The Effect of a Rhythmic Speech Cuing Protocol on Speech Intelligibility in Patients with Parkinson's Disease

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THE EFFECT OF A RHYTHMIC SPEECH CUING PROTOCOL ON SPEECH INTELLIGIBILITY IN PATIENTS WITH PARKINSON’S DISEASE

By

Joy Ouellette

A THESIS

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THE EFFECT OF A RHYTHMIC SPEECH CUING PROTOCOL ON SPEECH
INTELLIGIBILITY IN PATIENTS WITH PARKINSON’S DISEASE

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The purpose of this study was to investigate the long-term effects of a Rhythmic Speech Cuing (RSC) protocol on severe speech impairments resulting from Parkinson’s disease (PD). Five individuals diagnosed with idiopathic PD and speech deficiencies resulting from PD participated in the study. Each participant received 12 treatment sessions of RSC over a 4-week period. Each 25-minute treatment session consisted of metered rhythmic cuing with fading (for 20 minutes) and conversational speech (for 5 minutes). For rhythmic cuing, participants hand-tapped and spoke each word syllable to an auditory metronome cue that was set to 60% of their habitual speech rate (HSR). Data were collected during three testing sessions: pre-, mid-, and post-test. Each 20-minute testing session consisted of the participant speaking a total of 22 sentences (i.e., 220 words) from the Assessment of Intelligibility of Dysarthric Speech (AIDS) (Yorkston & Beukelman, 1981a) at their own preferred pace with no cuing. A picture description task (PDT) was also used, in which participants reported what they observed in a color photo depicting an everyday scenario. The dependent variables observed via the AIDS were percentage of intelligible speech, speech rate (including duration and words per minute,
or WPM), and intelligible words per minute (IWPM). Unintelligible words per minute (UWPM) and communication efficiency ratio (CER) were also observed with the AIDS. Additionally, intelligible words and content of speech were observed via the PDT. The results showed that RSC had a statistically significant main effect on content of speech scores. Although scores for only one dependent variable achieved statistical significance, scores for six out of eight dependent variables generated large effect sizes, thus indicating practical significance. Findings revealed that the current RSC treatment protocol was most effective in the treatment of individuals with severe speech deficiencies. The participant whose speech was the most severely affected demonstrated marked improvements in all dependent variables in the current research. For example, his percentage of intelligible speech increased from 65% to 89%, which is a percentage that is comparable to typical speakers. Moreover, his CER increased from 0.14 to 0.28, showing his communication efficiency doubled from pre- to post-test. For this participant, spontaneous speech samples via the PDT indicated that scores for both intelligible words and content of speech increased from pre- to post-test. These increases suggest skill transfer may have occurred from training to spontaneous speech. Limitations within the current research included difficulty assessing speech deficiencies in the screening procedure, and a small and varied sample. Therefore, clinicians should be vigilant in utilizing an assessment tool that will accurately measure level of speech impairment. A precise tool will be helpful in identifying individuals with severe deficiencies who are most likely to benefit from use of this treatment protocol. The
current data demonstrate that within a one month RSC protocol, patients with severe speech impairments resulting from PD can maintain or improve functional speech.
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Chapter One

Introduction

Statement of the problem. Parkinson’s disease (PD) is a progressive neurodegenerative disorder that currently affects an estimated 1.5 million people in the United States with 60,000 new cases of PD being diagnosed each year (Adams & Jog, 2009; Hou & Lai, 2008). PD is caused by a deterioration of the basal ganglia, structures deep within the brain, and can cause a communication disorder known as hypokinetic dysarthria. Consequently, an estimated 60% to 80% of PD patients develop speech deficiencies as the disease progresses (Adams & Dykstra, 2009).

Hypokinetic dysarthria negatively affects all aspects of speech production; however, most deficiencies are exhibited in prosody, phonation, and articulation (Kent, 2005). Additionally, a decline in speech intelligibility is one of the most prominent features of hypokinetic dysarthria and is the result of disturbed speech rate. The decline in speech intelligibility associated with hypokinetic dysarthria negatively affects quality of life for patients with PD and therefore warrants effective rehabilitation.

Functional and intelligible speech is essential to quality of life. Without functional communication, a person must rely on others for assistance and may experience a loss of independence. In communicating, a message is deemed “intelligible” if the recipient is able to understand it. Additionally, a speaker is “intelligible” if listeners can comprehend messages that speaker produces (Kent, 2009). The abnormally rapid speech rate of hypokinetic dysarthric speakers has been addressed through a variety of treatments. While pharmacological treatments (i.e., levodopa), behavioral speech therapy, instrumental biofeedback, and prosthetic and assistive devices (Adams & Dykstra, 2009)
have all been used in the treatment of hypokinetic dysarthria, effectiveness of these treatments varies.

In early studies, individuals receiving levodopa medication showed initial improvements in intelligibility, fluency, voice quality, and pitch variation (Adams & Jog, 2009). More recently, numerous studies involving individuals who have been on dopaminergic medication for several years have failed to show improvements in multiple aspects of speech production, including speech fluency, intelligibility, and rate. Additionally, studies have suggested speech symptoms may begin to show a selective resistance to levodopa in individuals who have had PD for more than 10 years. These results imply that the effectiveness of dopaminergic medications upon hypokinetic speech deficits is inconsistent and variable.

The effectiveness of behavioral speech therapy in the treatment of hypokinetic dysarthria is less well documented than the use of pharmacological treatments. Behavioral speech therapy addresses expressive and receptive communication needs and deals with the mechanics of producing words, such as articulation, pitch, fluency, and volume. Adams and Dykstra (2009) state very few studies have addressed the use of behavioral speech therapy in PD. Studies that did address behavioral speech therapy usually lacked detailed descriptions of treatment methods and measures of treatment outcomes. Studies suggest individuals exhibited some improvements in facial mobility, intensity control, and speech articulator mobility during treatment sessions. However, these improvements failed to generalize outside of the clinical setting. The problem of transfer of treatment is documented by several researchers and appears to be a prominent issue in the treatment of PD speech. Determining if transfers have been made outside of
the clinical setting is a common concern in the treatment of most communication disorders.

With few exceptions, studies using biofeedback treatments have also shown problems in transference outside of the clinical setting. Visual biofeedback therapy using voice-operated oscilloscopes has typically been used to improve pitch and loudness variation. Studies suggest improvements can be achieved through biofeedback therapy mostly in intensity level and range, intensity during conversation and reading, and maximum pitch range. Adams and Dykstra (2009) note the greatest improvements in biofeedback therapy are achieved when it is used in conjunction with behavioral speech therapy. However, the problem of transfer of treatment still exists.

In an attempt to address the problem of transfer, Adams and Dykstra (2009) note the use of assistive speech devices has gained popularity. Assistive devices provide an immediate benefit to the individual’s communication. The most commonly-used assistive device in treatment with PD is the portable voice amplifier; however, little data are available on its prevalence or effectiveness of use. Assistive devices provide an easy solution for individuals who fail to transfer gains made in therapy.

Although immediately effective, the use of prosthetic devices such as the voice amplifier causes the individual to become dependent upon external aids and less independent upon his own resources. Additionally, problems in transfer of gains in behavioral speech and biofeedback therapies are limited and inconsistently effective as treatment strategies. These factors, along with the incidence of PD rising each year, warrant the need for additional rehabilitation techniques in the treatment of hypokinetic dysarthria.
The use of rhythm in the treatment of hypokinetic dysarthria has received considerable attention in the research literature. With speech regarded as a rhythmic behavior, utilizing auditory rhythmic cues to regulate dysfluent speech appears to be a viable treatment technique. Rhythmic Speech Cuing (RSC) has been shown to increase speech intelligibility in patients with hypokinetic dysarthria by decreasing their habitual speech rate (Thaut, McIntosh, McIntosh, & Hoemberg, 2001).

The result of decreased speech rate in patients with hypokinetic dysarthria is an overall increase in mean intelligibility (Thaut et al., 2001). In RSC, rhythmic auditory cues and physical cues such as hand-tapping, act as external timekeepers which entrain with damaged internal timing mechanisms (i.e., the basal ganglia) evident in PD. The result of entrainment is more coordinated and efficient movement of the muscles involved in speech production. As muscle movements improve, speech intelligibility is increased. Research evidence regarding the ability to perceive rhythm despite basal ganglia dysfunction shows support of RSC as an effective rehabilitative technique in the treatment of hypokinetic dysarthria. The long-term and transfer effects of RSC have not been addressed in the current research literature.

**Need for the study**

**Theoretical contributions.** The findings obtained in this study will offer a better understanding of how the auditory system interacts with and influences rhythmic behavior, such as speech. Central pattern generators (CPGs) which involve complex connections of neurons involved in the production of rhythmic motor behaviors (i.e., speech and gait) have been shown to be capable of modification via sensory input (i.e., rhythm) (Barlow, Finan, & Park, 2004). The incorporation of a physical cue (i.e., hand-
tapping) in addition to a rhythm may facilitate intersystemic reorganization (Simmons, 1978). This process involves the performance of an act (i.e., speaking) becoming functional as a result of being paired with a physical gesture (i.e., hand-tapping). The use of auditory rhythm in combination with a physical cue will provide a strong signal to modify or “re-set” the CPGs for fluent speech output.

**Clinical contributions.** The clinical contributions of this research will apply to a specific group of communication disorders resulting from damage to the basal ganglia (i.e., internal timing mechanism) that are associated with dysfluent and laborious speech. The influence of rhythm upon the timing of speech in the presence of basal ganglia dysfunction in PD will be observed. The effects of a long-term RSC protocol will be observed as well as transfer into spontaneous speech. This information may be beneficial to speech-language pathologists and music therapists in the treatment of dysfluent speech due to disrupted timing.

**Purpose of the study**

Efficient verbal communication is an essential aspect of everyday life. Without intelligible speech, individuals with hypokinetic dysarthria may become reliant on others or assistive devices for their communication needs and experience a loss of independence. The purpose of this study will be to investigate the effect of rhythm on the timing of speech output in the presence of basal ganglia dysfunction observed in PD. This study will investigate the long-term and transfer effects of a Rhythmic Speech Cuing protocol on speech intelligibility in patients with severe hypokinetic dysarthria resulting from PD.
Chapter Two

Review of Related Literature

This chapter will review research literature that is imperative to the understanding of typical speech production, the basal ganglia, and the role of rhythm in the treatment of specific speech disorders. The literature review is divided into four sections, including literature related to the neural control system for typical speech production and dysfunction of the basal ganglia in hypokinetic dysarthria. Additionally, the role of the basal ganglia in the perception of rhythm and the effect of rhythm on speech rate are discussed.

Neural control system for typical speech production. The neural control system for speech can be explained with regard to lateralization and compartmentalization (Kent, 2005). Lateralization of speech and language refers to most humans having left hemisphere dominance for language processing. Compartmentalization refers to the cortical and subcortical neural structures involved in speech and language. The primary structures involved in speech production include the insula, basal ganglia, cerebellum, supplementary motor area (SMA), Broca’s area, premotor cortex, motor cortex, periaqueductal gray matter (PAG), the brainstem, and spinal nuclei of various cranial and spinal nerves. The subcortical structures involved in speech, including the basal ganglia, cerebellum, thalamus, and the motor nuclei of various cranial and spinal nerves, are analogous to those involved in other motor systems (i.e., gross and fine motor control).
Murdoch (2004) notes models of basal ganglia-thalamocortical and cerebellar-cortical circuits have become crucial in understanding the role of the basal ganglia and cerebellum in speech motor function. The basal ganglia are comprised of structures including the neostriatum (NS), which consists of the putamen and the caudate nucleus (CN). Collectively, the additional structures of the globus pallidus (GP), substantia nigra pars compacta (SNPC), pars reticulate (SNPR), and the subthalamic nucleus (STN) form the major components of the basal ganglia. In general, the basal ganglia are considered to consist of “input” structures (i.e., the CN, putamen and ventral striatum) and “output” structures (i.e., the internal segment of the GP, the SNPR and the ventral pallidum). Input structures receive direct input from the cerebral cortex and output structures project information back to the cerebral cortex via the thalamus.

