured vocal exercises that aim to build vocal strength and to expand pitch range, typically done in the form of scales and arpeggios sung with a few basic vowels.

30. Solfeggio: Solfeggio refers to the name of the musical notes in the notation system (staff notation), there are seven names in solfeggio: Do, Re, Mi, Fa, Sol, La, Si based on the ancient Italian music theorist notation system developed by Guido d'Arezzo in the Medieval era (circa 10th century).

31. Music Notes Names: Refer to the music notation names in alphabetic letters, for example, C, D, E, F, G, A, B that is equal to Do, Re, Mi, Fa, Sol, La, Si in the ancient Italian system.

## REFERENCES


Aarsland, D., Larsen, J. P., Karlsen, K., Lim, N. G., & Tandberg, E. (1999). Mental symptoms in Parkinson's disease are important contributors to caregiver distress. *International Journal of Geriatric Psychiatry*, *14*(10), 866–874. https://doi.org/10.1002/(SICI)1099-1166(199910)14:10<866::AID-GPS38>3.0.CO;2-Z

Alkhani, A., & Lozano, A. M. (2001). Pallidotomy for parkinson disease: a review of contemporary literature. *Journal of Neurosurgery*, *94*(1), 43–49. https://doi.org/10.3171/jns.2001.94.1.0043

Altenmuller, E., & Schlaug, G. (2013). Neurobiological Aspects of Neurologic Music Therapy. *Music and Medicine*, *5*(4), 210–216. https://doi.org/10.1177/1943862113505328

Alves, G., Forsaa, E. B., Pedersen, K. F., Dreetz Gjerstad, M., & Larsen, J. P. (2008). Epidemiology of Parkinson's disease. *Journal of Neurology*, *255*(SUPPL. 5), 18–32. https://doi.org/10.1007/s00415-008-5004-3

Appleby, W., & Fowler, F. (1967). *Sing Together!* Oxford University Press. Retrieved from https://books.google.com.my/books?id=AwUfAAAACAAJ

Ang, M. F.(2018). Voice characteristics of people with Parkinson's disease (PwP): An overview on baseline vocal characteristics and guidelines for therapeutic singing. *Malaysian Journal of Music*, *7*, 208-224.

Apps, M. C. P., Sheaff, P. C., Ingram, D. A., Kennard, C., & Empey, D. W. (1985). Respiration and sleep in Parkinson ' s disease. *Journal of Neurology, Neurosurgery, and Psychiatry*, *48*(April), 1240–1245.

Atkinson-Clement, C., Sadat, J., & Pinto, S. (2015). Behavioral treatments for speech in Parkinson's disease: meta-analyses and review of the literature. *Neurodegenerative Disease Management*, *5*(3), 233–248. https://doi.org/10.2217/nmt.15.16

Baker, F., & Roth, E. a. (2004). Neuroplasticity and Functional Recovery: Training Models and Compensatory Strategies in Music Therapy. *Nordic Journal of Music Therapy*, *13*(1), 20–32. https://doi.org/10.1080/08098130409478095

Barnish, J., Atkinson, R. A., Barran, S. M., & Barnish, M. S. (2016). Potential benefit of singing for people with Parkinson's disease: A systematic review. *Journal of Parkinson's Disease*, *6*(3). https://doi.org/10.3233/JPD-160837

Beck, R. J., Cesario, T. C., Yousefi, A., & Enamoto, H. (2000). Choral Singing, Performance Perception, and Immune System Changes in Salivary Immunoglobulin A and Cortisol. *Music Perception: An Interdisciplinary Journal*, *18*(1), 87–106.

Benabid, A. L., Chabardes, S., Mitrofanis, J., & Pollak, P. (2009). Deep brain stimulation of the subthalamic nucleus for the treatment of Parkinson's disease. *The Lancet Neurology*, *8*(1), 67–81. https://doi.org/10.1016/S1474-4422(08)70291-6

Benedetto, P. Di. (2008). Voice and choral singing treatment: A new approach

for speech and voice disorders in Parkinson's disease, (December).

Berardelli, A. (2001). Pathophysiology of bradykinesia in Parkinson's disease. *Brain*, *124*(11), 2131–2146. https://doi.org/10.1093/brain/124.11.2131

Bernstein, C. J., Ellard, D. R., Davies, G., Hertenstein, E., Tang, N. K. Y., Underwood, M., & Sandhu, H. (2016). Behavioural interventions for people living with adult-onset primary dystonia : a systematic review. *BMC Neurology*. https://doi.org/10.1186/s12883-016-0562-y

Biousse, V., Skibell, B. C., Watts, R. L., Loupe, D. N., Drews-Botsch, C., & Newman, N. J. (2004). Ophthalmologic features of Parkinson's disease. *Neurology*, *62*(2), 177–180. https://doi.org/10.1212/01.WNL.0000103444.45882.D8

Black, J., Gerdtz, M., Nicholson, P., Crellin, D., Browning, L., Simpson, J., … Santamaria, N. (2015). Can simple mobile phone applications provide reliable counts of respiratory rates in sick infants and children? An initial evaluation of three new applications. *International Journal of Nursing Studies*, *52*(5), 963–969. https://doi.org/10.1016/j.ijnurstu.2015.01.016

