THE APPLICATION OF ALTERED AUDITORY FEEDBACK WITHIN THE FRAMEWORK OF MOTOR LEARNING GUIDED APPROACH IN PEOPLE WITH PARKINSON'S DISEASE

By

BETHANY JO HOWARD

Bachelor of Science in Communication Sciences and Disorders

Oklahoma State University

Stillwater, OK

2017

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
May, 2019

THE APPLICATION OF ALTERED AUDITORY FEEDBACK WITHIN THE FRAMEWORK OF MOTOR LEARNING GUIDED APPROACH IN PEOPLE WITH PARKINSON'S DISEASE

Thesis Approved:

Dr. Ramesh Kaipa

Thesis Adviser

Dr. Sabiha Parveen

Dr. Cheryl Giddens

ACKNOWLEDGEMENTS

First and foremost, I am deeply grateful to my supervisor and first reader of this thesis Dr. Ramesh Kaipa at Oklahoma State University for assisting me in every aspect of this project from beginning to end, and even now as it is complete. The aid you have lent me has proven to be invaluable, and I am deeply grateful for your guidance.

Additionally, I am sincerely appreciative of the help offered to me by Dr. Cheryl Giddens, Dr. Sabiha Parveen, and Dr. Roha Kaipa along the way. I could not have completed this project without their expertise and willingness to offer support and suggestions.

Also, to my participants, thank you for your willingness to participate in research and your contributions to the academic world.

Finally, I would like to thank my incredibly supportive family and friends. To my mom: thank you for instilling a love of learning in me from a young age and thank you for always making my time away from school something to look forward to. I cannot thank you enough for pointing me to Jesus and reminding me of an eternal perspective when stress gets the best of me.

Most of all, thanks be to God for being both my hope and assurance of a future.

Name: BETHANY HOWARD

Date of Degree: MAY, 2019

Title of Study: THE APPLICATION OF ALTERED AUDITORY FEEDBACK WITHIN THE FRAMEWORK OF MOTOR LEARNING GUIDED APPROACH IN PEOPLE WITH PARKINSON'S DISEASE

Major Field: COMMUNICATION SCIENCES AND DISORDERS

Abstract: The current study assessed the speech intelligibility retention gains in 4 people with Parkinson's disease through the use of Delayed Auditory Feedback (DAF) and the motor learning guided approach (MLGA). In this single-case experimental design, two participants practiced 75 sentences using DAF and two participants practiced 15 sentences 5 times each using DAF + MLGA. Twenty semi-trained listeners rated the participant's productions using perceptual outcome measures of speech rate and intelligibility. All participants were able to make some progress toward improving their speech rate and intelligibility through use of this treatment, albeit all progress was not significant. Further research is needed to determine the extent of the effectiveness of DAF and MLGA treatments. The outcomes of this study are advance our knowledge on the theoretical as well as practical underpinnings of structured motor learning.

TABLE OF CONTENTS

Section Page

I. INTRODUCTION 1

Current Study 7

II. METHODS 9

Participants 9
Treatment Design 11
Treatment Protocol 11
Baseline Phase 11
Treatment Phase 12
Retention Phase 13

III. DATA ANALYSIS 14

Speech Intelligibility 14
Speech Rate 15

IV. RESULTS 17

Speech Intelligibility 17
Speech Rate 19

V. DISCUSSION 21

Limitations 28

VI. CONCLUSION 29

REFERENCES 30

LIST OF TABLES

Table Page

1.Demographic information for the four participants….………………………….....…9

2.Visual representation of the treatment design …………………………….……...11

3.Results of Speech Intelligibility Analysis ………………………………………..….19

4.Results of Speech Rate Analysis …….………………………………..……….….20

CHAPTER I

INTRODUCTION

Parkinson's disease is a progressive neurological disorder characterized by an imbalance of the neurotransmitter dopamine in the basal ganglia, leading to motor and non-motor difficulties that are progressive in nature. Parkinson's disease can occur at any time during adulthood, but increases with age. The highest risk factor for Parkinson's disease is age, which peaks at age 80. Disease progression is typically outlined to be about 20 years (Kalia & Lang, 2015). The symptoms associated with Parkinson's disease are numerous, including a wide range of motor as well as non-motor difficulties, and can manifest differently in each patient. Some symptoms are bradykinesia, stooped posture, inappropriately scaled movements, rigidity, and tremor (Politis, et al., 2010; Jankovic, 2008). In addition to these symptoms, Parkinson's disease is also characterized by secondary motor symptoms such as dysphagia and dysarthria, as well as freezing and dystonia. There are also non-motor symptoms of Parkinson's disease, including sleep disorders, back pain and depression (Jankovic, 2008).

Diagnosis of Parkinson's disease typically relies on the presence of many of the above symptoms, but diagnosis can be difficult as the cause of Parkinson's disease remains unknown (Jankovic, 2008). The aforementioned symptoms associated with Parkinson's disease tend to be caused by a reduction of dopamine in the basal ganglia. Dopamine has been shown to help scale movements and manage neuronal activity in the nuclei of the basal ganglia within the brain. Without this important neurotransmitter in sufficient quantities, there is hypo-activity of the basal ganglia and the symptoms of Parkinson's disease will emerge (Benazzouz, Mamad, Abedi, Bouali-Benazzouz, & Chetrit, 2014).

One of the marked symptoms of Parkinson's disease includes speech impairment. Speech impairment is present in 49-70% of people with Parkinson's disease, and is commonly referred to as hypokinetic dysarthria. Hypokinetic dysarthria is an umbrella term that is characterized by one or more features of variable speech rate, monotonous, soft, and breathy speech, and quiet volume. These changes can also lead to errors in articulation, which further impairs intelligibility (Miller, 2017; Jankovic, 2008; Ho, Iansek, Marigliani, Bradshaw, & Gates, 1999). These speech characteristics are highly varied among patients and can differ widely, just as all symptoms of Parkinson's disease differ in the individual.

Treatment research for hypokinetic dysarthria secondary to Parkinson's disease or Parkinsonism (HDSPD) is still evolving. Although the empirical evidence for phonatory and articulatory deficits is growing (Fox, Ebersbach, Ramig, & Sapir, 2012; Sapir et al.,2002; Sapir, Spielman, Ramig, Story & Fox, 2007), gaps in treatment evidence for other deficits in HDSPD still remain. One such deficit is increased or variable speech rate, which is commonly noticed in individuals with HDSPD (Van Nuffelen, Bodt, Wuyts, & Heyning, 2009).