Input and output structures of the basal ganglia comprise an integral pathway involved in the planning, initiation, and coordination of speech (Weismer, 2007). Harrington and Haaland (1998) note the basal ganglia are in a strategic position to regulate the spatial and temporal coordination of converging cortical inputs. This coordination is in concordance with the assertion that the basal ganglia play a critical role in timing the movements of speech articulators (i.e., the lips, tongue, velum, etc.). Timing of these articulatory structures can determine speech rate (i.e., slow or fast) and directly affects speech intelligibility. Most outputs from the basal nuclei converge on the GP, which sends outputs to the thalamus. The thalamus then transmits the information to motor areas of the cortex, which in turn sends information back to the basal nuclei. In sum, the basal nuclei receive processed information by way of the GP, thalamus,
cortex, and basal nuclei. These structures form a motor loop referred to as the cortico-striato-pallido-thalamo-cortical loop (Murdoch, 2004).

In addition to a motor loop, Barlow, Finan, and Park (2004) note the possible involvement of central pattern generators (CPGs) in speech production. CPGs are neuronal circuits that can produce coordinated motor patterns in the absence of sensory feedback and in response to brief inputs (Enorka, 2002). Central pattern-generating circuits in the brain involve complex connections of neurons that are involved in the production of motor behaviors such as locomotion, respiration, swallowing, mastication, sucking, and possibly vocalization (Barlow et al., 2004). The role that CPGs play in speech production is largely unclear; however, a basic understanding of pattern-generating circuitry for respiration, suck, and mastication reveal multiple loci in the brainstem and motor cortex, as well as a combination of subsystems within the PAG. Located in the cerebral cortex, brainstem, and spinal cord, CPGs are mainly comprised of interneurons that direct output to lower motor neurons.

Barlow et al. (2004) note for certain CPGs, rhythmic motor patterns may be generated in the absence of sensory feedback. However, most research points to changes in sensory input (i.e., rhythm) resulting in the modification of neuronal networks which make up the CPG. Centrally generated motor patterns can be heavily influenced by phasic signals from nerves that respond to sensory stimuli. Phasic signals are defined as sensory signals which are necessary for typical motor patterning and contribute to the generation and maintenance of rhythmic activity (i.e., gait and speech).

Barlow et al. (2004) assert that a multitude of sensorimotor processes drive the central neural networks responsible for a patterned output response. An example of one
such process is entrainment, which occurs when external cues (i.e., a rhythmic pulse) act as a zeitgeber (i.e., pacemaker) to entrain or synchronize with internal oscillators. Entrainment is dependent upon the strength of the phasic signal in comparison to other signals from higher neural centers which may interrupt input to the CPGs (Haas, Distenfeld, and Axen, 1986). In order for entrainment to occur, a stable phasic relationship (i.e., a 1:1, 1:2, or 2:3 ratio) must exist between the external stimulus and the internal oscillator (Barlow et al., 2004).

The analysis of rhythmic entrainment patterns has been facilitated by the use of oscillator-coupling models where the periodicity (i.e., a tendency to occur at regular intervals) of an oscillator drives a second oscillator’s frequency (Thaut, Tian, and Azimi-Sadjadi, 1998). Entrainment research has observed frequency coupling in neural systems (i.e., CPGs for gait) and other biological response systems. Physiological entrainment occurs when the frequency of one system’s activity determines the activity of a second system. More specifically, an internal oscillator entrains to the more dominant influence of an external oscillator (i.e., a metronome pulse). Thaut et al. (1998) claim it is generally accepted that entrainment can occur if both system frequencies are close to a 1:1 ratio or consist of low-ratio integer harmonics (i.e., 1:2, 2:3, etc.). The result of rhythmic entrainment is more efficient and effective motor planning of rhythmically coordinated motor patterns (i.e., speech and gait).

A discussion of the coordination of speech articulators as they relate to speech perception is necessary in order to address speech intelligibility as it is relevant to speech production. Liberman (1996) notes two views of speech perception comprised of the General Auditory, or the conventional view, and the Specifically Phonetic, or the
unconventional view. The conventional view asserts that speech is perceived no
differently than other sounds and all acoustic events are processed by the primary
auditory cortex. After being received by the primary auditory cortex, the acoustic events
are then categorized as to what they represent (i.e., a squeaking door or stop consonant).
Contrary to this view, Liberman (1996) offers the unconventional view which asserts that
speech is perceived differently than other acoustic events.

The unconventional view of speech perception is proposed as being a specialized
phonetic mode that is different from the general auditory mode. Dissimilar to the
conventional view, perception is specialized for consonants and vowels. Specialization
for consonants and vowels in the unconventional view refers to the idea that speech
sounds are processed differently than other acoustic events. The specialization generates
only phonetic structures and claims not to be auditory, but rather gestural. For example,
[b] is a lip-closing gesture; [h] is a glottis-opening gesture; the combination of lip-closing
and glottis-opening produces [p], velum-lowering yields [m]. According to Liberman
(1996), speech production runs at an average rate of eight to ten segments per second.
Liberman (1996) states that gestures usually require the movements of several
articulators. Speech production is dependent upon the coordination and sequencing of
these articulators.

In order for speech production to occur in a rapid sequence, the muscles and
organs of the vocal tract must function independently from each other to some degree.
The unconventional view makes note of such a level of independence which makes the
performance of consecutive phonetic strings possible. Phonetic strings can be carried out
concurrently or with substantial overlap. For example, the gesture [d] is overlapped with
constituent gestures for the vowel sound [o] and the consonant sound [g] resulting in the word “dog”. This coarticulation results in the transmission of phonetic information at a rapid pace, which would not be possible if gestures were produced individually.

The coarticulation of gestures as defined by Liberman (1996) is of particular importance in regards to speech intelligibility since it is reliant upon an intact timing mechanism (i.e., the basal ganglia). Without proper timing, speech articulators cannot coordinate and the result is dysfluent speech. In turn, dysfluent speech leads to a decline in speech intelligibility and loss of efficient, well-timed verbal communication. This loss of efficient verbal communication is observed in hypokinetic dysarthria as the result of basal ganglia dysfunction in PD.

**Dysfunction of the basal ganglia in hypokinetic dysarthria.** Hypokinetic dysarthria is most often associated with Parkinson’s disease (PD), in which levels of the neurotransmitter dopamine are diminished in the basal ganglia (Weismer, 2007). The depletion of dopamine in the basal ganglia results from cell death in the substantia nigra and disrupts the motor feedback loop. The role of dopamine is critical in the coordination of movement; therefore, insufficient amounts of the neurotransmitter lead to deficits in movement.

Movement deficits in hypokinetic disorders are characterized by impairments in limb and trunk movements involving initiation, such as akinesia, and a reduction in the velocity of voluntary movements, bradykinesia (Murdoch, 2004). Additionally, muscular rigidity and resting tremors are often evident in hypokinetic disorders. In regard to the effect of these deficiencies in the speech-production mechanism, the resulting condition is known as hypokinetic dysarthria. For example, atypical speech breathing patterns
exhibited in patients with PD are largely attributed to the rigidity of the respiratory muscles. This rigidity limits movements of the chest wall and reduces respiratory capacity which imposes negative effects on speech production.

The negative effects of hypokinetic disorders on speech are evident in all facets of speech production, including respiration, phonation, resonance, articulation, and prosody (Kent, 2005). However, in patients presenting with hypokinetic dysarthria, most disturbances are likely to be exhibited in prosody, phonation, and articulation. More specifically, characteristics observed in hypokinetic dysarthric speech include monopitch, harsh voice quality, imprecise voice consonants, monoloudness, low pitch, inappropriate silences, variable rate, breathy voice, reduced stress, and short rushes. These deficiencies contribute to unintelligible and labored speech in the dysarthric speaker.

Disordered speech rate is frequently observed in patients with PD (Murdoch, Ward, and Theodoros, 2000). Patients with PD can demonstrate both a faster and slower overall speech rate than typical speakers, with research indicating a generally variable rate. Patients with PD have been noted to demonstrate an “accelerated” speech pattern as a result of short rushes of speech. These short rushes in verbal utterances of speakers with PD have been observed to be one of the most outstanding features of hypokinetic dysarthria. Some research indicates a progressive acceleration of speech within a speech segment being perceived in hypokinetic dysarthric speech.

The variable rate in dysarthric speech can be attributed to dysfunction of the basal ganglia. The role of the basal ganglia in typical speech is to inhibit unwanted movement patterns and permit selected ones (Woolsey, Hanaway, & Gado, 2003). In PD, damage in the basal ganglia disrupts the timing and coordination of articulatory structures involved
in speech production. As a result, inhibition of unwanted movements and selection of purposeful movements is not possible. The inability of the basal ganglia to impose inhibitory control on unwanted movements of speech articulators and to produce desired sounds makes well-timed speech difficult in patients with hypokinetic dysarthria.

**The role of the basal ganglia in the perception of rhythm.** Grahn and Brett (2007) hypothesized that the basal ganglia and supplementary motor areas (SMAs) of the brain would respond to the presence of a regular beat. This hypothesis arises from research data indicating the role of the basal ganglia in temporal sequencing and internally generated movements. Results revealed that metric simple patterns (i.e., intervals positioned to induce a perceptual accent at the beginning of a group of four) produced activation bilaterally in the putamen. Additional analysis indicated that the pallidum, putamen, caudate, and pre-SMA were more activated in the metric simple condition (i.e., intervals are identical to metric simple condition, however not regularly grouped). Activation of the basal ganglia, Pre-SMA, and SMA as shown by these data indicate that simple, predictable rhythms yield greater activation than complex and nonmetric rhythms.

Further support of activation in areas of the basal ganglia is provided by Penhune, Zatorre, and Evans (1998) who hypothesized central control of temporal processing centering around the cerebellum, basal ganglia, and sensory association areas of the brain. The research of Penhune et al. (1998) came as a result of other investigations that have shown the possible involvement of the basal ganglia in both motor and perceptual timing in a simple finger tapping task. The task conditions included perception of an isochronous sequence (i.e., all beat durations are equal), perception and reproduction of
isochronous sequences, perception and reproduction of a repeated sequence, and perception and reproduction of novel sequences.

For each condition, data were analyzed using a paired-image subtraction technique designed to observe changes in cerebral blood flow (CBF) related to a simple timed motor response (i.e., tapping a finger in synchrony with an external stimulus). The observation was made possible by subtracting activations related to perceptual input. Activations were observed in the left globus pallidus during the reproduction of an isochronous sequence minus perception. The globus pallidus is the primary output nucleus of the basal ganglia. This is consistent with the role of the basal ganglia in a simple timed motor response and consistent with other fMRI research showing basal ganglia involvement in the continuation of a simple tapping task.

The data for increased activation of the basal ganglia in the research of Grahn and Brett (2007) and Penhune et al. (1998) show strong implications for the use of simple, metric rhythms in the rehabilitation of hypokinetic dysarthric speech. The combined use of a metric, simple rhythm (i.e., metronome) and a simple timed motor response (i.e., hand-tapping) are necessary for the greatest activation of the basal ganglia. These two elements are critical in the use of Rhythmic Speech Cuing (RSC).

**The immediate effect of rhythm on speech rate.** RSC has been shown to be an effective rehabilitative technique in modifying rate control in patients with hypokinetic dysarthria in order to increase intelligibility. Thaut (2005) defines RSC as a rate-control technique that utilizes auditory rhythm in metronome form or within music to cue speech. The time patterns contained within the rhythm facilitate the modification of speech rate, resulting in enhanced speech intelligibility. The goal of RSC in the treatment of
hypokinetic dysarthria is to decrease speech rate since it is abnormally rapid. Research has shown the reduction of speech rate significantly improves intelligibility in hypokinetic dysarthric speakers (Thaut et al., 2001).

The reduction of speech rate is made possible in RSC through the use of either metric (metered) or patterned cuing. In metric cuing, the therapist equates rhythmic beats to syllables resulting in equal syllable length across a spoken phrase (Thaut, 2005). Metric cuing results in improved sequencing and timing of articulation, yet does not maintain normal qualities of speech inflection. In patterned cuing, the therapist utilizes rhythmic patterns that contain different beat durations in accordance to certain syllables that maintain the prosodic elements of a sentence. In contrast to metric cuing, the durations between beats in patterned speech cuing are asymmetrical and depend on the rhythmic patterns of typical speech (See Figure 1).