Boland, D. F., & Stacy, M. (2012). The economic and quality of life burden associated with Parkinson's disease: a focus on symptoms. *The American Journal of Managed Care*, *18*(september), S168-75. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/23039865

Bora, E., Walterfang, M., & Velakoulis, D. (2015). Theory of mind in Parkinson's disease: A meta-analysis. *Behavioural Brain Research*, *292*, 515–520. https://doi.org/10.1016/j.bbr.2015.07.012

Branchi, I., D'Andrea, I., Armida, M., Cassano, T., Pezzola, A., Potenza, R. L., … Alleva, E. (2008). Nonmotor symptoms in Parkinson's disease: Investigating early-phase onset of behavioral dysfunction in the 6-hydroxydopamine-lesioned rat model. *Journal of Neuroscience Research*, *86*(9), 2050–2061. https://doi.org/10.1002/jnr.21642

Bryan, K., & Robbin, G. (2011). 2011- Brain Plasticity and Behaviour in the Developing Brain.

Buetow, S. A., Talmage, A., McCann, C., Fogg, L., & Purdy, S. (2014). Conceptualizing how group singing may enhance quality of life with Parkinson's disease. *Disability and Rehabilitation*, *36*(5), 430–433. https://doi.org/10.3109/09638288.2013.793749

Cacciatore, F. M., Simone, D. De, Patrocinio, D., & Sallustio, V. (2012). Adverse drug reaction to dopamine agonists (DA) or appearance of a typical sign of Parkinson's Disease induced by DA. *Basal Ganglia*, *2*(3), e1–e87. https://doi.org/10.1016/j.baga.2012.10.001

Chaudhuri, K. R., Healy, D. G., & Schapira, a H. (2006). Non-motor symptoms of Parkinson's disease: diagnosis and management. *Lancet Neurol*, *5*(3), 235–245. https://doi.org/10.1016/s1474-4422(06)70373-8

Chaudhuri, K. R., Healy, D. G., & Schapira, A. H. V. (2006). Non-motor symptoms of Parkinson ' s disease : diagnosis and management, *5*(March).

Chung, T. H., Deane, K. H. O., Ghazi-Noori, S., Rickards, H., & Clarke, C. E. (2003). Systematic review of antidepressant therapies in Parkinson's

disease. *Parkinsonism and Related Disorders*, *10*(2), 59–65. https://doi.org/10.1016/S1353-8020(03)00108-1

Clark, J. P., Adams, S. G., Dykstra, A. D., Moodie, S., & Jog, M. (2014). Loudness perception and speech intensity control in Parkinson's disease. *Journal of Communication Disorders*, *51*, 1–12. https://doi.org/10.1016/j.jcomdis.2014.08.001

Clift, S., & Hancox, G. (2010). The significance of choral singing for sustaining psychological wellbeing: findings from a survey of choristers in England, Australia and Germany. *Music Performance Research*, *3*, 79–96. https://doi.org/Article

Clift, S., Hancox, G., Morrison, I., Hess, B., Kreutz, G., & Stewart, D. (2010). Choral singing and psychological wellbeing: Quantitative and qualitative findings from English choirs in a cross-national survey. *Journal of Applied Arts & Health*, *1*(1), 19–34. https://doi.org/10.1386/jaah.1.1.19/1

Clift, S., Hancox, G., Staricoff, R., & Whitmore, C. (2008). *Singing and Health: A Systematic Mapping and Review of Non-Clinical Research*. Sidney De Haan Research Centre for Arts and Health.

Cohen, N. S. (1994). Speech and song: Implications for therapy. *Music Therapy Perspectives*, *12*(1), 8–14. https://doi.org/10.1093/mtp/12.1.8

Cooper, J., Sagar, H., & Tidswell, P. (1994). Slowed central processing in simple and go/no-go reaction time tasks in Parkinson's disease. *Brain*, 517–529. Retrieved from http://brain.oxfordjournals.org/content/117/3/517.short

Darley, F. L., Aronson, A. E., & Brown, J. R. (1969). Differential diagnostic patterns of dysarthria. *Journal of Speech and Hearing Research*, *12*(2), 246–269. https://doi.org/10.1044/jshr.1202.246

de Lau, L. M. L., & Breteler, M. M. B. (2006). Epidemiology of parkinson's disease. *Lancet Neurol*, *5*, 525–535. https://doi.org/10.1016/S1016-3190(10)60044-4

Decker, H. A., & Kirk, C. J. (1995). *Choral Conducting: Focus on Communication*. Waveland Press. Retrieved from https://books.google.com.my/books?id=gYMMAAAACAAJ

Demarin, V., Morovic, S., & Bene, R. (2014). Neuroplasticity. *Periodicum Biologorum*, *116*(2), 209–211.