Despite strides made in the recent past, treatment for speech rate is still in its infancy. Increased speech rate is a marked deficit associated with HDSPD and can lead to many difficulties, including a decrease in intelligibility of a speaker. This decrease in intelligibility is presumably due to decreased amount of time for the tongue to reach the articulators as well as a decrease in the amount of time for a listener to process speech sounds. A commonly advocated treatment approach for speech rate deficits in individuals with HDSPD is the rate reduction approach (Hammen & Yorkston, 1996; Tjaden & Wilding, 2011). Rate-reduction techniques vary widely, including tapping along to a metronome, using a pacing board or alphabet board, computerized pacing programs, and using DAF (Hammen & Yorkston, 1996). Despite the wide variety of treatment options, these rate reduction techniques remain poorly understood. Specifically, the efficacy of generalized reduction of speaking rate outside the clinic settings has not been sufficiently researched. In addition, habituation to rate reduction devices has been shown to be a confounding factor, and it is imperative that rate reduction techniques be further examined. Hammen & Yorkston, (1996) examined speech rate in six individuals with Parkinson's disease as well as six healthy controls. The researchers applied computerized pacing control software called PACER to the participants as they read a passage. This computerized rate software was able to significantly reduce the rate of speakers with Parkinson's disease, but was unable to be generalized to spontaneous speech. The researchers argued that more examination was necessary to determine the efficacy of rate control treatments.

One rate control treatment of interest is the application of Altered Auditory Feedback (AAF). In a broader sense, AAF involves altering the auditory feedback that is delivered to the individual. Typically for treatment purposes, two of the most common types of AAF have been delayed auditory feedback (DAF) and frequency shifted feedback (FSF). In DAF, the auditory feedback that is relayed to the listener is delayed by few milliseconds through an external device. In FSF, the individual hears the auditory feedback in real time but with an altered frequency (Blanchet & Snyder, 2010; Lowit, Dobinson, Timmins, Howell, & Kröger, 2010). The role of AAF in improving speech production deficits have been investigated in a variety of clinical populations. For example, in persons who stutter, the implementation of AAF has proven to be very beneficial in increasing fluency (Ryan & Van Kirk, 1974; Borsel, Reunes, & Bergh, 2003). In a study by Ryan and Van Kirk (1974), 50 clients were administered AAF and experienced improved fluency as a result, regardless of prior treatment exposure. In addition, Borsel, Reunes, & Bergh (2003) applied AAF to nine individuals with fluency disorders over a three-month period. The clients' speech samples were video recorded and assessed during speaking situations using both non-altered feedback and AAF. It was discovered that AAF aided in reduction of stuttering moments, as well as promoted fluency over a longer period of time when used consistently. In addition to stuttering, AAF has been used to aid in speech difficulties in people with aphasia. In a study by Chapin et al. (1981), 10 individuals with fluent aphasia, 10 individuals with nonfluent aphasia, and ten non-affected controls were assessed for their ability to benefit from AAF. The participants attempted six tasks of varying difficulty, including naming, repetition, sentence production, nursery rhymes, reading, and answering questions. It was found that participants with conduction aphasia benefited from the use of AAF, while results were unclear for other types of aphasia. Because of the marked efficacy of AAF with other disorders as well as the gap in research, it is plausible that AAF could be beneficial in people with Parkinson's disease, and is in need of further study.

Within the context of Parkinson's disease, the use of AAF to enhance speech intelligibility has generated equivocal findings (e.g. Bullock-Rest, 2014; Brendel, Lowit & Howell, 2004; Dobbs et al., 1993; Blanchet & Snyder, 2010). McClain (2017) evaluated the role of AAF with a frequency shift and delay of 150ms in five individuals with Parkinson's disease and five age-matched controls. The participants were involved in monologue and reading tasks in presence and absence of AAF and the productions were audio-recorded. These productions were randomly presented to 20 naïve listeners who rated their speech intelligibility on 7-point rating scale. The results indicated that individuals with Parkinson's disease received higher intelligibility ratings than age-matched controls. The difference was trending significance, albeit not significant. Lowitt et al. (2010) compared the role of AAF in increasing speech intelligibility in 10 individuals with Parkinson's disease. The AAF included a 150-millisecond delay and a 1/2 octave frequency shift upward. The researcher employed an alternating treatment design to compare the effects of traditional rate-reduction therapy and altered feedback therapy. Each participant received both types of therapy, which were separated by a 6-week no treatment period. Five speakers started with AAF treatment and the remaining participants started with the traditional rate-reduction treatment. Each intervention was delivered for one session per week that lasted for 50-60 minutes for a total of 6 weeks. The outcome measures included speech rate (number of syllables/second) and intelligibility ratings. Results indicated that provision of AAF produced slower speech rates in individuals with Parkinson's disease in comparison to traditional rate-reduction treatment. However, these slower rates did not always translate into an increase in speech intelligibility. In a single case study of a severely unintelligible person with early onset

Parkinson's disease, AAF proved to be beneficial (Downie, Low, & Lindsay, 1981). In this study, the application of AAF to the patient with severe festinating speech maintained a very "useful benefit" and the patient's speech intelligibility improved for the duration of time that the AAF device was being worn with no signs or symptoms of device habituation. Finally, Blanchet and Hoffman (2014), also used AAF in three speakers with Parkinson's disease. After 16 sessions, all three participants demonstrated significant improvements in intelligibility as well as improvements in other speech characteristics. The most important aspect of this study, however, was the inclusion of verbal feedback to help the speakers correct their productions while using the AAF system. While the verbal feedback was not structured as in the case of MLGA, it was administrated in a similar way. When the feedback was implemented, the results for speech intelligibility further improved (Blanchet & Hoffman, 2014). This provides evidence that provision of AAF within the framework of structured motor learning is likely to enhance speech intelligibility of people with Parkinson's disease.