1. Metered (Metric) Cuing Example: Each syllable gets equal duration

\[ \text{♩ ♩ ♩ ♩ ♩ ♩ ♩} \]

2. Patterned Cuing Example: Maintains the rhythm of typical speech

\[ \text{♩ ♩ ♩ ♩ ♩} \]

*Figure 1. Metered versus patterned cuing*
Research has shown both metric and patterned cuing to be effective in improving speech intelligibility in hypokinetic dysarthria (Thaut et al., 2001). However, metric cuing is shown to be most effective in patients with more severe speech deficiencies (i.e., below 60% intelligibility). Patterned cuing is shown to be most effective in patients with milder deficiencies (i.e., above 80% intelligibility). Slowing of speech rate via RSC provides a preset time interval to prepare the speaker for initiation and articulation of the following word (Thaut, 2005). By generating pauses between words with RSC, phoneme articulation becomes more precise, particularly in word initiation.

In a study showing immediate results of cuing, rhythmic and visual cues were utilized by Pilon, McIntosh, and Thaut (1998) who measured their effect on the speech intelligibility of patients with mixed spastic-ataxic dysarthria. Three post-Traumatic Brain Injury (TBI) participants received one session per week for six weeks. Initially, each participant exhibited slow and imprecise articulation, hypernasality, monopitch, and monoloudness resulting from spastic-ataxic dysarthria. Two participants presented with a moderate to severe compromise in speech intelligibility, while one participant presented with a milder impairment. The study utilized four pacing conditions: no pacing (NP), singing pacing (SP), metronomic pacing (MP), and board pacing (BP).

During the NP condition, participants read 30 sentences aloud to provide baseline data for speech rate and intelligibility. During SP, a melody was sung at a tempo 20% slower than baseline (i.e., as defined as words per minute) while an accompanying chord pattern was played on the keyboard. The melody, tempo, stress, and intonation patterns closely of the singing resembled those that formed the inflection pattern and content of each sentence. For example, a sentence that was a question had a rise in intonation
toward the end of the sentence. Next, each participant was instructed to sing the sentence to the best of his ability using the same melody, stress, and intonation pattern with no assistance.

During MP, participants were instructed to read each sentence aloud in synchronization to a metronome cue. The metronome cue was set at 20% below each participant’s baseline speech rate and each word of the sentence was verbalized to each beat. No modeling was provided during this condition. During BP, one sentence at a time was presented on a pacing board. No rhythmic cue was given to facilitate slowed rate during this condition. The task of tapping one finger from left to right, along with each word while speaking each sentence constituted this condition.

Results of sentence analysis indicated all three pacing conditions yielded improved intelligibility scores, when averaged across participants and compared to baseline (NP = 66%), but changes were not significant. The MP condition showed the greatest improvement in speech intelligibility when values were averaged across participants. MP yielded an improvement to 80% intelligibility, what represented a 21.2% change over baseline. BP resulted in an increase to 75% intelligibility, what represented a 13.6% change over baseline. SP revealed a 74% intelligibility score, representative of a 12.1% increase over baseline. Results also indicated that the two patients with lower baseline intelligibility scores benefited more from a slowing of speech rate than the third participant who presented with milder impairments.

The authors conclude severely affected speech deficiencies are most responsive to rigid rate control techniques. Additionally, the authors note the consistency of the metronome to produce superior results may reflect the specific effectiveness of rhythmic
anticipatory cues to modify speech output when timing is a variable of experimental interest. These results offer support in favor of rhythmic cuing imposing a positive effect on unintelligible, dysarthric speech.

Thaut et al. (2001) also observed the immediate positive effects of auditory cues on the disturbed speech patterns in patients with hypokinetic dysarthria. All twenty patients were at a similar stage of PD and participated in one session each of metered and patterned rhythmic speech cuing. The first session included a motor speech assessment, an assessment of speech intelligibility, and reading of 36 experimental sentences with no pacing (i.e., baseline). The second session consisted of the two experimental conditions of metered cuing and patterned cuing counterbalanced across participants. Sentences were read by the participants with each set systematically modulated in speaking rate (i.e., habitual, 80% and 60% of habitual speech rate) and presentation of metered or patterned cuing.

Results of sentence analysis showed significant increases in mean intelligibility rates from 68.9% at pre-test to 82.5% at posttest. Metered and patterned cuing produced similar intelligibility results (i.e., metered: 81.2%; patterned: 83.6%). Thaut et al. (2001) make a distinction among the severity of deficits and improvements in intelligibility. The severely affected speakers (i.e., baseline intelligibility less than 60%) increased intelligibility from a mean of 44.2% to 85.1%. The moderately affected speakers (i.e., baseline intelligibility between 60% and 80%) improved non-significantly from 70.1% to 77.8% intelligibility. The mildly affected speakers (i.e., baseline intelligibility between 80% and 90%) showed no improvement in response to RSC with a pre-test value of 84.8% decreasing to 83.9% for post-test. Results indicate metered cuing reduced speech
intelligibility in the mildly affected speakers while patterned cuing yielded better, but not significant results. Metered speech cuing showed to be most effective in the treatment of severely impaired speakers.

The results of this study imply that temporally constraining techniques such as metered cuing appear to benefit severe intelligibility deficits more than milder impairments. Thaut et al. (2001) state higher levels of speech functioning may benefit more from other therapeutic techniques that are not as rigid and constraining as metered cuing. The authors note that in both experimental conditions, a decrease in speech intelligibility resulted from speaking at 80% of habitual speech rates. The authors propose that in rhythmic cuing, optimal levels of speech intelligibility can occur at the habitual speech rate and at rates that are considerably different from habitual speech rates (i.e., 60%). When modifying speech rates with external cues at frequencies that are only slightly different from intrinsic values, the closeness of the two frequencies may generate an interference effect. This interference effect involves the attractor function of a natural speech rhythm oscillator and decreases the precision of speech motor output. Speech rate modification techniques should not utilize frequencies in close proximity to intrinsic rates in order to avoid possible entrainment interference.

Yorkston, Hammen, Beukelman, and Traynor (1990) also observed the immediate effects of the modification of rate on dysarthric speech. Eight participants whose sentence intelligibility was less than 90% took part in the study. Four participants presented with hypokinetic dysarthria as a result of PD, 2 with ataxic dysarthria, and 2 with mixed dysarthria with a component of ataxic dysarthria. Additionally, four healthy individuals
with no history of neurologic disorders served as controls for the rating of speech naturalness.

Speech naturalness, phoneme intelligibility, and sentence intelligibility were observed after four treatment conditions utilizing various visual and auditory cuing methods. For each condition, participants spoke at their habitual rate as well as at 80% and 60% of their habitual rate. Data were analyzed to show which treatment conditions (i.e., metered or patterned) were most effective. Only data from the 60% condition were selected for analysis because the largest changes in intelligibility scores were noted in this condition. In both visual and auditory modalities, metered conditions produced higher mean sentence intelligibility for both groups over patterned conditions.

In conclusion, the slowing in speech rate of severely affected dysarthric speakers by Yorkston et al. (1990) resulted in improvements in sentence intelligibility for both ataxic and hypokinetic groups. Evidence from this research indicates metered pacing is most effective in increasing sentence intelligibility in severely affected dysarthric speakers. Although metered strategies were deemed to be slightly less natural than habitual speech, the authors note this issue as insignificant due to the already severely disturbed speech of dysarthric speakers.

**The long-term effect of rhythm on speech rate.** In a related yet more long-term study, Yorkston and Beukelman (1981b) observed the effects of treatment based on intelligibility and prosodic considerations in four patients with ataxic dysarthria. Speech intelligibility scores in all cases were less than 30% and excessively hypernasal. Speech treatment was initiated from two to six weeks post injury onset and commenced eight to ten months post injury onset.
During the treatment phase, differing rigid rate control techniques were used with each patient. An alphabet board was used which required pointing to the first letter of each word as it was spoken. This method slowed down the speaker’s rate and provided extra information in the formation of the initial letter of each word. A pacing board was also used in which the speaker pointed to each word as it was spoken. Patterned cuing was later used as a means of transition from the rigid rate control techniques to each patient’s self-monitored speech. This method consisted of the clinician reading a passage and imposing a slower rate with appropriate pausing and phrasing. This transitional step resulted in speech with more natural prosody than the “one-word-at-a-time” rigid control methods previously used in this research.

During the course of treatment, clinicians utilized an additional procedure of rate monitoring with feedback of intelligibility. As a result of this procedure, the authors noted a substantial improvement in the ability of the patients to monitor their own speech rates. The monitoring process involved three stages. Initially, the patients were minimally aware of the consequences of rates that were too quick for adequate target intelligibility. The clinician had to impose the rate control at this stage. In the next stage, patients showed voluntary control as they began to recognize excessively fast rates during treatment activities. The final stage involved control of speaking rate being generalized to other speaking situations. The authors noted at the time of discharge that some patients were not able to increase their rate beyond the point at which they could maintain target intelligibility. This research shows the positive influence of rigid rate control techniques in increasing intelligibility in patients with ataxic dysarthria and the importance of self-monitoring.
In an earlier long-term study, Simmons (1978) observed another form of rate and rhythm control on a patient with aphasic and apraxic speech via the use of a finger counting task. The finger counting task consisted of producing each word in a simple sentence while concurrently raising a finger as each word was produced. Additionally, stimulus cards with the words written on them were utilized during the study. First, the clinician said a sentence and raised one finger (i.e., as in counting) while the participant watched. Then, the clinician modeled the sentence production paired with the finger counting and the participant joined the clinician in unison production of the sentences. Clinician modeling was eventually reduced to mouthing as the participant continued to produce the sentences on her own. Finally, the participant answered related questions using finger counting. The finger counting was incorporated into other therapy tasks, including simple imitation and sentence formulation.

Results of the finger counting task indicated an increase of 21 percentile points in intelligibility scores on the Porch Index of Communicative Ability (PICA). Simmons (1978) hypothesized that the addition of a cue (i.e., finger counting) resulted in an intersystemic reorganization of the speech process. Intersystemic reorganization involves incorporating a behavior (i.e., finger counting) into the performance of an act (i.e., speaking) that was not previously integral to the successful performance of the act. In this case, speech was reorganized and became functional as a result of being paired with finger counting. These results show the positive influence of rhythm upon disturbed speech patterns resulting from apraxia and aphasia.

The effects of rate and rhythm on the accuracy of speech in a patient with apraxia and aphasia were also of interest to Wambaugh and Martinez (2000). The participant
presented with slow rate, an inability to increase rate while maintaining phonemic integrity, numerous sound distortions, and frequent errors in words of increasing length. The task required the participant to produce one syllable of a three syllable word per beat while tapping his hand in unison with a metronome. Clinician participation was eventually faded out and the rate of speech was gradually increased to a more normal rate.

Results indicated an increase from baseline data to final evaluation for correct production of words and correct production of consonants. Improvements in articulation and fluency were also observed after rate modification methods were employed. The authors hypothesize the improvements in speech production were facilitated by the metronome and hand-tapping cues. Both forms of cuing provided a temporal patterning needed for accurate speech production and may have resulted in more efficient and effective motor planning. Wambaugh and Martinez (2000) speculate more efficient motor planning arises from a facilitation of functioning in internal oscillatory mechanisms such as CPGs. The authors explain that the importance of CPGs lies in the perception of time as well as in the control of timing of skilled movements (i.e., speech production). The treatment used in this study was a form of entrainment to an external stimulus. Wambaugh and Martinez (2000) speculate the entrainment may have operated to reset the central oscillator or to have strengthened its response to stimulation.

Summary of Related Literature

Speech production timing mechanisms are similar to those involved in the coordination of other motor systems (i.e., gross and fine motor control). Input and output structures of the basal ganglia form pathways that are critical to the planning, initiation,
and coordination of purposeful movement. The basal ganglia play a crucial role in the timing of speech articulators which determine speech rate and directly affect speech intelligibility. Due to basal ganglia dysfunction in PD, patients may experience deficiencies in the timing of speech articulators resulting in hypokinetic dysarthria.

Hypokinetic dysarthria is the result of diminished levels of the neurotransmitter dopamine in the basal ganglia. It is most frequently associated with PD, in which decreased levels of dopamine disrupt the motor feedback loop resulting in dysfluent speech output. Hypokinetic dysarthria imposes negative effects on all aspects of speech, but mostly on prosody, phonation, and articulation. A disordered speech rate, most typically short rushes of speech, is most frequently observed in patients with hypokinetic dysarthria. Disturbed speech rate is the most outstanding feature of the disorder. The inability of the basal ganglia to inhibit unwanted movements or to produce desired movements makes the coordination of speech articulators difficult for hypokinetic dysarthric speakers.