Deuschl, G., Bain, P., & Brin, M. (2008). Consensus Statement of the Movement Disorder Society on Tremor. *Movement Disorders*, *13*(S3), 2–23. https://doi.org/10.1002/mds.870131303

Dorsey, E. R., Constantinescu, R., Thompson, J. P., Biglan, K. M., Holloway, R. G., Kieburtz, K., … Tanner, C. M. (2007). Projected number of people with Parkinson disease in the most populous nations, 2005 through 2030. *Neurology*, *68*(5), 384–386. https://doi.org/10.1212/01.wnl.0000247740.47667.03

Dorsey, E. R., & Elbaz, A. (2018). Articles Global , regional , and national burden of Parkinson ' s disease , 1990 – 2016 : a systematic analysis for the Global Burden of Disease Study 2016. *Lancet Neurol*, *17*, 939–953. https://doi.org/10.1016/S1474-4422(18)30295-3

Doyon, J., & Benali, H. (2005). Reorganization and plasticity in the adult brain during learning of motor skills. *Current Opinion in Neurobiology*, *15*(2), 161–167. https://doi.org/10.1016/j.conb.2005.03.004

Dyduch, A., & Załuska, M. (2014). Depression in Parkinson's disease: the effectiveness and risk of pharmacotherapy. Clinical review. *Psychogeriatrics : The Official Journal of the Japanese Psychogeriatric Society*, 1–7. https://doi.org/10.1111/psyg.12078

Elefant, C., Baker, F. a, Lotan, M., Lagesen, S. K., & Skeie, G. O. (2012). The Effect of Group Music Therapy on Mood, Speech, and Singing in Individuals with Parkinson's Disease -- A Feasibility Study. *Journal of Music Therapy*, *49*(3), 278–302. https://doi.org/10.1093/jmt/49.3.278

Elston, J., Honan, W., Powell, R., Gormley, J., & Stein, K. (2010). Do metronomes improve the quality of life in people with Parkinson's disease? A pragmatic, single-blind, randomized cross-over trial. *Clinical Rehabilitation*, *24*, 523532. https://doi.org/10.1177/0269215509360646

Evans, C., Canavan, M., Foy, C., Langford, R., & Proctor, R. (2012). Can group singing provide effective speech therapy for people with Parkinson's disease? *Arts & Health*, *4*(1), 83–95. https://doi.org/10.1080/17533015.2011.584883

Fogg-Rogers, L., Buetow, S., Talmage, A., McCann, C. M., Leao, S. H. S., Tippett, L., … Purdy, S. C. (2015). Choral singing therapy following stroke or Parkinson's disease: an exploration of participants' experiences. *Disability and Rehabilitation*, *8288*(November), 1–11. https://doi.org/10.3109/09638288.2015.1068875

Fox, C. M., & Ramig, L. O. (1997). Vocal Sound Pressure Level and Self-Perception of Speech and Voice in Men and Women with Idiopathic Parkinson Disease. *American Journal of Speech-Language Pathology*, *6*(2), 85–94. https://doi.org/10.1044/1058-0360.0602.85

Furman, C. E. (1996). *Effectiveness of music therapy procedures: documentation of research and clinical practice*. National Association for Music Therapy. Retrieved from https://books.google.com.my/books?id=j4_SbimjYEoC

Furman, C. E. (2000). *Effectiveness of Music Therapy Procedures: Documentation of Research and Clinical Practice*. American Music Therapy Association. Retrieved from https://books.google.com.my/books?id=lKpLAQAAIAAJ

Giovannoni, G., van Schalkwyk, J., Fritz, V. U., & Lees, A. J. (1999). Bradykinesia akinesia inco-ordination test (BRAIN TEST): an objective computerised assessment of upper limb motor function. *Journal of Neurology, Neurosurgery, and Psychiatry*, *67*(5), 624–629. https://doi.org/10.1136/jnnp.67.5.624

Goetz, C. G., Chmura, T. A., & Lanska, D. J. (2001). The History of Parkinson's Disease. *Movement Disorders*, *16*(3), 156–161. https://doi.org/10.1002/mds.1114

Goh, J., & Park, D. C. (2009). Neuroplasticity and cognitive aging. *Restor Neurol Neurosci*, *27*(5), 391–403. https://doi.org/10.3233/RNN-2009-

0493.Neuroplasticity

Grape, C., Sandgren, M., Hansson, L.-O., Ericson, M., & Theorell, T. (2003). Does singing promote well-being?: An empirical study of professional and amateur singers during a singing lesson. *Integrative Physiological and Behavioral Science*, *38*(1), 65–74. https://doi.org/10.1007/BF02734261

Guridi, J., & Lozano, A. M. (1997). A Brief History of Pallidotomy. *Neorosurgery*, *41*(5), 1169–1183.