The above studies present equivocal support for the use of AAF in improving speech intelligibility in individuals with Parkinson's disease. The basic premise of rate reduction treatment for people with HDSPD is to establish a new speech motor routine through reorganization of the speech motor system, and this can be achieved by administering the treatment within the context of structured motor learning. There is strong empirical evidence to demonstrate long-term retention gains of speech motor skills through structured motor learning approaches (Bislick, Weir, Spencer, Kendall, & Yorkston, 2012). Despite the beneficial effects of structured learning approaches, existing rate control treatment approaches, including AAF, are not administered within the context of motor learning. Hence, it is not surprising to note that there has been no retention data on speech intelligibility in individuals with Parkinson's disease who have received rate control treatments. This lack of retention data has presented a formidable challenge in arguing the effectiveness of current rate control treatment approaches for Parkinson's disease. One of the treatment approaches to have received considerable attention in the recent years was the Motor Learning Guided Approach. (MLGA). This is an empirically validated approach that utilizes motor learning principles to facilitate speech motor learning (Lasker, Stierwalt, Hageman, & LaPointe, 2008; Kim, Kang, Pirruccello, Kweon, & Oh, 2017). The MLGA combines multiple practice opportunities that use meaningful stimuli practiced in a random fashion in various situations. In this approach, the clinician provides a summary knowledge of results (KR) type of feedback every 5th attempt, or following a 20% schedule (Johnson, 2014). In the past, MLGA has been used to treat speech deficits in individuals with disorders of the speech motor system such as apraxia of speech, but has not been used to treat the speech deficits associated with Parkinson's disease.

Current Study

The current study addressed the critical gap in the prior literature by comparing the speech intelligibility retention gains of DAF administered within the context of the motor learning guided approach to just DAF in people with HDSPD. The current study harnessed perceptual (speech intelligibility) outcome measures to examine retention benefits of structured speech motor learning in treating speech rate deficits in people with HDSPD through the use of a single-case experimental design. The outcomes of this study are likely to advance our knowledge on the theoretical as well as practical underpinnings of structured motor learning.

CHAPTER II

METHODS

Participants

Four individuals with HDSPD participated in this single-subject research design. The participant inclusion criteria were: males over the age of 50 with a history of Parkinson's disease, increased speech rate of varying degrees, and less than desired intelligibility. Intelligibility and speech rate were determined both by patient report and researcher agreement before treatment began. If marked cognitive deficits or severe comorbid conditions were present, participants were excluded from the study. Prior to the start of the experiment, each participant was required to fill out a demographic questionnaire and was administered the Montreal Cognitive Assessment as well as portions of the Unified Parkinson's Disease Rating Scale. In addition, each participant completed a detailed informational sheet about their medical history, onset of Parkinson's disease medication, treatment history and symptoms they have experienced as a result of their disorder. The participants' demographic and medical history are presented in Table 1.

Table 1: Demographic information for the four participants

	Participant 1	Participant 2	Participant 3	Participant 4
Age	69	73	50	69

Years since Diagnosis	7	8	3	2
Medication	Stalevo Levodopa	Rytary Levodopa Requip XL Azilect	Accordion Pill Carbidopa/ Levodopa Neupro Patch	Carbidopa-Levodopa Oral
Reported speech symptoms	Speech “runs together”	Faster, mumbling speech	Slurred, runs together, “I sound drunk”	Soft and slurred. Improves when he “takes his time”
Hearing Screening	Right ear 1000 Hz – Pass 2000 Hz – Pass 4000 Hz – Refer Left ear 1000 Hz – Pass 2000 Hz – Pass 4000 Hz – Refer Able to understand speech at the conversational level	Right ear 1000 Hz – Pass 2000 Hz – Pass 4000 Hz – Refer Left ear 1000 Hz – Refer 2000 Hz – Refer 4000 Hz – Refer Mastoidectomy in the left ear. Able to understand speech at the conversational level	Right ear 1000 Hz – Pass 2000 Hz – Pass 4000 Hz – Pass Left ear 1000 Hz – Pass 2000 Hz – Pass 4000 Hz – Pass	Right ear 1000 Hz – Pass 2000 Hz – Pass 4000 Hz – Pass Left ear 1000 Hz – Pass 2000 Hz – Pass 4000 Hz – Pass
MOCA Score	26/30 Normal	29/30 Normal	30/30 Normal	29/30 Normal
Previous Therapy	Participated in the SPEAK OUT!® program 2 years prior	Participated in the SPEAK OUT!® program 1 year prior	No previous therapy	No previous therapy
UPDRS Part III Motor Exam score	29/136 possible	32/136 possible	49/136 possible	45/136 possible
Hoehn and Yahr Stage	2: Bilateral Involvement without impairment of balance	1: Unilateral Involvement Only	1: Unilateral Involvement Only	1: Unilateral Involvement Only
Random Assignment	DAF + MLGA	DAF + MLGA	DAF	DAF

Treatment Design

Each participant took part in 6 experimental treatment sessions on 6 consecutive days and a delayed retention session after a break of two days for a total of 7 sessions. The participants were randomly assigned to one of the two treatment conditions using an iPhone app which used a spinner to randomly assign participants. Two participants were administered DAF during each of the six treatment sessions. The remaining two participants received DAF delivered within the context of MLGA. The treatment protocol for each group is illustrated in Figure 1.

Table 2. Visual representation of the treatment design

		Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Session 7
2 Participants	Baseline	DAF + MLGA	DAF + MLGA	DAF + MLGA	DAF + MLGA	DAF + MLGA	DAF + MLGA	Delayed Retention
2 Participants	Baseline	DAF	DAF	DAF	DAF	DAF	DAF	Delayed Retention

Treatment Protocol

Baseline Phase: Participants in both the groups participated in a baseline phase. They produced five sentences in their habitual speech rate. These sentences, as well as the rest of the sentences used in the study, were selected from the Harvard Sentences. Selected sentences were 8-10 syllables in length and randomized for the purposes of this study. The Harvard sentences are phonetically balanced and equally represent the sounds and structure in the same frequency they appear in the English language (1969). The participant's productions were recorded to estimate their speech intelligibility prior to the treatment phase.