Improvements in the timing of speech and increases in intelligibility have been observed in patients with hypokinetic dysarthria with the use of rhythm. Metered cuing, consisting of hand-tapping and metronome cue, has been shown to be most effective in the treatment of severely disturbed speech rate in comparison to other pacing conditions (Pilon et al., 1998; Thaut et al., 2001; Wambaugh & Martinez, 2000). This effect is likely due to activations in the basal ganglia in the presence of simple, predictable rhythms which are utilized in metered cuing (Grahn & Brett, 2007). Additional support is provided by Penhune et al. (1998) who show activation of the left globus pallidus (i.e.,
output structure of the basal ganglia) during the reproduction (i.e., finger tapping) of isochronous rhythmic sequences.

Thaut et al. (2001) propose that rhythm acts as a zeitgeiber, or external timekeeper, which re-sets internal oscillators when neurological damage is evident. The authors speculate the use of hand-tapping or finger counting helps to reinforce the zeitgeiber (i.e., rhythmic cue) that entrains with internal timing oscillators, such as central pattern generators. Use of a physical gesture to facilitate this intersystemic reorganization has also been observed by Simmons (1978) and during various pacing conditions (Wambaugh & Martinez, 2000; Yorkston & Beukelman, 1981b). As a result, coordination of speech timing mechanisms are facilitated by the zeitgeiber, despite dysfunction in neural structures involved in initiating, sequencing, and timing of movements (i.e., basal ganglia).

Speaking at 60% of an individual’s habitual speech rate was observed to be more effective than speaking at 80% in the treatment of severely affected dysarthric speech (Yorkston et al., 1990; Thaut et al., 2001). This finding may be due to 80% of the habitual speech rate being too close to intrinsic speech rates. As previously noted, Thaut et al. (2001) note speech modification techniques should not utilize frequencies in close proximity to intrinsic rates in order to avoid possible entrainment interference. In sum, speaking at 60% of the individual’s habitual speech rate was shown to be most effective in the rehabilitation of severely dysarthric speech. The addition of a metronome cue (i.e., external cue) and hand-tapping (i.e., a cue to reinforce the zeitgeiber) make Rhythmic Speech Cuing a viable treatment option for patients with severe hypokinetic dysarthria.
**Research questions.** The purpose of the present study will be to investigate a treatment effect of Rhythmic Speech Cuing on intelligibility in patients with hypokinetic dysarthria due to Parkinson’s disease. The treatment will utilize both a metronome cue at 60% of each patient’s habitual speech rate and a physical gesture (i.e., hand-tapping). The following research questions will be addressed during the present study:

Will participation in a Rhythmic Speech Cuing program influence:

1) Percentage of intelligible words?
2) Speaking rate (duration and words per minute, or WPM)?
3) Number of intelligible words per minute (IWPM)?
4) Number of unintelligible words per minute (UWPM)?
5) The difference between rate of intelligible speech in patients with PD compared to typical speakers (communication efficiency ratio or CER)?
6) Intelligibility of spontaneous speech (intelligible words and content of speech)?
Chapter Three

Method

Participants. Participants were recruited from various support groups for Parkinson’s disease (PD) in the Miami area, by means of the distribution of flyers (See Appendix A), attending support group meetings, and speaking with the prospective participants. Both genders and all ethnic backgrounds were invited to participate in this study. The age range of the recruited participants was from 50 to 85 years old. Participants were recruited by means of self-reported diagnoses of speech deficiencies resulting from PD. Speech deficiencies were most likely the result of hypokinetic dysarthria, which is frequently observed in patients with PD.

Hypokinetic dysarthria negatively affects all aspects of speech production; however, most deficiencies are exhibited in prosody, phonation, and articulation (Kent, 2005). More specifically, characteristics observed in hypokinetic dysarthria include monopitch, harsh voice quality, imprecise voiced consonants, monoloudness, low pitch, inappropriate silences, variable rate, breathy voice, reduced stress, and short rushes. Additionally, a decline in speech intelligibility is a prominent feature of hypokinetic dysarthria and is largely the result of disturbed speech rate. Some, if not all, of the aforementioned features of hypokinetic dysarthria were observed in each participant. Despite these observations, a diagnosis of hypokinetic dysarthria could not be confirmed since the researcher did not have access to medical records. Informed consent was obtained prior to participation.
Per self-report, participants did not have any diagnosis of a co-morbid mental disorder. Participants were proficient in speaking and reading English and had adequate hearing and vision as well as the ability to read out loud and follow verbal directions. Each participant was required to be on dopaminergic medication to control for the symptoms of PD and did not undergo a change in medication while involved in this investigation.

Prior to enrollment in this investigation, each participant was required to partake in a screening procedure. The screening procedure consisted of an assessment of speech intelligibility which utilized the “Speech Intelligibility Inventory: Self-Assessment Form” (Kent, 1994) (See Appendix B). The assessment was completed by the participants and their primary caregiver prior to enrollment in the study. Completion of the assessment was done with the intention of identifying more severely affected speakers. Evidence from extant research by Pilon et al. (1998) as well as Thaut et al. (2001) identified more severely affected speakers as most likely to benefit from this type of rigid rate control protocol. The assessment was administered in person by the researcher in each participant’s home. The participant’s ability to hand-tap with an auditory cue was also assessed at this time.

The intelligibility assessment is comprised of 21 items which determine the degree of intelligibility in various circumstances of daily life and one item regarding an overall rating for speech intelligibility. The data were translated into numeric scores as follows: “always” = 1, “often” = 2, “sometimes” = 3, “seldom” = 4, and “never” = 5. A score of 21 to 63 on each the self-assessment and caregiver assessments met criteria for participation in this investigation. Scores in this range placed the majority of the
assessment items in the “always,” “often,” and “sometimes” categories which implied a lower level of intelligibility.

In an earlier study, Haneishi (2001) determined test-retest reliability for Kent’s speech intelligibility assessment. In her study, each caregiver was required to complete the assessment form one week prior to treatment and at the initiation of the first treatment session. Reliability between the two administrations of the speech intelligibility assessment was determined by the calculation of a correlation coefficient between the two test scores. The result was $r = .90$, which indicates high reliability.

**Materials.** The Assessment of Intelligibility of Dysarthric Speech (AIDS) (Yorkston & Beukelman, 1981a) is comprised of two assessment sections, one for word intelligibility and another for sentence intelligibility. Only the portion for sentence intelligibility was used in the present research. In the AIDS, sentences are grouped into sets according to the number of words contained in each sentence. Sentences may contain 5 to 15 words. Each set contains 100 different sentences. All sentences used in the AIDS are selected from adult level reading material. Each sentence has the following characteristics: (1) phrases and sentences contain 5 to 15 words with contractions counted as a single word, (2) words are chosen from 30,000 most frequently occurring words (Thorndike & Lorge, 1944), and (3) phrases and sentences contain no quotations, parenthesis, proper names, hyphenated words, or numbers larger than 10. A total of 1,100 sentences are available through the AIDS.

The AIDS and a picture description task (PDT) were used to collect data. Sentence samples from the AIDS were generated by randomly choosing two sentences from each sentence length set using the random numbers table supplied with the AIDS.
This procedure resulted in three sample sets containing 22 sentences each, and each set included a total of 220 words. The sentences used during testing were the 22 sentences contained in the sample sets. A different sample set was used for each testing session in order to avoid participant familiarity with any of the sentences. While a different sample set was used in each testing session, sets were consistent across all participants.

Reliability for the sentences used in the AIDS, not the test itself, was determined using data from a study done by Beukelman and Yorkston (1977). Interjudge reliability, intersample reliability, and intrajudge correlations were assessed by calculating Pearson product-moment correlations. Interjudge reliability was defined as pairs of judges listening to identical speech samples spoken by 13 different individuals with dysarthria. The correlation coefficient for intelligibility of these data ranged from .93 to .99 and was consistently .99 for the rate of intelligible speech or intelligible words per minute (IWPM). Intersample reliability was defined as different judges listening to different samples all spoken by the same dysarthric speaker. The correlation coefficient for intelligibility of these data ranged from .92 to .99 and was .98 to .99 for rate of intelligible speech (IWPM). Intrajudge (within judge) correlations were defined as the same judges judging different samples. The correlation coefficient for intelligibility of these data ranged from .96 to .99 and was consistently .99 for rate of intelligible speech (IWPM).

Data for spontaneous speech generation were collected using a picture description task (PDT). Participants were asked to describe in 3 to 5 sentences what they saw on a color photograph (See Appendix C). A different photograph, depicting an everyday scenario, was used in each testing session, but was consistent across all participants.
**Equipment.** The recorder used to gather speech data in this study was an ICD-UX200 Stereo Digital Voice Recorder manufactured by Sony. The metronome used to provide rhythmic cuing was a Boss Dr. Beat DB-88.

**Design and variables.** The design used in the current research was a Repeated-Measures design. A repeated-measures design refers to a research situation that involves a group of participants who have undergone the same treatment condition and are observed at two or more testing times (Gravetter & Wallnau, 2008). The dependent variables in the current study were: duration, words per minute (WPM), intelligible words per minute (IWPM), unintelligible words per minute (UWPM) and communication efficiency ratio (CER). Additionally, values for intelligible words and content of speech were observed.

**Procedure.** All testing and treatment sessions took place in the participants’ homes over a four-week period. Participants who met inclusionary criteria from screening were enrolled in the study. Upon enrollment, participants completed informed consent, audio consent, and a demographics questionnaire (See Appendices D, E, & F). Five individuals participated in the present research and received treatment in the form of Rhythmic Speech Cuing (RSC). Three treatment sessions were given each week of the 4-week period for a total of 12 sessions. A pre-test took place prior to treatment, a mid-test occurred two weeks into treatment, and a post-test was administered within one week after treatment was completed (See Table 1). All tests consisted of the AIDS and the PDT.

Administration of the AIDS and PDT during testing sessions lasted approximately 20 minutes for each participant. During the AIDS, each participant was
asked to speak a total of 22 sentences (i.e., 220 words) in each testing session. The researcher first indicated the sentence that was to be read by pointing to the sentence. Second, the researcher read the sentence aloud one time and instructed the participant to look at the sentence as it was being read. This process insured intelligibility was not reduced by the participant misreading the sentences or because of reading difficulties. Third, the researcher recorded each participant as they read each sentence aloud. If any portion of the sentence was read incorrectly (i.e., words were incorrect), the researcher re-recorded the entire sentence and erased the original attempt. Recordings of the AIDS were then randomly assigned to judges for assessing.

Table 1

*Time Line of Participant Activities*

<table>
<thead>
<tr>
<th>Participant #</th>
<th>Pre-test</th>
<th>Week 1</th>
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<th>Mid-test</th>
<th>Week 3</th>
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*Note.* * = testing sessions; X = treatment (3 sessions per week)

Judges for the AIDS test were two undergraduate students from a private university in Coral Gables, Florida. Random assigning of samples was used to control for judges becoming familiar with any one participant’s speech. The judges were instructed to listen to each sentence in its entirety one time and then a second time, only stopping when it was necessary to transcribe each word onto a scoring sheet. The scoring sheets
used by the judges for transcription were supplied with the AIDS (See Appendix G). Transcriptions were then given to the researcher for scoring.

The researcher used a key to score the transcriptions. Each key was created prior to each session and contained the sentences used in each testing session. During scoring, all incorrectly transcribed words were marked out. The total of correctly and incorrectly transcribed words was tallied. The researcher also measured the duration of the sample (i.e., total speaking time) in seconds, then converted that value to minutes. Only the duration of the participant’s speaking time was measured. Intersentence pauses were not included in the total time; however, pauses that took place within sentences (intrasentence pauses) were included in total duration. In addition to duration of the samples, other values were calculated. These values included words per minute (WPM, or rate of speech), percentage of intelligible speech, and communication efficiency ratio (CER). Additional values of rate of intelligible speech (IWPM) and rate of unintelligible speech (UWPM) were also tabulated.