Haneishi, E. (2001). Effects of a music therapy voice protocol on speech intelligibility, vocal acoustic measures, and mood of individuals with Parkinson's disease. *Journal of Music Therapy*, *38*(4), 273–290. https://doi.org/10.1093/jmt/38.4.273

Hanson, D. G., Gerratt, B. R., & Ward, P. H. (1984). Cinegraphic observations of laryngeal function in Parkinson's disease. *Laryngoscope*. https://doi.org/10.1288/00005537-198403000-00011

Hely, M. A., Morris, J. G. L., Reid, W. G. J., & Trafficante, R. (2005). Sydney Multicenter Study of Parkinson's disease: Non-L-dopa-responsive problems dominate at 15 years. *Movement Disorders*, *20*(2), 190–199. https://doi.org/10.1002/mds.20324

Hill, C. E. (2009). *Helping Skills: Facilitating Exploration, Insight, and Action*. American Psychological Association.

Hoehn, M. M., & Yahr, M. D. (1967). Parkinsonism : onset, progression, and mortality Parkinsonism: onset, progression, and mortality. *Neurology*, *17*(5), 427–442. https://doi.org/10.1212/WNL.17.5.427

Hogikyan, N. D., & Sethuraman, G. (1999). Validation of an instrument to measure voice-related quality of life (V-RQOL). *Journal of Voice : Official Journal of the Voice Foundation*, *13*(4), 557–569. https://doi.org/10.1016/s0892-1997(99)80010-1

Hogikyan, N. D., Wodchis, W. P., Terrell, J. E., Bradford, C. R., & Esclamado, R. M. (2000). Voice-related quality of life (V-RQOL) following type I thyroplasty for unilateral vocal fold paralysis. *Journal of Voice*, *14*(3), 378–386. https://doi.org/10.1016/S0892-1997(00)80083-1

Howe, T. E., Lövgreen, B., Cody, F., Ashton, V. J., & Oldham, J. A. (2003). Auditory cues can modify the gait of persons with early-stage Parkinson's disease: a method for enhancing parkinsonian walking performance? *Clinical REhabilitation*, *17*, 363–367. https://doi.org/10.1191/0269215503cr621oa

Hughes, A. J., Daniel, S. E., Blankson, S., & Andrew, J. L. (1993). A Clinicopathologic Study of 100 Cases of Parkinson ' s Disease. *Arch Neurol*, *50*.

Hughes, A. J., Daniel, S. E., Kilford, L., & Lees, A. J. (1992). Accuracy of clinical diagnosis of idiopathic Parkinson ' s disease : a clinico-pathological study of 100 cases, 181–184. https://doi.org/10.1136/jnnp.55.3.181

Hunt, P. (2003). *Voiceworks 2: A Further Handbook for Singing*. OUP Oxford. Retrieved from https://books.google.com.my/books?id=fDqfAQAACAAJ

Hyman, N. (1995). Self-reported Functioning and Well-being in Patients with Parkinson ' s Disease : Comparison of the Short-form Health Survey ( SF-36 ) and the Parkinson ' s Disease Questionnaire ( PDQ-39 ), 505–509.

Jacobson, B. H., Johnson, A., Grywalski, C., Silbergleit, A., Jacobson, G., Benninger, M. S., & Newman, C. W. (1997). The Voice Handicap Index (VHI)Development and Validation. *American Journal of Speech-Language Pathology*, *6*(3), 66–70. https://doi.org/10.1044/1058-0360.0603.66

Jankovic, J. (2008). Parkinson's disease: clinical features and diagnosis. *Journal of Neurology, Neurosurgery & Psychiatry*, *79*(4), 368–376. https://doi.org/10.1136/jnnp.2007.131045

John, J., & Malhotra, G. (2012). Poster 327 The Role of Singing as a Rehabilitation Intervention. *PMRJ*, *4*(10), S301. https://doi.org/10.1016/j.pmrj.2012.09.939

Juslin, P. N., & Sloboda, J. A. (2010). Handbook of music and emotion. *Theory, Research, Applications*. OUP Oxford. https://doi.org/10.1093/acprof

Kelly, P. J., & Gillingham, F. J. (1980). The long-term results of stereotaxie surgery and L-dopa therapy in patients with Parkinson's disease A 10-year follow-up study. *Journal of Nerosurgery*, *53*, 332–337.

Kemp, J., Després, O., Sellal, F., & Dufour, A. (2012). Theory of Mind in normal ageing and neurodegenerative pathologies. *Ageing Research Reviews*, *11*(2), 199–219. https://doi.org/10.1016/j.arr.2011.12.001

Kempermann, G. (2008). The neurogenic reserve hypothesis: what is adult hippocampal neurogenesis good for? *Trends in Neurosciences*, *31*(4), 163–169. https://doi.org/10.1016/j.tins.2008.01.002

Kempermann, G., Wiskott, L., & Gage, F. H. (2004). Functional significance of adult neurogenesis. *Current Opinion in Neurobiology*, *14*(2), 186–191. https://doi.org/10.1016/j.conb.2004.03.001

Kolb, B., & Whishaw, I. (1985). *Fundamentals of Human Neuropsychology*. *Journal of Neurology, Neurosurgery & Psychiatry* (Vol. 58). https://doi.org/10.1136/jnnp.49.4.483-b

Krack, P., Batir, A., Van Blercom, N., Chabardès, S., Fraix, V., Ardouin, C., … Pollak, P. (2003). Five-year follow-up of bilateral stimulation of the subthalamic nucleus in advanced Parkinson's disease. *New England Journal of Medicine*, *349*(20), 1925–1934. https://doi.org/10.1056/NEJMoa035275

Krause, M., Fogel, W., Heck, a, Hacke, W., Bonsanto, M., Trenkwalder, C., & Tronnier, V. (2001). Deep brain stimulation for the treatment of Parkinson's disease: subthalamic nucleus versus globus pallidus internus. *Journal of Neurology, Neurosurgery, and Psychiatry*, *70*(4), 464–470. https://doi.org/10.1136/jnnp.70.4.464

Krauss, T., & Galloway, H. (1982). Melodic intonation Language Delayed Therapy Apraxic with. *Journal of Music Therapy*, *19*(2), 102–113.