Treatment Phase: Prior to the beginning of the treatment session on the first day, participants in both the phases produced 5-10 sentences delivered through DAF to allow for adjustment to the altered feedback. Participants' speech was delayed by 150 milliseconds due to positive results found with this measure in other intelligibility studies (McClain, 2018; Blanchett & Hoffman, 2014). The DAF was administered to the participants through an iOS app called "simply DAF" using in-the-ear headphones. The volume of the DAF was adjusted by a few decibels for each participant based on their comfort level and to ensure the DAF could be easily heard during the experiment. During each of the DAF-only sessions, the participants read 75 sentences. At the end of the 75 sentences, the participants were required to repeat 5 sentences that were practiced from the list as well as five novel sentences. The participant productions were video/audio recorded for the purpose of data analysis. In the DAF + MLGA treatment group, the participants were required to practice only 15 sentences a total of five times each. After the initial presentation of each sentence, the participants were required to pause for few seconds and then repeat the sentence. After 5 productions of the same sentence, the participant was given verbal feedback regarding his 5 productions as per the MLGA. After each participant completed 75 productions in total, he was required to repeat 5 sentences that were practiced from the list as well as five novel sentences without further practice or feedback. This method was used to assess for immediate retention as well as transfer effects.

Retention Phase: After the completion of the practice sessions, participants from both treatment groups participated in a delayed retention session taking place two days later to examine how speech rate and intelligibility have been affected subsequent to the treatment. In the delayed retention task, the participants read 5 new sentences, as well as 5 sentences that were practiced during the treatment sessions. These productions were also video/audio recorded for the purposes of analysis.

CHAPTER III

DATA ANALYSIS

Twenty semi-trained listeners evaluated the speech intelligibility of the speakers during each phase of treatment. The semi-trained listeners were in their second year of speech language pathology graduate school, likely making them more effective in rating speech intelligibility as compared to naïve listeners. The listeners were instructed as to how to rate speech intelligibility based on a seven-point intelligibility rating scale. The participants were given audio and video anchor points to aid in ratings. The listening task took place in a distraction-free, comfortable, classroom setting and each audio sample was presented via in-the-ear headphones. The listeners were presented the recordings of sentence production of each participant randomly. After each speech sample was presented, participants were given 10-15 seconds to rate the intelligibility of the speech sample. Mean ratings for each of the samples were determined for the purposes of statistical analysis. In addition to these ratings, speech rate was assessed by calculating syllables per second and creating a mean value for rate of each of the speaker's 75 productions. SPSS 23.0 was used for statistical analysis. The outcome measures for the study were speech intelligibility and speech rate.

Speech Intelligibility

The semi trained listeners rated the speech intelligibility of four participants diagnosed with Parkinson's disease throughout their course of treatment. An intraclass correlation was carried out using SPSS to determine the inter-rater reliability. The ratings of twenty semi trained listeners for each of the sentences produced by the four participants diagnosed with Parkinson's disease throughout their treatment phase were subjected to mixed model analysis of variance (ANOVA). The data was analyzed as a function of participants and learning. The between group factor was participants (four participants), whereas the within-group factor was learning (baseline, immediate retention novel, immediate retention practice, delayed retention novel and delayed retention practice). This allowed us to investigate the main effect of participants, main effect of learning and interaction of these two factors. Participants 1 and 2 followed DAF +MLGA and participants 3 and 4 followed DAF during their treatment sessions.

Speech Rate

The speech rate was determined by calculating the ratio of syllables per second for each utterance spoken by the participant. This calculation was completed by counting each produced syllable divided by the total length in seconds of the utterance determined using Pratt software (i.e. # of syllables/seconds). The ratios obtained for each utterance of the participants were subjected to a mixed model analysis of variance (ANOVA). The data was analyzed as a function of participants and learning. The between group factor was participants (four participants), whereas the within-group factor was learning (baseline, immediate retention novel, immediate retention practice, delayed retention novel and delayed retention practice). This allowed us to investigate the main effect of participants, main effect of learning and interaction of these two factors.

CHAPTER IV

RESULTS

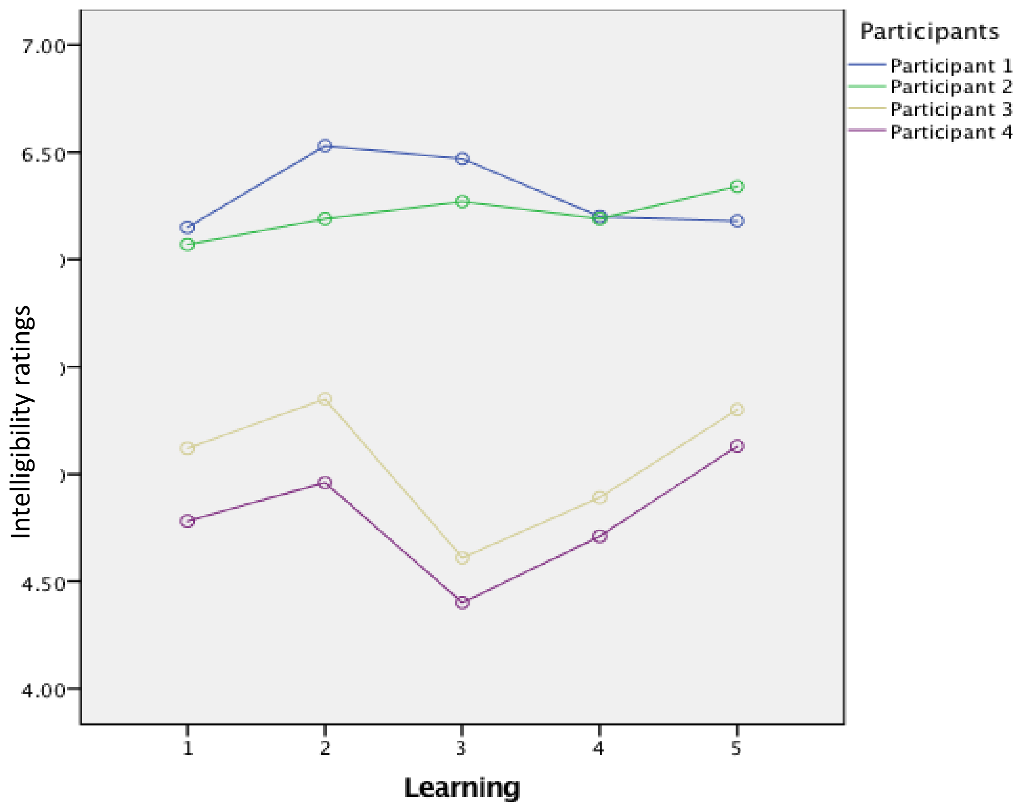
Speech Intelligibility

The intra class correlation revealed that there was a high degree of reliability across the raters for speech intelligibility of the participants with Parkinson's disease throughout their treatment phases. The average measure intra class correlation coefficient was .93 with a 95% confidence interval from .901 to .948, [F (99,1881) = 18.80, p <.001].