Each value was calculated given formulas which were included in the AIDS (Yorkston & Beukelman, 1981a). The number of words correctly transcribed by each judge was divided by the total number of words possible (220) and resulted in the percentage of intelligible speech. WPM was calculated by dividing the total number of words (220) by the duration of the sample in minutes. IWPM was obtained by dividing the number of correctly transcribed words by the total duration of the sample. UWPM was obtained by dividing the number of unintelligible words by the total time of the sample. CER was calculated by dividing IWPM by the mean rate of intelligible speech produced by typical speakers (i.e., 190 WPM).
Prior to the scoring of all samples, three AIDS recordings were randomly selected by the researcher. All three recordings were separately scored by each judge and by the researcher, and percent agreement was used to establish interrater reliability (Huck, 2008). Percent agreement was tabulated by calculating the number of items both judges agreed upon. The number of agreed-upon items was then divided by the sum of agreed-upon items plus disagreed-upon items. The three agreement values, 99%, 97%, and 77%, produced an average reliability of 91% which indicated a high level of agreement between judges.

Different judges were selected to evaluate recordings made of the PDT. The judges were comprised of one undergraduate student and one graduate student from the previously mentioned private university in Coral Gables, Florida. Recorded speech samples for the PDT were randomly assigned to the judges to control for familiarity with any one participant’s speech. The judges were instructed to listen to each sample two times in its entirety then give two subjective ratings (See Appendix H).

The judges were asked to first rate each recording based on the number of intelligible words. The rating scale for number of intelligible words consisted of the following:

0 = “no words”
1 = “very few words”
2 = “some words”
3 = “most words”
4 = “all words”
The judges were then asked to rate each recording based on how well they understood the content of each speech sample. The rating scale for content of the speech sample was comprised of the following:

0 = “I have no idea what this person is describing.”

1 = “I’m struggling to understand what this person is describing. For example, I can detect certain words, but I don’t know how they are related.”

2 = “I have a basic idea of what this person is saying, but I need more details in order to put the words together in a context.”

3 = “I have a good idea of what this person is describing, but additional details would help form a more clear idea.”

4 = “I understand perfectly what this person is describing.”

Prior to the scoring of all samples, five PDT samples were randomly selected by the researcher. The five recordings were separately assessed by each judge to establish interrater reliability using the same procedure that was used for the AIDS. The number of items both judges agreed upon was calculated. The number of agreed upon items was then divided by the sum of agreed-upon items plus disagreed-upon items resulting in 90% agreement, thus indicating a high level of consistency between judges.

*Rhythmic speech cuing.* The procedure for Rhythmic Speech Cuing (RSC) that was used in treatment consisted of the following steps. First, the researcher read through each sentence out loud one time with hand-tapping and the metronome cue set at 60% of each participant’s habitual speech rate (i.e., rate of speech) in order to model what was expected. The participant watched, listened, and tapped along without speaking. 60% of each participant’s habitual speech rate was used per observations made by Thaut et al.
Results indicated that for patients with disturbed speech rate, improvements in speech intelligibility are most likely to occur at rates that are considerably different from habitual speech rates (i.e., 60%). For the purpose of clarity in this study, habitual speech rate (HSR) will be referred to as rate of speech and accounted for in words per minute (WPM).

Second, the participant joined the researcher in reading each sentence out loud one time with hand-tapping and the metronome cue. Then, the participant spoke the sentence two times with the metronome cue and hand-tapping, but without researcher modeling. Next, the participant spoke each sentence one time with metronome cuing, but the researcher faded the cuing half-way through each sentence. To conclude the metered cuing and fading portion of the treatment, the participant spoke each sentence one time with no cuing.

Sentences used in treatment were also randomly selected from the AIDS test, but were different from the sentences used in testing. Each approximately 25-minute individual treatment session consisted of two portions: metered cuing with fading (20 minutes) and conversational speech (3 to 5 minutes). In metered cuing, the therapist equates rhythmic beats to syllables resulting in equal syllable length across a spoken phrase (Thaut, 2005). Metered cuing does not maintain normal qualities of speech inflection, but does enhance speech intelligibility for more severely impaired speakers (See Figure 1).
1. Metered (Metric) Cuing: Each syllable gets equal duration

I want to eat a cook - ie

♩ ♩ ♩ ♩ ♩ ♩ ♩ ♩

2. Patterned Cuing: Maintains the rhythm of typical speech

I want to eat a cook - ie

♩ ♩ ♩ ♩ ♩ ♩ ♩ ♩

*Figure 1. Metered versus patterned cuing*

During the metered cuing and fading portion, experimental sentences from the AIDS (Yorkston & Beukelman, 1981a) were read by the participants at 60% of their habitual speech rate. A total of 22 sentences were attempted during each treatment session. Two sentences from each category of sentences containing 5 to 15 words were used. Participants began with sentences containing 5 words and progressed to sentences containing 15 words. The final portion of each treatment session focused on the transfer of skill to conversational speech. Participants were asked a series of questions on a given topic. The topics varied and included some aspect of their lives (i.e., how they met their spouse, a favorite memory, sports, etc.). The participant engaged in a 3 to 5 minute conversation with the researcher on the given topic. During this portion of treatment, the researcher prompted each participant with open-ended questions pertaining to the given topic (i.e., “Where/how did you meet your spouse?”, “What happened with your football team during this week’s game?”, etc.).
Chapter Four

Results

This chapter will describe results obtained from data collection and the statistical analyses conducted on the data. Descriptive and inferential results from the statistical analyses will be provided for each of the six research questions. The analyses were performed utilizing the Statistical Package for the Social Sciences (SPSS) version 20.0. Prior to showing the results from the analyses, a brief review of the protocol will be discussed.

Participants

Five individuals diagnosed with idiopathic Parkinson’s disease (PD) and self-reported diagnoses of speech deficiencies resulting from PD participated in the present research (See Table 2). Four out of five participants were male and the age of the participants ranged from 55 to 84 years of age with a mean age of 71.6 years. The average age of at the time of diagnosis was 65 years and ranged from 49 to 78 years of age. All participants were right hand dominant. Side of disease onset was the right side for all male participants. The female participant and one male reported their left side currently being most affected, while two other participants reported their right side being most affected. One participant reported being equally affected bilaterally. Time on medication ranged from 4 months to 10 years with an average time of 6.3 years.

In an effort to identify patients with severe speech deficiencies the Speech Intelligibility Inventory: Self-Assessment Form (Kent, 1994) was completed by both the patient and his/her primary caregiver. A score of 21 to 63 on each of the self-assessments and caregiver assessments was believed to indicate more severely impaired speech.
### Table 2

**Demographics of Participants**

<table>
<thead>
<tr>
<th>Participant</th>
<th>Sex</th>
<th>Age</th>
<th>Age at Diagnosis</th>
<th>Side of Onset</th>
<th>Side More Affected</th>
<th>Dominant Hand</th>
<th>Time on Medication</th>
<th>Participant Speech Intelligibility Assessment Score*</th>
<th>Caregiver Speech Intelligibility Assessment Score*</th>
<th>Percent Agreement for Speech Intelligibility Assessment Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>80</td>
<td>70</td>
<td>Right</td>
<td>Right</td>
<td>Right</td>
<td>10 years</td>
<td>33</td>
<td>43</td>
<td>77%</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>55</td>
<td>49</td>
<td>Right</td>
<td>Both</td>
<td>Right</td>
<td>6 years</td>
<td>41</td>
<td>49</td>
<td>84%</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>84</td>
<td>78</td>
<td>Left</td>
<td>Left</td>
<td>Right</td>
<td>6 years</td>
<td>44</td>
<td>44</td>
<td>100%</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>81</td>
<td>72</td>
<td>Right</td>
<td>Left</td>
<td>Right</td>
<td>9 years</td>
<td>50</td>
<td>35</td>
<td>70%</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>58</td>
<td>56</td>
<td>Right</td>
<td>Right</td>
<td>Right</td>
<td>4 months</td>
<td>57</td>
<td>21</td>
<td>37%</td>
</tr>
</tbody>
</table>

*Note. Possible scores on this assessment ranged from 21 to 105. Lower scores (21 to 63) indicate a lower level of speech intelligibility.
Participant self-assessment scores ranged from 33 to 57 with a mean score of 45, while caregiver assessment scores ranged from 21 to 49 with a mean score of 38.4. The percent agreement between self and caregiver assessments ranged from 37% to 100% with an average agreement of 73.6%. The observed speech deficiencies were most likely the result of hypokinetic dysarthria which is frequently observed in patients with PD. Various features of hypokinetic dysarthria were observed in each participant, however, a formal diagnosis could not be made since the researcher did not have access to medical records.

Each participant received 12 treatment sessions of Rhythmic Speech Cuing (RSC) over a 4-week period. Data were collected during three testing sessions: pre-, mid-, and post-test.

Each 20-minute testing session consisted of each participant speaking a total of 22 sentences (i.e., 220 words) from the Assessment of Intelligibility of Dysarthric Speech (AIDS) (Yorkston & Beukelman, 1981a) at their own preferred pace with no cuing. A picture description task (PDT) in which participants reported what they observed in a color picture depicting an everyday scenario was also utilized. Each 25-minute treatment session consisted of metered cuing with fading (for 20 minutes) and conversational speech (for 3 to 5 minutes). Data were collected solely at the three testing time points. Values for intelligible speech, rate (duration and words per minute, or WPM), and intelligible words per minute (IWPM), were calculated with the instructions given via the Assessment of Dysarthric Speech (AIDS) (Yorkston & Beukelman, 1981a). Unintelligible words per minute (UWPM) and communication efficiency ratio (CER) were also observed via the AIDS. Additionally, values for intelligible words and content of speech as related to spontaneous speech were obtained via the PDT. The following
sections show the statistical results obtained from the analyses of each dependent variable.

A one-way repeated measures analysis of variance (ANOVA) was conducted on each dependent variable in order to investigate the effect of a RSC program on speech deficiencies in patients with PD. Prior to running each ANOVA, the three basic assumptions of homogeneity of variance, multivariate normality, and sphericity associated with using one-way repeated measures ANOVAs were examined. Homogeneity of variance was satisfied by utilizing equal sample sizes at each testing time point. Multivariate normality was examined by looking at the univariate normality of each dependent variable. Normality was met to the degree that could be expected given the limitation of a small sample size. The most important assumption of sphericity was made prior to interpreting any models using Mauchly’s Test of Sphericity. When sphericity was violated, effects were interpreted based on the Huynh-Feldt correction. When not violated, sphericity was assumed.

Effect sizes were also examined using Partial Eta Squared ($\eta^2_p$). Effect sizes for $\eta^2_p$ when comparing means across all testing times were interpreted by using the following criteria: .01 = small effect, .06 = medium effect, and .14 = large effect. Additionally, pairwise comparisons were made for each set of means: pre- to mid, mid- to post, and pre- to post-test. Each set of means comparisons was reported as a change score ($M_C$). A change score refers to the difference in scores between two testing time points that are under the same testing condition (Bonate, 2000). The two means used to determine change scores were examined according to Cohen’s $d$ and interpreted using the
following criteria: .20 = small effect, .50 = medium effect, and .80 = large effect (Huck, 2008b).

**Raw data.** Due to small sample size, presentation of the raw data is beneficial for interpretation of the results. Table 3 displays data for each participant at the three testing time points as measured by the Assessment of Dysarthric Speech Test (AIDS). Table 4 presents data for each participant at the three testing time points as measured by a Picture Description Task (PDT).

Each participant demonstrated change differently over time. Percentage of intelligible speech increased from pre- to post-test for Participants 1 and 4, decreased in two other participants (i.e., 2 and 3), and remained the same for Participant 5. IWPM decreased for Participants 2, 3, and 4 from pre- to mid-test, yet each showed an increase from mid- to post-test. Additionally, UWPM decreased in three out of five participants (i.e., 1, 4, and 5) from pre- to post-test, while values increased for Participants 2 and 3. The data also showed an increase in CER from pre- to post-test for Participants 1 and 4, but decreased for Participants 2, 3, and 5.