LaGasse, a. B., & Thaut, M. H. (2013). The Neurobiological Foundation of Neurologic Music Therapy. *Music and Medicine*, *5*(4), 228–233. https://doi.org/10.1177/1943862113502547

Lethlean, J. B., Chenery, H. J., & Murdoch, B. E. (1990). Disturbed Respiratory and Prosodic Function in Parkinson's Disease: A Perceptual and Instrumental Analysis. *Australian Journal of Human Communication Disorders*, *18*(2), 83–97. Retrieved from http://search.proquest.com/docview/85540669?accountid=14772%5Cnhttp://sfx.library.uu.nl/utrecht?url_ver=Z39.88-2004&rft_val_fmt=info:ofi/fmt:kev:mtx:journal&genre=article&sid=ProQ:ProQ%3Allbashell&atitle=Disturbed+Respiratory+and+Prosodic+Function+in+Park

Lew, S. (2010). *EFFECTS OF SPEECH AND VOICE CHANGES ON THE QUALITY OF LIFE OF PEOPLE WITH PARKINSON'S DISEASE*. *University Malaya*.

Lim, S.-Y., Fox, S. H., & Lang, A. E. (2009). Overview of the extranigral aspects of Parkinson disease. *Archives of Neurology*, *66*(2), 167–172. https://doi.org/10.1001/archneurol.2008.561

Lim, S.-Y., Puvanarajah, S., Lee, M. K., Chee, K. Y., Viswanathan, S., Tan, A. H., … Azrin, K. (2012). 2012 Consensus Guidelines for the Treatment of Parkinson's Disease.

Lim, S. Y., Puvanarajah, S., & Ibrahim, N. M. (2011). *Parkinson's Disease-Information for people living with Parkinson's*.

Lindestad, P. Å., Fritzell, B., & Persson, A. (1991). Quantitative Analysis of Laryngeal EMG in Normal Subjects Quantitative Analysis of Laryngeal EMG in Normal Subjects, *6489*(March). https://doi.org/10.3109/00016489109100770

Logemann, J. A., Fisher, H. B., Boshes, B., & Blonsky, E. R. (1978). FREQUENCY AND COOCCURRENCE OF VOCAL TRACT DYSFUNCTIONS IN THE SPEECH OF A LARGE SAMPLE OF PARKINSON PATIENTS. *Journal of Speech and Hearing Disorders*, 47–57.

Marsh, J., & Fitch, J. (1970). The effect of singing on the speech articulation of negro disadvantaged children. *Journal of Music Therapy*, *7*, 88–94. https://doi.org/10.1002/eat.20931.Psychometric

Massano, J., & Bhatia, K. P. (2012). Clinical Approach to Parkinson ' s Disease : *Cold Spring Harbor Laboratory Press*, 1–16.

MedTerms. (n.d.). Retrieved February 21, 2016, from http://www.medicinenet.com/medterms-medical-dictionary/article.htm

Meireles, J., & Massano, J. (2012). Cognitive impairment and dementia in Parkinson's disease: Clinical features, diagnosis, and management. *Frontiers in Neurology*, *MAY*(May), 1–16. https://doi.org/10.3389/fneur.2012.00088

Michel, D. E., & May, N. H. (1974). The development of music therapy procedures with speech and language disorders. *Journal of Music Therapy*, *11*, 74–80.

Miller, N., Deane, K. H. O., Jones, D., Noble, E., & Gibb, C. (2011). National survey of speech and language therapy provision for people with

Parkinson's disease in the United Kingdom: therapists' practices. *International Journal of Language & Communication Disorders / Royal College of Speech & Language Therapists*, *46*(2), 189–201. https://doi.org/10.3109/13682822.2010.484849

Miller, N., Noble, E., Jones, D., & Burn, D. (2006). Life with communication changes in Parkinson's disease. *Age and Ageing*, *35*(3), 235–239. https://doi.org/10.1093/ageing/afj053

Pacchetti, C., Mancini, F., Aglieri, R., Fundarò, C., Martignoni, E., & Nappi, G. (2000). Active music therapy in Parkinson's disease: an integrative method for motor and emotional rehabilitation. *Psychosomatic Medicine*, *62*, 386–393. https://doi.org/10.1097/00006842-200005000-00012