The findings of mixed model ANOVA using Greenhouse Geisser Correction revealed that there was a significant main effect of learning, [F (3.89, 1542.08) = 8.05, p < .01]. Surprisingly participants during the immediate retention of novel sentences exhibited better speech intelligibility (M = 5.76, SD = 1.29) when compared to delayed retention of practice sentences (M = 5.73, SD = 1.37), delayed retention of novel sentences (M = 5.50, SD = 1.35), immediate retention of practice sentences (M = 5.44, SD = 1.51) and baseline (M = 5.53, SD = 1.35). There was also significant difference in speech intelligibility of the four participants involved in the study over the course of the treatment, [F (1, 396) = 105.61, p < .01]. Multiple comparison using Tukey's HSD revealed that Participant 1 and 2 were significantly different from 3 and 4 and Participant 3 was significantly different from participant 4 (p < .05).

The main effect of learning was qualified by a significant interaction of participants * learning, [$F (11.68, 1542.08) = 3.98$, $p < .01$]. The post hoc test analyzing the interactive effects revealed that the participant 1 was rated to have significantly better speech intelligibility for immediate retention of novel sentences (M = 6.53, SD = 2.26) when compared to baseline learning conditions (M = 6.15, SD = 2.44) ($p < .001$). Participant 3 exhibited significantly lower speech intelligibility for immediate retention practice condition (M = 4.61, SD =2.38) when compared to all the other conditions, ($p <.01$), immediate retention of novel sentences (M = 5.35, SD = 2.26) were significantly better than delayed retention of novel sentences (M = 4.89, SD =2.32) ($p <.01$). While Participant 4 exhibited higher speech intelligibility for delayed retention practice condition when compared to all the other conditions (M = 5.13, SD = 2.54), ($p <.01$), Immediate retention of novel sentences (M = 4.96 , SD = 2.26) was significantly better than immediate retention practice (M = 4.4, SD = 2.38) ($p <.01$).

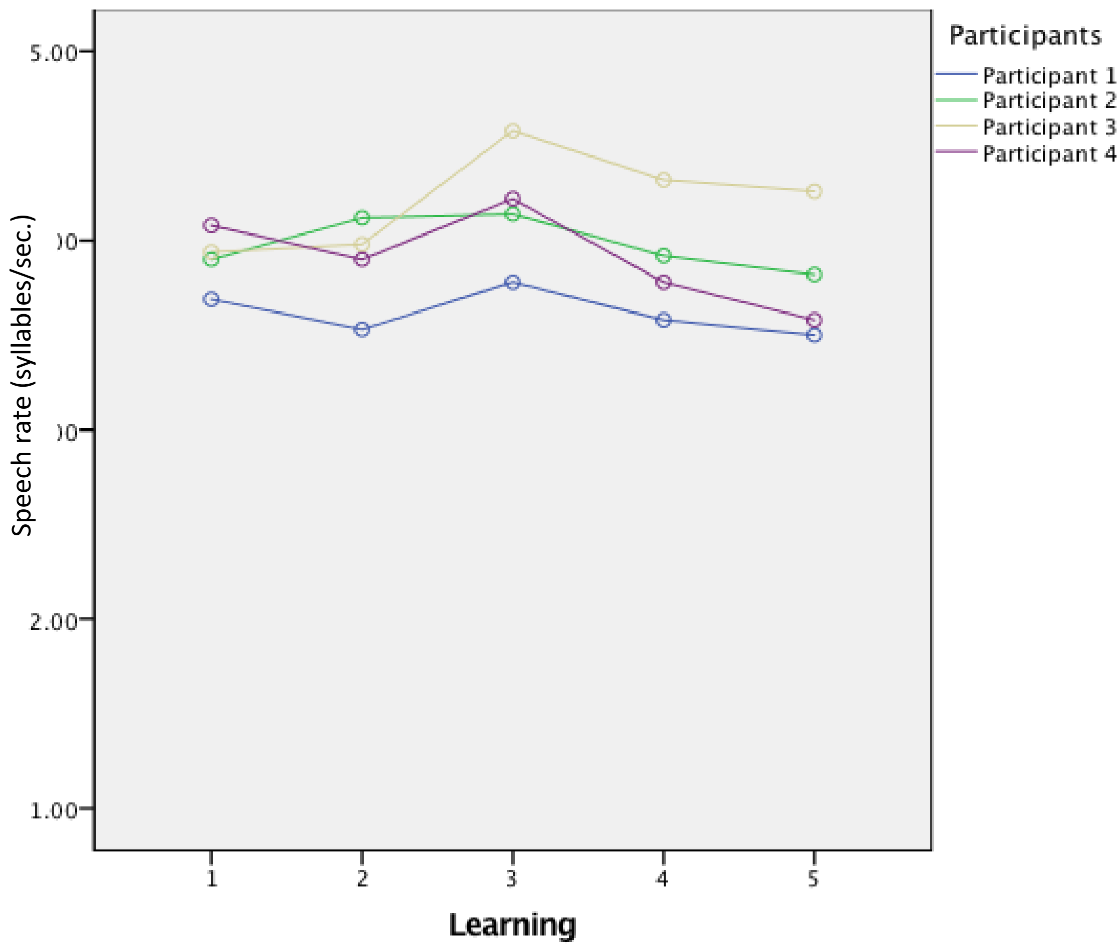
Table 3. Results of Speech Intelligibility Analysis



Speech Rate

The findings of mixed model ANOVA revealed that there was no significant main effect of speech rate on learning, F (4, 64) = 2.31, p =.07. However, the between subjects' effects suggested that there was a significant difference between the participants on the speech rate F (1, 3) = 6.43, p =0.005. The post hoc test revealed that the speech rate of participant 3 (M = 4.22, SD = .19) was significantly different from participant 1 (M = 3.62, SD = .19) (p < .001).