Among the five participants, data in Table 3 indicate that Participant 1 showed the most improvement across the testing time points, specifically from pre- to mid-test. During this time, percentage of intelligible speech, words per minute (WPM), intelligible words per minute (IWPM), and communication efficiency ratio (CER) increased. At the same time, unintelligible words per minute (UWPM) and duration of speech sample decreased. Participant 1 also made a large increase in WPM from pre- to post-test.
Table 3

*Raw Data for Each Participant as Measured by the Assessment of Intelligibility of Dysarthric Speech Test*

<table>
<thead>
<tr>
<th>Participant</th>
<th>Variable</th>
<th>Pre-test</th>
<th>Mid-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Percentage of Intelligible Speech</td>
<td>65%</td>
<td>96%</td>
<td>89%</td>
</tr>
<tr>
<td>1</td>
<td>Duration of Speech Sample (minutes)</td>
<td>5.5</td>
<td>3.73</td>
<td>3.6</td>
</tr>
<tr>
<td>1</td>
<td>Words per Minute</td>
<td>40</td>
<td>58</td>
<td>61</td>
</tr>
<tr>
<td>1</td>
<td>Intelligible Words per Minute</td>
<td>26</td>
<td>56</td>
<td>55</td>
</tr>
<tr>
<td>1</td>
<td>Unintelligible Words per Minute</td>
<td>14</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>1</td>
<td>Communication Efficiency Ratio</td>
<td>0.14</td>
<td>0.29</td>
<td>0.28</td>
</tr>
<tr>
<td>2</td>
<td>Percentage of Intelligible Speech</td>
<td>98%</td>
<td>95%</td>
<td>91%</td>
</tr>
<tr>
<td>2</td>
<td>Duration of Speech Sample (minutes)</td>
<td>1.48</td>
<td>1.55</td>
<td>1.45</td>
</tr>
<tr>
<td>2</td>
<td>Words per Minute</td>
<td>148</td>
<td>141</td>
<td>151</td>
</tr>
<tr>
<td>2</td>
<td>Intelligible Words per Minute</td>
<td>146</td>
<td>134</td>
<td>138</td>
</tr>
<tr>
<td>2</td>
<td>Unintelligible Words per Minute</td>
<td>2</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>2</td>
<td>Communication Efficiency Ratio</td>
<td>0.76</td>
<td>0.71</td>
<td>0.73</td>
</tr>
<tr>
<td>3</td>
<td>Percentage of Intelligible Speech</td>
<td>98%</td>
<td>97%</td>
<td>96%</td>
</tr>
<tr>
<td>3</td>
<td>Duration of Speech Sample (minutes)</td>
<td>1.45</td>
<td>1.72</td>
<td>1.48</td>
</tr>
<tr>
<td>3</td>
<td>Words per Minute</td>
<td>151</td>
<td>127</td>
<td>148</td>
</tr>
<tr>
<td>3</td>
<td>Intelligible Words per Minute</td>
<td>148</td>
<td>123</td>
<td>142</td>
</tr>
<tr>
<td>3</td>
<td>Unintelligible Words per Minute</td>
<td>3</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>Communication Efficiency Ratio</td>
<td>0.78</td>
<td>0.65</td>
<td>0.75</td>
</tr>
<tr>
<td>4</td>
<td>Percentage of Intelligible Speech</td>
<td>97%</td>
<td>99%</td>
<td>99%</td>
</tr>
<tr>
<td>4</td>
<td>Duration of Speech Sample (minutes)</td>
<td>2.23</td>
<td>2.47</td>
<td>2.27</td>
</tr>
<tr>
<td>4</td>
<td>Words per Minute</td>
<td>98</td>
<td>89</td>
<td>96</td>
</tr>
<tr>
<td>4</td>
<td>Intelligible Words per Minute</td>
<td>95</td>
<td>88</td>
<td>96</td>
</tr>
<tr>
<td>4</td>
<td>Unintelligible Words per Minute</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Communication Efficiency Ratio</td>
<td>0.5</td>
<td>0.46</td>
<td>0.51</td>
</tr>
<tr>
<td>Participant</td>
<td>Variable</td>
<td>Pre-test</td>
<td>Mid-test</td>
<td>Post-test</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------------------------------------</td>
<td>----------</td>
<td>----------</td>
<td>-----------</td>
</tr>
<tr>
<td>5</td>
<td>Percentage of Intelligible Speech</td>
<td>99%</td>
<td>99%</td>
<td>99%</td>
</tr>
<tr>
<td></td>
<td>Duration of Speech Sample (minutes)</td>
<td>1.15</td>
<td>1.47</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>Words per Minute</td>
<td>191</td>
<td>149</td>
<td>146</td>
</tr>
<tr>
<td></td>
<td>Intelligible Words per Minute</td>
<td>189</td>
<td>147</td>
<td>146</td>
</tr>
<tr>
<td></td>
<td>Unintelligible Words per Minute</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Communication Efficiency Ratio</td>
<td>0.99</td>
<td>0.77</td>
<td>0.77</td>
</tr>
<tr>
<td>Participant</td>
<td>Variable</td>
<td>Pre-test</td>
<td>Mid-test</td>
<td>Post-test</td>
</tr>
<tr>
<td>-------------</td>
<td>-------------------</td>
<td>----------</td>
<td>----------</td>
<td>-----------</td>
</tr>
<tr>
<td>1</td>
<td>Intelligible words</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Content of speech</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Intelligible words</td>
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<td></td>
<td>Content of speech</td>
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<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Intelligible words</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Content of speech</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Intelligible words</td>
<td>2</td>
<td>3</td>
<td>3</td>
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<tr>
<td></td>
<td>Content of speech</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>Intelligible words</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Content of speech</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

*Note.* Possible score range was 0 to 4.
Regarding responses to the PDT, Table 4 shows that scores for intelligible words increased for Participants 1 and 4 from pre- to post-test, while scores for Participants 2, 3, and 5 exhibited no change during that time. Intelligible words scores decreased for Participant 2 from pre- to mid-test, but increased from mid- to post-test. Data for content of speech reveal that four out of five participants (i.e., 1, 2, 3, and 4) increased their scores from pre- to post-test while Participant 5 showed no change in scores across the three testing times.

**Research Question 1: Will participation in a Rhythmic Speech Cuing (RSC) program influence percentage of intelligible speech in patients with PD?**

**Descriptive analysis.** Table 5 provides descriptive statistics for percentage of intelligible speech at the three testing time points. Intelligibility percentage was calculated using the number of words correctly transcribed by the judges in each sample divided by the total number of words spoken in each sample (i.e., 220). Mean intelligibility percentage for all participants at the pre-test was 91.40% \((SD = 14.77)\). At the mid-test, mean intelligibility percentage was 97.20% \((SD = 1.79)\) which was an increase of 5.80% from the pre-test. Post-test mean intelligibility percentage was 94.80% \((SD = 4.60)\) which was a decrease of 2.40% from the mid-test; however, this score was a 3.40% increase from the pre-test.

**Inferential analysis.** For the repeated measures ANOVA testing for the differences in percentage of intelligible speech across pre-, mid-, and post-test measures, the assumption of sphericity was violated (Mauchly’s \(W(2) = .071, p = .019\); See Table 6). With the Huynh-Feldt correction, the main effect of RSC on speech intelligibility percentage was not statistically significant, \(F(1.08, 4.30) = .72, p = .45\), but showed a
Table 5

*Means and Standard Deviations for the Dependent Variables as measured by the Assessment of Intelligibility of Dysarthric Speech*

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Pre-test Mean</th>
<th>Pre-test SD</th>
<th>Mid-test Mean</th>
<th>Mid-test SD</th>
<th>Post-test Mean</th>
<th>Post-test SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of intelligible speech</td>
<td>91.40%</td>
<td>14.77</td>
<td>97.20%</td>
<td>1.79</td>
<td>94.80%</td>
<td>4.60</td>
</tr>
<tr>
<td>Duration of speech sample (minutes)</td>
<td>2.36</td>
<td>1.80</td>
<td>2.19</td>
<td>0.95</td>
<td>2.06</td>
<td>0.93</td>
</tr>
<tr>
<td>Words per minute (WPM)</td>
<td>125.60</td>
<td>58.12</td>
<td>112.80</td>
<td>38.33</td>
<td>120.40</td>
<td>40.24</td>
</tr>
<tr>
<td>Intelligible words per minute (IWPM)</td>
<td>120.40</td>
<td>62.24</td>
<td>109.40</td>
<td>37.27</td>
<td>115.20</td>
<td>39.69</td>
</tr>
<tr>
<td>Unintelligible words per minute (UWPM)</td>
<td>4.80</td>
<td>5.17</td>
<td>3.20</td>
<td>2.39</td>
<td>5.00</td>
<td>5.39</td>
</tr>
<tr>
<td>Communication efficiency ratio (CER)</td>
<td>0.63</td>
<td>0.33</td>
<td>0.58</td>
<td>0.20</td>
<td>0.61</td>
<td>0.21</td>
</tr>
</tbody>
</table>
Table 6

Repeated Measures ANOVA Table for Dependent Variables as Measured by the Assessment of Dysarthric Speech Test

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
<th>$\eta^2_p$</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of intelligible speech</td>
<td>84.93</td>
<td>1.08</td>
<td>79.03</td>
<td>0.72</td>
<td>.452</td>
<td>0.15</td>
<td>0.10</td>
</tr>
<tr>
<td>Error</td>
<td>473.07</td>
<td>4.30</td>
<td>110.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>558.00</td>
<td>5.38</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration of speech sample (minutes)</td>
<td>0.23</td>
<td>1.04</td>
<td>0.22</td>
<td>0.42</td>
<td>.558</td>
<td>0.10</td>
<td>0.08</td>
</tr>
<tr>
<td>Error</td>
<td>2.18</td>
<td>4.16</td>
<td>0.52</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2.41</td>
<td>5.20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Words per minute</td>
<td>414.40</td>
<td>2.00</td>
<td>207.20</td>
<td>1.07</td>
<td>.387</td>
<td>0.21</td>
<td>0.18</td>
</tr>
<tr>
<td>Error</td>
<td>1548.93</td>
<td>8.00</td>
<td>193.62</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1963.33</td>
<td>10.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intelligible words per minute</td>
<td>302.80</td>
<td>2.00</td>
<td>151.40</td>
<td>0.65</td>
<td>.547</td>
<td>0.14</td>
<td>0.13</td>
</tr>
<tr>
<td>Error</td>
<td>1859.87</td>
<td>8.00</td>
<td>232.48</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2162.67</td>
<td>10.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unintelligible words per minute</td>
<td>9.73</td>
<td>2.00</td>
<td>4.87</td>
<td>0.28</td>
<td>.761</td>
<td>0.07</td>
<td>0.08</td>
</tr>
<tr>
<td>Error</td>
<td>137.60</td>
<td>8.00</td>
<td>17.20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>147.33</td>
<td>10.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication efficiency ratio</td>
<td>0.008</td>
<td>2.00</td>
<td>0.004</td>
<td>0.68</td>
<td>.535</td>
<td>0.15</td>
<td>0.13</td>
</tr>
<tr>
<td>Error</td>
<td>0.05</td>
<td>8.00</td>
<td>0.006</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>0.058</td>
<td>10.00</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

*p < .05
large effect size ($\eta^2_p = .15$) via Partial Eta Squared. Pairwise comparisons revealed an increase in mean differences from pre- to mid ($M_C = 5.80, p = .41, d = .55$), a decrease from mid- to post ($M_C = 2.40, p = .15, d = .69$), and an increase from pre- to post-test ($M_C = 3.40, p = .56, d = .31$). No mean differences for pairwise comparisons were statistically significant. Both pre- to mid and mid- to post comparisons showed medium effect sizes and pre- to post-test comparisons revealed a small effect size, as indicated by Cohen’s $d$.

**Research Question 2: Will participation in a RSC program influence rate of speech (duration and words per minute, or WPM) in patients with PD?**

**Descriptive analysis.** Table 5 provides descriptive statistics for speaking rate at the three testing time points. This research question was measured in two ways: duration of the speech sample (i.e., minutes spent speaking the 220 words) and words per minute (WPM). Mean duration of the speech sample at the pre-test was 2.36 minutes (SD = 1.80). At the mid-test, mean duration of the speech sample was 2.19 minutes (SD = 0.95) which was a decrease of 0.17 minutes from the pre-test. Post-test mean duration of the speech sample was 2.06 minutes (SD = 0.93) which was a decrease of 0.13 minutes from the mid-test as well as a decrease of 0.30 minutes from the pre-test.

WPM was obtained by dividing the total number of words per sample (i.e., 220) by the total duration of the speech sample. The pre-test mean was 125.60 WPM (SD = 58.12). Mean WPM at the mid-test was 112.80 WPM (SD = 38.33) which was a decrease of 12.8 words from the pre-test. At the post-test, mean WPM was 120.40 words (SD = 40.24) which indicated an increase of 5.2 words from the mid-test and a decrease of 5.2 words from the pre-test.
Inferential analysis. For the repeated measures ANOVA testing for differences in duration of the speech sample in the pre-, mid-, and post-test measures, the assumption of sphericity was violated (Mauchly’s $W(2) = .039, p = .008$; See Table 6). With the Huynh-Feldt correction, the main effect of RSC on duration of the speech sample was not statistically significant, $F(1.04, 4.16) = .42, p = .56$), but showed a medium effect size ($\eta^2_p = .10$) with Partial Eta Squared. Pairwise comparisons showed a decrease in mean differences from pre- to mid ($M_C = .17, p = .69, d = .12$), a decrease from mid- to post ($M_C = .13, p = .05, d = .14$), and a decrease from pre- to post-test ($M_C = .30, p = .50, d = .21$). No pairwise comparisons were statistically significant and all showed small effect sizes, according to Cohen’s $d$.