Pagonabarraga, J., Kulisevsky, J., Strafella, A. P., & Krack, P. (2015). Apathy in Parkinson's disease: Clinical features, neural substrates, diagnosis, and treatment. *The Lancet Neurology*, *14*(5), 518–531. https://doi.org/10.1016/S1474-4422(15)00019-8

Park, D. C., Lodi-Smith, J., Drew, L. M., Haber, S., Hebrank, A., Bischof, G. N., & Aamodt, W. (2014). The impact of sustained engagement on cognitive function in older adults: the Synapse Project. *Psychological Science*, *25*(1), 103–112. https://doi.org/10.1177/0956797613499592

Pinto, S., Chan, A., Guimarães, I., Rothe-Neves, R., & Sadat, J. (2017). A cross-linguistic perspective to the study of dysarthria in Parkinson's disease. *Journal of Phonetics*, *64*(January), 156–167. https://doi.org/10.1016/j.wocn.2017.01.009

Pinto, S., Ozsancak, C., Tripoliti, E., Thobois, S., Limousin-dowsey, P., & Auzou, P. (2004). Review Treatments for dysarthria in Parkinson ' s disease. *Neurology*, *3*(September), 547–556.

Pinto, S., Ozsancak, C., Tripoliti, E., Thobois, S., Limousin-Dowsey, P., & Auzou, P. (2004). Treatments for dysarthria in Parkinson's disease. *Lancet Neurology*, *3*(9), 547–556. https://doi.org/10.1016/S1474-4422(04)00854-3

Poletti, M., Enrici, I., Bonuccelli, U., & Adenzato, M. (2011). Theory of Mind in Parkinson's disease. *Behavioural Brain Research*, *219*(2), 342–350. https://doi.org/10.1016/j.bbr.2011.01.010

Politis, M., Wu, K., Molloy, S., Bain, P. G., Chaudhuri, K. R., & Piccini, P. (2010). Parkinson's disease symptoms: The patient's perspective. *Movement Disorders*, *25*(11), 1646–1651. https://doi.org/10.1002/mds.23135

Pont-Sunyer, C., Hotter, A., Gaig, C., Seppi, K., Compta, Y., Katzenschlager, R., … Tolosa, E. (2015). The onset of nonmotor symptoms in parkinson's disease (the onset pd study). *Movement Disorders*, *30*(2), 229–237. https://doi.org/10.1002/mds.26077

Portone, C. R., Hapner, E. R., McGregor, L., Otto, K., & Johns, M. M. (2007). Correlation of the Voice Handicap Index (VHI) and the Voice-Related Quality of Life Measure (V-RQOL). *Journal of Voice*, *21*(6), 723–727. https://doi.org/10.1016/j.jvoice.2006.06.001

Prediger, R. D. S., Matheus, F. C., Schwarzbold, M. L., Lima, M. M. S., & Vital,

M. A. B. F. (2012). Anxiety in Parkinson's disease: A critical review of experimental and clinical studies. *Neuropharmacology*, *62*(1), 115–124. https://doi.org/10.1016/j.neuropharm.2011.08.039

Pringsheim, T., Jette, N., Frolkis, A., & Steeves, T. D. L. (2014). The prevalence of Parkinson's disease: A systematic review and meta-analysis. *Movement Disorders*, *29*(13), 1583–1590. https://doi.org/10.1002/mds.25945

Pursiainen, V., Haapaniemi, T. H., Korpelainen, J. T., Sotaniemi, K. A., & Myllyla, V. V. (2007). Sweating in Parkinsonian patients with wearing-off. *Movement Disorders*, *22*(6), 828–832. https://doi.org/10.1002/mds.21422

Rahman, S., Griffin, H. J., Quinn, N. P., & Jahanshahi, M. (2008). Quality of life in Parkinson's disease: The relative importance of the symptoms. *Movement Disorders*, *23*(10), 1428–1434. https://doi.org/10.1002/mds.21667

Ramaker, C., Marinus, J., Stiggelbout, A. M., & van Hilten, B. J. (2002). Systematic evaluation of rating scales for impairment and disability in Parkinson's disease. *Movement Disorders*, *17*(5), 867–876. https://doi.org/10.1002/mds.10248

Ramig, L., & Fox, C. (2007). Speech disorders in Parkinson's disease and the effects of pharmacological, surgical and speech treatment with emphasis on Lee Silverman voice treatment (LSVT). *Parkinson's Disease Foundation News and Review*.

Ramig, L. O., Fox, C., & Sapir, S. (2007). Speech disorders in Parkinson's disease and the effects of pharmacological, surgical and speech treatment with emphasis on Lee Silverman voice treatment (LSVT). In *Handbook of Clinical Neurology* (Vol. 83, pp. 385–399). https://doi.org/10.1016/S0072-9752(07)83017-X

Ramig, L. O., Fox, C., & Sapir, S. (2008). Speech treatment for Parkinson's disease. *Expert Reviews of Neurotherapeutics*, *8*(2), 299–311. https://doi.org/10.1586/14737175.8.2.297

Reyno-Briscoe, K. A. (1997). *Acoustic Correlates of Monopitch and Monoloudness in Parkinson's Disease*.