Table 4. Results of Speech Rate Analysis



CHAPTER V

DISCUSSION

To our knowledge, the current study is the first study to include MLGA and DAF in treatment with participants with HDSPD. There are limited studies, however, which have demonstrated the effects of using DAF as a treatment tool for speech rate and intelligibility in those with Parkinson's disease. Despite the fact that other studies have not included MLGA and DAF, some comparisons can be made. Lowit et al. (2010), discussed above, compared DAF with a delay of 150 milliseconds and a frequency shift and found that DAF produced decreased speech rate in individuals with HDSPD, but the reduction in rate did not correlate to increased intelligibility consistently. Results of Lowit et al. (2010) suggest varied responses to DAF between individuals. Some participants improved, while others regressed or remained consistent. Similar variability was found in the current studies' results, with different types of participants responding in variable ways to use of DAF. This leads to a possible conclusion that certain participants are more successful with the use of DAF or may be better served to benefit from DAF and/or MLGA in a more significant way based on symptoms or previous treatment exposure.

Blanchet and Hoffman (2014), also found significant improvements in speech intelligibility for three speakers with Parkinson's disease who used DAF and "verbal feedback." With feedback, participants were able to make greater progress. These results suggested that participants' may have more success when given a structured type of feedback. However, the expected result did not occur in the current study. The current results likely occurred due to differences in the nature of feedback, with MLGA being more structured than feedback offered in Blanchet and Hoffman (2014). As discussed above, it is also possible that the application of multiple treatments may not be beneficial for those with Parkinson's disease. Additionally, participants in Blanchet and Hoffman's (2013) study that shared similar speech deficits showed similar progress, as with the current study. While all three participants made progress in decreasing deficits, two participants sharing similar features improved in speech fluency, while a third participant improved in intelligibility. Finally, McClain (2018) found that the use of DAF produced improved speech intelligibility in those with Parkinson's disease as rated by trained listeners. When DAF delays of 150 ms and a frequency shift of 1/20 of an octave, participants with Parkinson's disease experienced improved speech intelligibility as a group.

The current study does not contradict previous literature based on the findings that all participants in the study received a measurable increase in intelligibility as a result of DAF. Previously cited studies herein found similar variation in progress among participants, with an overall trend toward increased intelligibility, as with the current study. While further research is necessary to determine the benefit of DAF + MLGA in those with HDSPD, current findings share similarities with previous research.

This preliminary study aimed to compare the speech intelligibility outcomes of two participants with Parkinson's disease who received DAF within the framework of structured motor learning to two participants with Parkinson's disease who received DAF alone. Based on the theoretical underpinnings of the motor learning approach, it was hypothesized that participants who received DAF in a structured motor learning approach would present with a slower speech rate and improved speech intelligibility in comparison to participants who received DAF alone. However, the results indicated that all the participants demonstrated similar extent of learning regardless of the treatment condition received. The findings of the current study are discussed below within a clinical and theoretical framework.

On an overall note, it is interesting to note that participants 1 and 2 (DAF + MLGA treatment protocol) demonstrated similar patterns of learning. The learning outcomes of participant 1 during the immediate retention of novel sentences phase was perceived significantly better than the baseline, but participant 1 demonstrated no other significant differences. Additionally, participant 2 did not demonstrate any significant differences across the five data collection points. Descriptively, the speech intelligibility scores of participants 1 and 2 increased slightly during the production of novel sentences in the immediate retention phase. The intelligibility scores continued to be nearly stable across the immediate retention of practiced sentences and delayed retention of novel sentences before slightly increasing during the delayed retention of practiced sentences phase.

Participants 3 and 4, who received DAF across the five treatment days, also demonstrated very similar patterns of learning. Learning outcomes of participant 3 during the immediate retention of novel sentences phase was better than immediate retention of practiced sentences and delayed retention of novel sentences. Additionally, delayed retention of the practiced sentences was significantly better than the immediate retention of the delayed sentences. In the case of participant 4, performance during the immediate retention of novel sentences was significantly better than the immediate retention of practiced sentences. Performance during the delayed retention of practice sentences was perceived as significantly better than the immediate retention of practiced sentences and delayed retention of novel sentences. On a descriptive note, both participants 3 and 4 demonstrated considerable improvement during the immediate retention of novel sentences when compared to baseline. However, this was followed by a dramatic decrease in speech intelligibility during immediate retention of previously practiced sentences. Participant 3's speech intelligibility continued to improve during the delayed retention of novel sentences condition and reached its peak with the delayed retention of practiced sentences condition. Overall, the learning trajectory of P1 and P2 differed significantly when compared to the learning trajectory of P3 and P4. This could have been influenced by many variables including both participant variables and training variables.

The stable performance of P1 and P2 from baseline through delayed retention of practiced sentences begs the question, "was motor learning occurring at all?" The answer to this question may be found in these participants' prior history of speech therapy through the SPEAK OUT!® program. Both participants received an average of one month of SPEAK OUT!® therapy 3 times weekly followed by moderate attendance to a maintenance program called LOUD Crowd®, targeting vocal intensity. In addition to prior therapy, participants' UPDRS Subtest III scores indicated a moderate level of severity. This information indicates that both participants 1 and 2 were at an advantage upon beginning the training protocol. This advantage was evidenced by the increased baseline scores of the participants when compared with participants 3 and 4.

Although there was a lack of significant statistical difference, descriptively the data reveals that there was a slight increase in speech intelligibility scores of the novel as well as practiced sentences during their delayed retention phase. This data suggests that people with HDSPD who are in the mild-to-moderate stages may need considerable practice to demonstrate significant improvements in their motor learning efforts. The need for more intense practice may be a primary reason for the lack of perceptual improvement in participants 1 and 2. Additionally, given the slight increase in the scores of participants 1 and 2, there is an indication that participants with similar phenotypes are likely to be able to demonstrate progress in speech motor skills, but may need a more intense approach.

Participants 3 and 4 demonstrated a very different learning trajectory when compared to participants 1 and 2. Both participants 3 and 4 demonstrated an improvement in their speech intelligibility during the immediate retention of novel sentences, followed by a decrease in their intelligibility scores during the immediate retention of practiced sentences. This phenomenon could likely be attributed to the order of practice effect. While sentences were randomized overall, 5 novel sentences and then 5 previously practiced sentences were presented in the same order, with novel being read first. Participants practiced the motor skill and were initially able to generalize the newly learned skill to the first 5 novel sentences. Next, participants may have become habituated back to their natural speech rate when they reached the second set of 5 previously practiced sentences. Practice effect was indicated by the dip in participants' scores during the immediate retention of practiced sentences, noted in Figure 1.