For the repeated measures ANOVA testing for the differences in WPM in the pre-, mid-, and post-test measures, the assumption of sphericity was met (Mauchly’s $W(2) = .35, p = .21$). The main effect of RSC on WPM was not statistically significant, $F(2, 8) = 1.07, p = .39$), but showed a large effect size ($\eta^2_p = .21$), per Partial Eta Squared. Pairwise comparisons exhibited a decrease in mean differences from pre- to mid ($M_C = 12.80, p=.27, d = .23$), an increase from mid- to post ($M_C = 7.60, p = .13, d = .07$), and a decrease from pre- to post-test ($M_C = 5.20, p=.66, d = .10$). No pairwise comparisons were statistically significant and small effect sizes were observed for each comparison, per Cohen’s $d$.

Research Question 3: Will participation in a RSC program influence the rate of intelligible speech (Intelligible Words per Minute or IWPM) in patients with PD?

Descriptive analysis. Table 5 provides descriptive statistics for intelligible words per minute (IWPM) at the three testing time points. IWPM was obtained by dividing the
number of words correctly transcribed by the judges in each sample by the total duration of the speech sample. Mean IWPM at the pre-test was 120.40 words (SD = 62.24) while mean IWPM at the mid-test was 109.40 words (SD = 37.27) which reflected a decrease of 11 words. At the post-test, mean IWPM was 115.20 (SD = 39.69) which indicated a 5.8 word increase from the mid-test, however, showed a 5.2 word decrease from the pre-test.

**Inferential analysis.** For the repeated measures ANOVA testing for the differences in IWPM in the pre-, mid-, and post-test measures, the assumption of sphericity was met (Mauchly’s W(2) = .28, p = .15; See Table 6). The main effect of RSC on IWPM was not statistically significant, F(2, 8) = .65, p = .55), but a large effect size was observed (η²_p = .14), according to Partial Eta Squared. Pairwise comparisons revealed a decrease in mean difference values from pre- to mid (M_C = 11, p = .40, d = .21), an increase from mid- to post (M_C = 5.80, p=.21, d = .15), and a decrease from pre-to post-test (M_C = 5.20, p = .67, d = .10). No pairwise comparisons were statistically significant and small effect sizes were observed for all comparisons, as revealed by Cohen’s d.

**Research Question 4: Will participation in a RSC program influence the rate of unintelligible speech (Unintelligible Words per Minute or UWPM) in patients with PD?**

**Descriptive analysis.** Table 5 provides descriptive statistics for unintelligible words per minute (UWPM) at the three testing time points. UWPM was obtained by dividing the number of unintelligible words transcribed by the judges in each sample by the total duration of the speech sample. Mean UWPM at the pre-test was 4.80 UWPM (SD = 5.17) and mean UWPM at the mid-test was 3.20 words (SD = 2.39), thus revealing
a decrease of 1.6 words. At the post-test, mean UWPM was 5.00 words (SD = 5.39) which was an increase of 1.8 words from the mid-test, and an increase of 0.20 words from the pre-test.

**Inferential analysis.** For the repeated measures ANOVA testing for the differences in UWPM in the pre-, mid-, and post-test measures, the assumption of sphericity was met (Mauchly’s W(2) = .51, p = .36; See Table 6). The main effect of RSC on UWPM was not statistically significant, $F(2, 8) = .28, p = .76$), yet a medium effect size was observed ($\eta^2_p = .07$) via Partial Eta Squared. Pairwise comparisons showed a decrease in mean differences from pre- to mid (MC = 1.60, $p = .60$, $d = .40$), an increase from mid- to post (MC = 1.80, $p = .30$, $d = .43$), and an increase from pre- to post-test (MC = .20, $p = .95$, $d = .04$). No pairwise comparisons yielded results that were statistically significant. All three effect sizes were small, per Cohen’s $d$.

**Research Question 5:** Will participation in a RSC program influence the difference between rate of intelligible speech in patients with PD compared to typical speakers (i.e., Communication Efficiency Ratio or CER)?

**Descriptive analysis.** Table 5 provides descriptive statistics for the Communication Efficiency Ratio (CER) at the three testing time points. Higher CER values (i.e., closer to 1.0) indicate higher functioning speech or more intelligible speech. Lower CER values indicate less intelligible speech as compared to typical speakers. CER was obtained by dividing IWPM by the mean rate of intelligible speech of typical speakers (i.e., 190 WPM) (Yorkston & Beukelman, 1981a). Mean CER at the pre-test was .63 (SD = 0.33). At the mid-test, mean CER was .58 (SD = 0.20) which was a
decrease of .05 from the pre-test. Post-test mean CER was .61 ($SD = 0.21$) which was an increase of .03 from the mid-test, however, was a decrease of .03 from the pre-test.

**Inferential analysis.** For the repeated measures ANOVA testing for the differences in CER in the pre-, mid-, and post-test measures, the assumption of sphericity was met (Mauchly’s $W(2) = .28$, $p = .15$; See Table 6). The main effect of RSC on CER was not statistically significant, $F(2, 8) = .68$, $p = .54$), however showed a large effect size ($\eta^2_p = .15$), according to Partial Eta Squared. Data for pairwise comparisons displayed a decrease in mean differences from pre- to mid ($M_C = .06$, $p = .40$, $d = .64$), an increase from mid- to post ($M_C = .03$, $p = .18$, $d = .16$), and a decrease from pre- to post-test ($M_C = .03$, $p = .68$, $d = .03$). No pairwise comparisons were statistically significant. A medium effect was observed pre- to mid while small effect sizes were displayed for mid- to post and pre- to post-test comparisons, per Cohen’s $d$.

**Research Question 6: Will participation in a RSC program influence the intelligibility of spontaneous speech in patients with PD?**

**Descriptive analysis.** Table 7 provides descriptive statistics for data collected at the three testing time points via conversational speech. Intelligibility of spontaneous speech was measured in two ways: intelligible words and content of speech. The mean score for intelligible words for the pre-test was 2.60 ($SD = 1.14$). At the mid-test, the mean score for intelligible words was 2.60 ($SD = 1.14$) which showed no difference from the pre-test. Post-test intelligible words mean score was 3.00 ($SD = 0.71$) which was an increase of .40 from both the pre-test and the mid-test. The rating scale for intelligible words was subjective and ranged from 0 = “no words understood” to 4 = “all words understood.”
Table 7

**Means and Standard Deviations for the Dependent Variables of Spontaneous Speech as Measured by a Picture Description Task**

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Pre-test Mean</th>
<th>Pre-test SD</th>
<th>Mid-Test Mean</th>
<th>Mid-test SD</th>
<th>Post-test Mean</th>
<th>Post-test SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intelligible Words</td>
<td>2.60</td>
<td>1.14</td>
<td>2.60</td>
<td>1.14</td>
<td>3.00</td>
<td>0.71</td>
</tr>
<tr>
<td>Content of Speech</td>
<td>2.20</td>
<td>1.10</td>
<td>2.60</td>
<td>0.89</td>
<td>3.00</td>
<td>0.71</td>
</tr>
</tbody>
</table>

*Note. Possible score range was 0 to 4*
The mean score for content of speech at the pre-test was 2.20 ($SD = 1.10$). At the mid-test, the mean score for content of speech was 2.60 ($SD = 0.89$) which was an increase of 0.40 from the pre-test. The mean post-test score for content of speech was 3.00 ($SD = 0.71$) which was an increase of 0.80 from the pre-test and an increase of 0.40 from the mid-test. The rating scale for content of speech was subjective and ranged from 0 = “I have no idea what this person is describing” to 4 = “I understand perfectly what this person is describing.”

**Inferential analysis.** For the repeated measures ANOVA testing for the differences in intelligible words in the pre-, mid-, and post-test measures, the assumption of sphericity was met (Mauchly’s $W(2) = .87, p = .81$; See Table 8). The main effect of RSC on intelligible words was not statistically significant, $F(2, 8) = 1.46, p = .29$), yet a large effect size was observed ($\eta^2_p = .27$), per Partial Eta Squared. Pairwise comparisons demonstrated no change in mean difference values from pre- to mid ($Mc = 0, p = 1, d = 0$), an increase from mid- to post ($Mc = .40, p = .18, d = .42$) and an increase from pre- to post-test ($Mc = .40, p = .18, d = .42$). No changes were statistically significant. Small effect sizes were observed for each comparison, according to Cohen’s $d$.

For the repeated measures ANOVA testing for the differences in content of speech in the pre-, mid-, and post-test measures, the assumption of sphericity was met (Mauchly’s $W(2) = .94, p = .91$; See Table 8). The main effect of RSC on content of speech was statistically significant, $F(2, 8) = 6, p = .03$) and a large effect size was observed ($\eta^2_p = .60$), as revealed by Partial Eta Squared. Pairwise comparisons revealed an increase in mean differences from pre- to mid ($Mc = .40, p = .18, d = .40$) and from mid- to post-test ($Mc = 4.00, p = .18, d = .50$), but these changes were not statistically
Table 8

Repeated Measures ANOVA Table for Dependent Variables of Spontaneous Speech as Measured by a Picture Description Task

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
<th>η²p</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intelligible words</td>
<td>0.53</td>
<td>2.00</td>
<td>0.27</td>
<td>1.46</td>
<td>.289</td>
<td>0.27</td>
<td>0.23</td>
</tr>
<tr>
<td>Error</td>
<td>1.47</td>
<td>8.00</td>
<td>0.18</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2.00</td>
<td>10.00</td>
<td>0.18</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content of speech</td>
<td>1.60</td>
<td>2.00</td>
<td>0.80</td>
<td>6.00</td>
<td>.026*</td>
<td>0.60</td>
<td>0.72</td>
</tr>
<tr>
<td>Error</td>
<td>1.07</td>
<td>8.00</td>
<td>0.13</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2.67</td>
<td>10.00</td>
<td>0.13</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p<.05
significant. Pre- to mid-test comparisons showed a small effect size while mid- to post-test showed a medium effect size, per Cohen’s $d$. Data for pairwise comparisons demonstrated an increase in mean differences from pre- to post-test ($M_{c} = .80$, $p=.02, d = .87$). Statistical significance was achieved at the pre- to post comparison and a large effect size was observed, according to Cohen’s $d$. 
Chapter 5

Discussion

The purpose of the current research was to examine the long-term effect of a Rhythmic Speech Cuing (RSC) protocol on speech intelligibility in patients with speech deficiencies associated with Parkinson’s disease (PD). Specifically, the study investigated whether participation in a RSC program would influence speaking rate, number of intelligible words per minute (IWPM), and number of unintelligible words per minute (UWPM). Additionally, differences between rates of intelligible speech in patients with speech deficiencies associated with PD after RSC treatments were compared to the rate of typical speakers. The effect of RSC on the intelligibility of spontaneous speech was also observed in patients with speech deficiencies resulting from PD.

As described in previous chapters, five participants with speech deficiencies associated with PD received 12 treatment sessions of RSC over a 4-week period. Data were collected during three testing sessions: pre-, mid-, and post-test. This chapter will discuss the descriptive and inferential analyses of the data in regard to each research question. Furthermore, limitations of the current study will be discussed along with recommendations for future research, theoretical implications, and clinical implications.

Discussion of the Research Questions

Research question 1. Will participation in a Rhythmic Speech Cuing (RSC) program influence percentage of intelligible speech in patients with PD? Results of the current study indicate that RSC did not have a statistically significant main effect on percentage of speech intelligibility. In spite of not obtaining statistical significance, increases in intelligibility scores were observed from pre- to mid-test for Participants 1
and 4, and an increase from pre- to post-test was observed for Participant 1. Participant 5, who showed a high percentage of intelligible speech at the pre-test, maintained the same percentage of intelligible speech scores across all testing time points. Individual participant scores differed in what they revealed in regard to changes in percentage of intelligible speech over time.