Richardson, K., Sussman, J. E., Stathopoulos, E. T., & Huber, J. E. (2014). The effect of increased vocal intensity on interarticulator timing in speakers with Parkinson's disease: A preliminary analysis. *Journal of Communication Disorders*, *52*, 44–64. https://doi.org/10.1016/j.jcomdis.2014.09.004

Rutten, S., Ghielen, I., Vriend, C., Hoogendoorn, A. W., Berendse, H. W., Leentjens, A. F. G., … van den Heuvel, O. A. (2014). Anxiety in Parkinson's disease: Symptom dimensions and overlap with depression and autonomic failure. *Parkinsonism and Related Disorders*. https://doi.org/10.1016/j.parkreldis.2014.11.019

Sackley, C. M., Smith, C. H., Rick, C., Brady, M. C., Ives, N., Patel, R., … Clarke, C. (2014). Lee Silverman voice treatment versus standard NHS speech and language therapy versus control in Parkinson's disease (PD COMM pilot): study protocol for a randomized controlled trial, *15*, 1–7. https://doi.org/10.1186/1745-6215-15-213

Sadagopan, N., & Huber, J. E. (2007). Effects of loudness cues on respiration in individuals with Parkinson's disease. *Movement Disorders*, *22*(5), 651–659. https://doi.org/10.1002/mds.21375

Sapir, E. (1927). SPEECH AS A PERSONALITY TRAIT EDWARD. *American Journal of Sociology*, *32*(6), 892–905. https://doi.org/10.1086/521238

Schulz, G. M., & Grant, M. K. (2000). Effects of speech therapy and pharmacologic and surgical treatments on voice and speech in Parkinson's disease: a review of the literature. *Journal of Communication Disorders*, *33*, 59–88. https://doi.org/10.1016/S0021-9924(99)00025-8

Scott, S., & Caird, F. I. (1983). Speech therapy for Parkinson' s disease. *Journal of Neurology, Neurosurgery, and Psychiatry*, *46*(October 1982), 140–144. Retrieved from http://jnnp.bmj.com/content/46/2/140.full.pdf+html

Senard, J. M., Raï, S., Brefel, C., Rascol, O., Rascol, a, & Montastruc, J. L. (1997). Prevalence of orthostatic hypotension in Parkinson ' s disease Prevalence of orthostatic hypotension in Parkinson ' s disease. *Psychiatry: Interpersonal and Biological Processes*, 584–589.

Seybold, C. D. (1971). The value and use of music activities in the treatment of speech delayed children. *Journal of Music Therapy*, *8*(3), 102–110. https://doi.org/10.1093/jmt/8.3.102

Shih, L. C., Piel, J., Warren, A., Kraics, L., Silver, A., Vanderhorst, V., … Tarsy, D. (2012). Singing in groups for Parkinson's disease (SING-PD): A pilot study of group singing therapy for PD-related voice/speech disorders. *Parkinsonism and Related Disorders*, *18*(5), 548–552. https://doi.org/10.1016/j.parkreldis.2012.02.009

Shulman, L. M., Taback, R. L., Rabinstein, A. A., & Weiner, W. J. (2002). Non-recognition of depression and other non-motor symptoms in Parkinson's disease. *Parkinsonism & Related Disorders*, *8*(3), 193–197. https://doi.org/10.1016/S1353-8020(01)00015-3

Song, J. H., Zhou, P. Y., Cao, Z. H., Ding, Z. G., Chen, H. X., & Zhang, G. B. (2015). Rhythmic auditory stimulation with visual stimuli on motor and balance function of patients with Parkinson's disease. *European Review for Medical and Pharmacological Sciences*, *19*(11), 2001–2007.

Stannard, K. (2003). *Junior Voiceworks 1: 33 Songs for Children*. Oxford University Press. Retrieved from https://books.google.com.my/books?id=WO78PAAACAAJ

Stegemöller, E. L., Radig, H., Hibbing, P., Wingate, J., & Sapienza, C. (2016a). Effects of singing on voice, respiratory control and quality of life in persons with Parkinson's disease. *Disability & Rehabilitation*, *39*(6), 594–601. https://doi.org/10.3109/09638288.2016.1152610

Stegemöller, E. L., Radig, H., Hibbing, P., Wingate, J., & Sapienza, C. (2016b). Effects of singing on voice, respiratory control and quality of life in persons with Parkinson's disease. *Disability and Rehabilitation*, *39*(6), 594–600. https://doi.org/10.3109/09638288.2016.1152610

Tanday, S. (2016). Feature How the power of singing is helping patients to breathe again. *The Lancet Respiratory*, *2600*(16), 2600.

https://doi.org/10.1016/S2213-2600(16)00002-3

Tanner, M. A., & Tanner, M. A. (2012). Voice Improvement in Parkinson ' s Disease : Vocal Pedagogy and Voice Therapy Combined by Doctor of Philosophy In Faculty of Rehabilitation Medicine Dedication This thesis is dedicated to my grandmother Elsie Faison Mitchell Newland , my parents Doris Els.