Surprisingly, the scores of participants 3 and 4 began to increase during the delayed retention of novel sentences phase and eventually peaked during delayed retention of practiced sentences. Essentially, the practiced sentences that garnered the lowest intelligibility scores during the immediate retention phase were perceived significantly better during the participants' delayed retention of practiced sentences. From a theoretical perspective, this phenomenon can be explained by the Memory Consolidation Hypothesis. The time interval of approximately 48 hours between immediate and delayed retention allowed for long-term memory consolidation. Practice and allowing for time for memory consolidation could have helped participants to recall their practiced sentences more effectively than the novel sentences. Although the above-mentioned order of practice effect was shown during the immediate retention phase, it was not present in the delayed retention phase. If long-term habituation occurred due to the order of stimuli, similar patterns would have been reflected across both the immediate and delayed retention phases. The delayed retention phase was the true indicator of long term learning, and was represented by the increase of intelligibility in the practiced sentences after memory consolidation had occurred. Furthermore, as anticipated, participants 3 and 4 demonstrated better retention of practiced sentences over novel, indicating a lack of generalization of the learned skill to the novel sentences.

The current results do not support our initial hypothesis that individuals who received DAF + MLGA would demonstrate increased motor learning. Based on results of the current study, it is likely that the nature of practice is not an imperative factor in the determination of learning outcomes when compared to the intensity of practice. Participants 3 and 4 partook in more intense practice due to their exposure to 75 different sentences each practice session, while participants 1 and 2 were exposed to only 15 sentences 5 times each. Participants 1 and 2 received a more restricted training, with blocked practice occurring on the 15 practiced sentences each session, while participants 3 and 4 were trained on diverse stimuli. This diversity likely led to more motor learning growth and opportunity for skill generalization. Essentially, the number of opportunities a participant had to demonstrate and practice a skill in different contexts was shown to contribute to increased motor learning.

However, in the current case, there may be additional explanation for the findings. As discussed previously, participants 1 and 2 possessed inherent differences from participants 3 and 4. It is possible that participants 3 and 4 had a better chance to progress in and improve speech motor skills, simply due to a larger margin available for improvement. Participant 3 and 4 demonstrated a lower quality of speech at baseline and a higher UPDRS Subtest III score, which may have allowed for motor learning to occur more quickly. Participant 3 and 4 were in a position to improve and did not have useful skills to aid in increasing their intelligibility (i.e. prior therapy techniques), leading to a more favorable response to treatment exposure. Based on this conclusion, it is likely that participants 1 and 2 needed increased amounts of practice and increa diversity of practice to make gains from their current high level of performance. With some practice, participants 1 and 2 were able to improve, but results would likely increase if they were offered even more practice. It is also important to mention that the addition of multiple variables (i.e. MLGA + DAF) may not have helped these participants make further progress. Instead, multiple variables may offer minimal to no increase in improvement over the focused and intense use of only one practice regimen (i.e. DAF alone).

Limitations

Based on the above discussion, it would be beneficial for the researcher to administer a similar experiment where MLGA + DAF is administered on participants without prior treatment exposure. Due to the randomization of participants to practice conditions, this measure was not possible in the current study. Greater knowledge could have been acquired if participants with similar qualities and symptoms were matched for comparison, as in the case of the two participants with prior treatment exposure and moderate Parkinson's disease. An additional limitation to this study is the use of a small sample size with fairly heterogenous participants, affecting the generalizability of results to the rest of the population. The small sample size occurred due to the limited availability of participants fitting the prescribed qualities who were willing or able to participate. Future research should investigate the effects of DAF and MLGA on the speech intelligibility with a greater number of people with Parkinson's disease. Additionally, a healthy control group should be used for comparison of patient progress. A final limitation to the study was the use of sentences for the stimulus. It may have been beneficial to use the DAF with a more naturalistic type of speech such as conversation to create an environment more akin to daily life. However, the use of phonetically balanced stimuli offered standardization and ensured consistency across participants.

CHAPTER VI

CONCLUSION

Overall, this study provided support for the use of DAF to improve the speech intelligibility in individuals diagnosed with Parkinson's disease. While results were not statistically significant, all participants experienced some improvement in speech intelligibility. This study offers valuable information for those interested in the use of DAF and MLGA for patients with Parkinson's disease and may lead to impacts in service-delivery models when future research is implemented. It is important to mention that all participants felt that use of the DAF was beneficial for their speech and stated that they would consider using DAF in the future for conversational and formal speaking tasks. The preceding evidence should incite future researcher to investigate these treatment protocols and their effects on many individuals with Parkinson's disease.

REFERENCES

Benazzouz, A., Mamad, O., Abedi, P., Bouali-Benazzouz, R., & Chetrit, J. (2014). Involvement of dopamine loss in extrastriatal basal ganglia nuclei in the pathophysiology of Parkinson's disease. *Frontiers in aging neuroscience,* 6. doi:10.3389/fnagi.2014.00087

Blanchet P.G., Hoffman P.R. (2014) Factors Influencing the Effects of Delayed Auditory Feedback on Dysarthric Speech Associated with Parkinson's Disease. *Communication Disorders, Deaf Studies, and Hearing Aids* 2:106. doi: 10.4172/2375-4427.1000106

Blanchet, P. G., & Snyder, G. J. (2010). Speech rate treatments for individuals with dysarthria: a tutorial. *Perceptual and motor skills*, 110(3), 965-982.

Borsel, J., Reunes, G., & Bergh, N. (2003). Delayed auditory feedback in the treatment of stuttering: clients as consumers. *International Journal of Language & Communication Disorders*, 38(2), 119-129. doi: 10.1080/1368282021000042902

Brendel, B., Lowit, A., & Howell, P. (2004). The effects of delayed and frequency shifted feedback on speakers with Parkinson's Disease. *Journal of Medical Speech-Language Pathology*, 12, 131–138.

Bullock-Rest, N. (2014). Speech Intelligibility Changes Associated with Altered Auditory Feedback in Parkinson's Disease and Deep Brain Stimulation. Rush University.