Thaut, M. H. (2015). *The discovery of human auditory-motor entrainment and its role in the development of neurologic music therapy*. *Progress in Brain Research* (1st ed., Vol. 217). Elsevier B.V. https://doi.org/10.1016/bs.pbr.2014.11.030

Thaut, M. H., Gardiner, J. C., Holmberg, D., Horwitz, J., Kent, L., Andrews, G., … McIntosh, G. R. (2009). Neurologic music therapy improves executive function and emotional adjustment in traumatic brain injury rehabilitation. *Annals of the New York Academy of Sciences*, *1169*(2), 406–416. https://doi.org/10.1111/j.1749-6632.2009.04585.x

Thaut, M. H., & McIntosh, G. C. (2014). Neurologic Music Therapy in stroke rehabilitation. *Current Physical Medicine and Rehabilitation Reports*, *2*, 106–113. https://doi.org/10.1007/s40141-014-0049-y

Ungerleider, L., Doyon, J., & Karni, A. (2002). Imaging brain plasticity during motor skill learning. *Neurobiol Learn Mem*, *78*, 553–564. https://doi.org/10.1006/nlme.2002.4091

Vella-Burrows, T., Hancox, G., & Sidney De Haan Research Centre for Arts and Health. (2012). Singing and people with Parkinson ' s, 24. Retrieved from http://www.canterbury.ac.uk/Research/Centres/SDHR/Documents/SingingandpeoplewithParkinsons.pdf

Velseboer, D. C., de Haan, R. J., Wieling, W., Goldstein, D. S., & de Bie, R. M. a. (2011). Prevalence of orthostatic hypotension in Parkinson's disease: A systematic review and meta-analysis. *Parkinsonism & Related Disorders*, *17*(10), 724–729. https://doi.org/10.1016/j.parkreldis.2011.04.016

Verbaan, D., Marinus, J., Visser, M., Van Rooden, S. M., Stiggelbout, A. M., & Van Hilten, J. J. (2007). Patient-reported autonomic symptoms in Parkinson disease. *Neurology*, *69*(4), 333–341. https://doi.org/10.1212/01.wnl.0000266593.50534.e8

Viola, I. C., & Madureira, S. (2007). Voice qualities and speech expressiveness. *Voice Qualities and Speech Expressiveness*, (May), 65–70. Retrieved from http://www2.dfki.de/paraling07/papers/14.pdf

Web-based Medical dictionary. (n.d.). Retrieved February 21, 2016, from http://medical-dictionary.thefreedictionary.com/web-based

Wee, N., Kandiah, N., Acharyya, S., Chander, R. J., Ng, A., Au, W. L., & Tan, L. C. S. (2016). Depression and anxiety are co-morbid but dissociable in mild Parkinson's disease: A prospective longitudinal study of patterns and predictors. *Parkinsonism & Related Disorders*, *23*, 50–56. https://doi.org/10.1016/j.parkreldis.2015.12.001

Wertheimer, J., Gottuso, A. Y., Nuno, M., Walton, C., Duboille, A., Tuchman, M., & Ramig, L. (2014). The impact of STN deep brain stimulation on speech

in individuals with Parkinson's disease: The patient's perspective. *Parkinsonism and Related Disorders*, *20*(10), 1065–1070. https://doi.org/10.1016/j.parkreldis.2014.06.010

Wiens, M. E., Reimer, M. A., C, R. N. C. N. N., & Guyn, H. L. (1999). Music Therapy as a Treatment Method for Improving Respiratory Muscle Strength in Patients with Advanced Multiple Sclerosis : A Pilot Study, *24*(2), 74–80.

Wight, S., & Miller, N. (2015). Lee Silverman Voice Treatment for people with Parkinson's: Audit of outcomes in a routine clinic. *International Journal of Language and Communication Disorders*, *50*(2). https://doi.org/10.1111/1460-6984.12132

Williams, D. R., Watt, H. C., & Lees, A. J. (2006). Predictors of falls and fractures in bradykinetic rigid syndromes: A retrospective study. *Journal of Neurology, Neurosurgery and Psychiatry*, *77*(4), 468–473. https://doi.org/10.1136/jnnp.2005.074070

Woolsey, W. (2004). Effects of varied types of music on singing voice and articulation in patients with Parkinson's disease. *University of the Pacific Theses and Dissertations*. Retrieved from https://scholarlycommons.pacific.edu/uop_etds/599

Xi, C., Zhu, Y., Mu, Y., Chen, B., Dong, B., Cheng, H., … Wang, K. (2015). Theory of mind and decision-making processes are impaired in Parkinson's disease. *Behavioural Brain Research*, *279*, 226–233. https://doi.org/10.1016/j.bbr.2014.11.035

Yap, S. E. (2017). *A Music Therapy based Coping Assessment in Older adults with Parkinson's Disease in Malaysia*. University Putra Malaysia.

York, G. K., & Steinberg, D. A. (2011). Hughlings Jackson's neurological ideas. *Brain*, *134*(10), 3106–3113. https://doi.org/10.1093/brain/awr219