Chapin, C., Blumstein, S. E., Meissner, B., & Boller, F. (1981). Speech production mechanisms in aphasia: a delayed auditory feedback study. *Brain and Language*, 14(1), 106-113. doi:10.1016/0093-934X(81)90068-7

Dobbs, R. J., Bowes, S. G., Henley, M., Charlett, A., O'Neill, C. J. A., Dickins, J., Nicholson, P. W. and Dobbs, S. M. (1993), Assessment of the bradyphrenia of parkinsonism: a novel use of delayed auditory feedback. *Acta Neurologica Scandinavica*, 87:262–267. doi:10.1111/j.1600-0404.1993.tb05505.x

Downie, A. W., Low, J. M., & Lindsay, D. D. (1981). Speech disorder in parkinsonism-usefulness of delayed auditory feedback in selected cases. *International Journal of Language & Communication Disorders*, 16(2), 135-139. doi:10.3109/13682828109011394

Fox, C., Ebersbach, G., Ramig, L., & Sapir, S. (2012). LSVT LOUD and LSVT BIG: behavioral treatment programs for speech and body movement in Parkinson disease. *Parkinson's Disease*, 2012. doi:10.1155/2012/391946

Hammen, V. L., & Yorkston, K. M. (1996). Speech and pause characteristics following speech rate reduction in hypokinetic dysarthria. *Journal of communication disorders*, 29(6), 429- 445. doi:10.1016/0021-9924(95)00037-2

Ho, A. K., Iansek, R., Marigliani, C., Bradshaw, J. L., & Gates, S. (1999). Speech impairment in a large sample of patients with Parkinson’s disease. *Behavioral neurology*, 11(3), 131-137. doi:10.1155/1999/327643

IEEE recommended practice for speech quality measurements. (1969). New York, NY: Institute of Electrical and Electronics Engineers.

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

Johnson, R. K. (2014). A Comparison of Motor Learning Guided and Sound Production Treatment Approaches for Training Novel Speech in Healthy Adults. The Florida State University.

Kalia, L., & Lang, A. (2015). Parkinson's disease. *Lancet (London, England), 386*(9996), 896-912.

Kim, I. S., Kang, H. S., Pirruccello, L., Kweon, S., & Oh, C. (2017). Motor learning theory- based approach for teaching English as a second language. *Speech, Language and Hearing*, *20*(2), 63-70.

Lasker, Joanne & Stierwalt, J.A.G. & Hageman, C.F. & La Pointe, L.L.. (2008). Using motor learning guided theory and augmentative and alternative communication to improve speech production in profound apraxia: A case example. *Journal of Medical Speech-Language Pathology*. 16. 225-231.

Levitt, J. S. (2014). A case study: The effects of the "SPEAK OUT!®" Voice Program for Parkinson's disease. *International Journal of Applied Science and Technology,* 4(2).

Levitt, J. S., Chitnis, S., & Walker-Batson, D. (2015). The Effects of the "SPEAK OUT!®" and "LOUD Crowd®" Voice Programs for Parkinson. *International Journal of Health Sciences*, 3(2), 13-19. doi: 10.15640/ijhs.v3n2a3

Lowit, A., Dobinson, C., Timmins, C., Howell, P., & Kröger, B., (2010) The effectiveness of traditional methods and altered auditory feedback in improving speech rate and intelligibility in speakers with Parkinson's disease, *International Journal of Speech-Language Pathology,* 12:5, 426-436, doi:10.3109/17549507.2010.497559

McClain, N., (2018) Perceptual Evaluation of Speech Intelligibility of Individuals with Parkinson's Disease Following Speech Rate Modification through Altered Auditory Feedback. Master's Thesis, Oklahoma State University.

Miller, N. (2017). Communication changes in Parkinson's disease. *Practical Neurology, 17*(4), 266-274.

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

Ryan, B. P., & Van Kirk, B. (1974). The establishment, transfer, and maintenance of fluent speech in 50 stutterers using delayed auditory feedback and operant procedures. *Journal of Speech and Hearing Disorders,* 39(1), 3-10.

Sapir, S., Ramig, L. O., Hoyt, P., Countryman, S., O'Brien, C., & Hoehn, M. (2002). Speech loudness and quality 12 months after Intensive Voice Treatment (LSVT®) for Parkinson's disease: a comparison with an alternative speech treatment. *Folia Phoniatrica et Logopaedica*, 54(6), 296-303. doi:10.1159/000066148

Sapir, S., Spielman, J. L., Ramig, L. O., Story, B. H., & Fox, C. (2007). Effects of intensive voice treatment (the Lee Silverman Voice Treatment [LSVT]) on vowel articulation in dysarthric individuals with idiopathic Parkinson disease: acoustic and perceptual findings. *Journal of Speech, Language, and Hearing Research*, 50(4), 899-912.

Tjaden, K., & Wilding, G. (2011). The Impact of Rate Reduction and Increased Loudness on Fundamental Frequency Characteristics in Dysarthria. *Folia Phoniatrica Et Logopaedica,63*(4), 178-186. doi:10.1159/000316315

Van Nuffelen, G., Bodt, M. D., Wuyts, F., & Heyning, P. V. (2009). The Effect of Rate Control on Speech Rate and Intelligibility of Dysarthric Speech. *Folia Phoniatrica Et Logopaedica,61*(2), 69-75. doi:10.1159/000208805

Whitfield, J. A. (2014). Speech motor sequence learning in parkinson disease and normal aging: Acquisition, consolidation, and automatization. Bowling Green State University.

VITA

Bethany Jo Howard

Candidate for the Degree of

Master of Science

Thesis: THE APPLICATION OF ALTERED AUDITORY FEEDBACK WITHIN THE FRAMEWORK OF MOTOR LEARNING GUIDED APPROACH IN PEOPLE WITH PARKINSON'S DISEASE

Major Field: COMMUNICATION SCIENCES AND DISORDERS

Biographical:

Education:

Completed the requirements for the Master of Science in Communication Sciences and Disorders at Oklahoma State University, Stillwater, Oklahoma in May, 2019.

Completed the requirements for the Bachelor of Science in Communication Sciences and Disorders at Oklahoma State University, Stillwater, Oklahoma in 2017.

Professional Memberships:

National Student Speech Language and Hearing Association