Individual scores pertaining to percentage of intelligible speech for Participants 2, 3, 4, and 5 indicated a high level of intelligibility at the pre-test (i.e., scores ranged from 97% to 99%), implying a ceiling effect. A ceiling effect refers to the inability of participants to score any lower or higher on the dependent measure because of intrinsic or extrinsic constraints (Gamst, Meyers, & Guardino, 2008). In this case, high scores at the pre-test allowed little to no chance for increases in intelligibility scores for Participants 2, 3, 4, and 5. On the contrary, Participant 1 showed a substantially lower level of intelligibility with a pre-test score of 65%. Furthermore, this participant showed the most improvement out of the five participants in speech intelligibility percentage over time.

Participant 1 was the sole participant whose pre-test score indicated his speech was “severely affected” in terms of speech impairment most likely due to dysarthria. Prior to enrollment in this investigation, each participant was required to complete a screening procedure which consisted of submitting the “Speech Intelligibility Inventory: Self-Assessment Form” (Kent, 1994). The assessment was completed by each participant and his/her primary caregiver prior to enrollment in the study (See Appendix B). Completion of the assessment was done with the intention of identifying more severely affected speakers. Possible scores on the assessment range from 21 to 105 with scores of 21 to 63 indicating lower intelligibility levels or more severe speech deficiencies. A score
of 21 to 63 on each the self-assessment and the caregiver assessment were therefore deemed adequate for participation in this investigation.

All participant and caregiver scores on the screening assessment fell within the score range of 21 to 63 suggesting low intelligibility levels. However, Participants 2, 3, 4 and 5 exhibited high intelligibility scores at the pre-test (i.e., their scores ranged from 97% to 99%). The screening assessment indicated a severe level of impairment for Participants 2, 3, 4, and 5; however, these participants’ pre-test scores suggested they were only mildly affected. Only Participant 1 demonstrated a severe speech impairment with both his self-assessment score and pre-test score (i.e., 65%).

Previous research has reported that patients with lower levels of intelligibility (i.e., severely to moderately affected speakers) resulting from mixed spastic-ataxic dysarthria benefited more from a slowing of speech rate than more mildly affected speakers (Pilon et al., 1998). Findings revealed that more severe speech deficiencies were most responsive to rigid rate control techniques. The present research confirms previous conclusions regarding rigid rate control techniques being the most beneficial to patients with severe speech deficiencies as opposed to those with milder impairments.

In a later study, Thaut et al. (2001) further distinguished among the severity of deficits and improvements while observing significant increases in mean intelligibility scores of patients with PD after exposure to RSC conditions. The researchers noted severely affected speakers showed the most improvement in mean intelligibility scores while moderately affected speakers exhibited little improvement in mean scores. Mildly affected speakers showed no improvement as well as a decrease from pre-test to post-test in mean intelligibility scores. Moreover, results indicated metered cuing reduced speech
Intelligibility in the mildly affected speakers and it was most effective in the treatment of the severely affected speakers.

Results of the present research corroborate previous findings showing that temporally constraining techniques such as metered cuing appear to benefit patients with severe intelligibility deficits more than those with milder speech impairments. Participant 1, who was severely affected, demonstrated a marked improvement in intelligibility scores from pre- to post-test. The other four mildly affected participants showed more variable results. Participants 2 and 3 showed a consistent decline in intelligibility scores over time which corroborates extant research pertaining to patients with mild speech impairments. Participant 4 showed a small improvement in intelligibility scores from pre- to mid-test, then no change in scores from mid- to post-test, which is inconsistent with previous findings relating to speakers who are less severely affected. Participant 5 showed no change in intelligibility scores over time, which is also inconsistent with existing literature concerning patients with mild speech deficiencies.

**Research question 2.** Will participation in a RSC program influence rate of speech in patients with PD? This research question was measured in two ways: duration of the speech sample (i.e., minutes spent speaking 220 words) and words per minute (WPM). As mentioned in previous chapters, patients with PD can demonstrate both a faster and slower overall speech rate than typical speakers (i.e., 190 words per minute), with research indicating a generally variable rate (Murdoch, Ward, & Theodoros, 2000). Additionally, patients with PD have been noted to demonstrate an “accelerated” speech pattern as a result of short rushes of speech. These short rushes have been observed to be one of the most outstanding features of hypokinetic dysarthria.
Evidence from the current research agrees with previous findings regarding the variability of speech rate in patients with PD. For example, excessively slow rates were observed in Participant 1 (i.e., 40 WPM) and Participant 4 (i.e., 98 WPM) at the pre-test. Pre-test rates indicative of slower than typical rates were also exhibited by Participant 2 (i.e., 148 WPM) and Participant 3 (i.e., 151 WPM). By contrast, Participant 5 revealed an already average rate of 191 WPM at the pre-test.

Although the pre-test score for Participant 5 indicated a rate comparable to typical speakers, anecdotal observations revealed that his speech rate was highly variable. For example, Participant 5 had a speech pattern that would start out at a slow rate and gradually accelerate toward the end of sentences. Participants 2 and 3 also showed accelerated rates toward the end of sentences and their overall speech patterns exhibited a slurred quality which varied from interaction to interaction. Participants 1 and 4 presented with slow rates which frequently included long pauses in between words and within words. Due to the high variability in participants’ speech rates, the goal of the current research was to stabilize the speech rate of each participant. The expectation of stabilizing the participants’ speech rates was to establish a more consistent and predictable rate over time. In order to achieve this stabilization, participants spoke at 60% of their habitual speech rate (HSR) during treatment sessions in the present study.

Previous research has reported that patients with hypokinetic dysarthria resulting from PD made significant improvements in mean intelligibility when speaking at 60% of their HSR in a metered cuing condition (Thaut et al., 2001). Previous findings by Yorkston, Hammen, Beukelman, and Traynor (1990) revealed speaking at 60% of an individual’s HSR produced improvements in intelligibility scores in patients with various
types of dysarthria. Outcomes regarding speaking at 60% of HSR from the cited studies suggested similar results could be anticipated in the current study.

Results of the present study revealed that RSC did not have a statistically significant main effect on duration of the speech sample or WPM. Although statistically significant results were not achieved, changes were observed in the participants’ speech rates. Participant 1, who was the most severely affected, showed the most consistent change in rate over time. His speech sample duration decreased as his WPM increased across all testing time points. Thus, he spoke at a faster speech rate. For this participant, a faster speech rate may be interpreted as an improvement since his pre-test speech rate was excessively slow (i.e., 40 WPM). The increases in Participant 1’s speech rate were observed when no rhythmic cue was provided, thus, by stabilizing his speech rate at a slower rate, he was able to re-organize his motor plan to speak at a faster rate when not cued.

Since his initial speech rate was already excessively slow, the rhythmic cuing for Participant 1 was slightly different than the other participants’ cuing. Speaking at 60% of Participant 1’s speech rate resulted in a tempo of 24 beats per minute (BPM) which was extremely slow and perceptually difficult to follow. Consequently, the metronome rate was doubled to 48 BPM and Participant 1 hand-tapped and spoke on every other beat. Thus, another plausible explanation for Participant 1’s speech rate increase may be that he was hearing an auditory cue that was twice as fast as his hand-tapping cue and speaking.

By contrast, results for Participants 2, 3, 4, and 5 showed different changes regarding speech rate in comparison to Participant 1. For these participants, the most
noticeable changes occurred from pre- to mid-test; no trends arose at the other testing time points. Pre- to mid-test values revealed an increase in speech sample durations and a decrease in WPM. Thus, these participants were speaking at a slower rate. A slowing of rate resulted in a stabilizing of rate for Participants 2, 3, and 5 whose habitual speech patterns exhibited acceleration toward the end of sentences. A stabilizing of rate also ensued for Participant 4, whose pre-test rate was slow and presented numerous pauses between and within words. These initial changes from pre- to mid-test of decreased speech sample duration and increased WPM were anticipated since the RSC treatments utilized metronome and hand-tapping cues that were set to 60% of each participant’s HSR. Changes in speech rate may reflect entrainment with a rhythmic auditory cue.

Previous research has reported entrainment effects regarding rate occur with speech patterns when metronome and hand-tapping cues are employed in the treatment of specific neurogenic speech disorders (Wambaugh & Martinez, 2000). Both metronome and hand-tapping cues are noted to provide a temporal patterning needed for accurate speech production and may result in more efficient and effective motor planning. Wambaugh and Martinez (2000) speculate that more efficient motor planning results from activation of internal oscillatory mechanisms, such as central pattern generators (CPGs). In both the present and aforementioned research, entrainment to rhythm may have operated to reset the central oscillators in participants or to have strengthened their response to stimulation.

Thaut et al. (2001) also propose that auditory rhythm acts as a zeitgeber, or external timekeeper, which re-sets internal oscillators when neurological damage is evident. The authors speculate that the use of hand-tapping helps to reinforce the
zeitgeiber (i.e., rhythmic cue) that entrains the internal timing oscillators for speech. This intersystemic organization was previously observed by Simmons (1978) and involves incorporating a physical gesture (i.e., hand-tapping) into the performance of an act (i.e., speaking) that was not previously integral to the successful performance of the act. This entrainment effect was the most evident in Participant 1, who was the most severely affected. The combination of the metronome cue and the physical gesture of hand-tapping may have aided in Participant 1 attaining a faster speech rate. The evidence from the current research further substantiates the assertion that rigid rate control techniques are most appropriate for speakers who are severely affected.

**Research questions 3 and 4.** Will participation in a RSC program influence the rate of intelligible speech (Intelligible Words per Minute or IWPM), and unintelligible speech (Unintelligible Words per Minute or UWPM) in patients with PD? Results of the present study indicate that RSC did not have a statistically significant main effect on IWPM or UWPM. In the current research, IWPM were anticipated to increase while UWPM were expected to decrease over time.

The most evident changes in IWPM and UWPM were noted from pre- to post-test for all participants, therefore only these changes will be discussed. Results showed Participants 1 and 4 increased IWPM and decreased UWPM from pre- to post-test; thus indicating an improvement in intelligible speech rate. By contrast, Participants 2 and 3 exhibited decreases in IWPM and increases in UWPM from pre- to post-test, indicating a decline in intelligible speech rate. Lastly, Participant 5 showed decreases in both IWPM and UWPM from pre- to post-test, also exhibiting a decline in intelligible speech rate. Since the constructs of IWPM and UWPM are associated with speech intelligibility, these
results were compared to extant research regarding speech intelligibility and rate control techniques.

As previously reported, results from prior research indicate metered cuing reduces speech intelligibility in mildly affected speakers and is most effective in the treatment of severely affected speakers (Thaut et al., 2001). Evidence from the present research agrees with cited research in that rigid rate control techniques seem to aid patients who are more severely affected, rather than those who are mildly affected (Pilon et al., 1998; Thaut et al., 2001). Participant 1, who was more severely affected, showed the most improvement out of all the participants in IWPM and UWPM from pre- to post-test. From pre- to post-test, his IWPM more than doubled and his UWPM decreased by more than half. These improvements are consistent with extant literature pertaining to patients with severe speech impairments. Participant 4, who was more mildly affected, also showed an improvement in IWPM and UWPM from pre- to post-test which is inconsistent with the cited literature relating to speakers who are less severely affected. Participants 2 and 3, who were also mildly affected, demonstrated a decline in IWPM and an increase UWPM from pre- to post-test which is consistent with the previous research concerning speakers with mild deficiencies. Participant 5, who was also mildly affected, showed a decline in IWPM from pre- to post-test which corroborates cited research regarding mildly impaired speakers. However, he demonstrated a decrease in UWPM from pre- to post-test which does not substantiate previous research relating to speakers who are less affected.

**Research question 5.** Will participation in a RSC program influence the difference between rate of intelligible speech in patients with PD compared to typical speakers (i.e., Communication Efficiency Ratio or CER)? Results of the current study
indicate that RSC did not have a statistically significant main effect on CER. CER is computed by dividing the rate of intelligible speech (IWPM) produced by the affected speaker with the mean rate of intelligible speech for typical speakers (i.e., 190 WPM) (Yorkston & Beukelman, 1981a). A CER value of 1.0 is indicative of a typical speaker. Yorkston and Beukelman (1981a) demonstrated the importance of evaluating a CER.

According to Yorkston and Beukelman (1981a), some mildly affected speakers may exhibit high intelligibility scores, but still have low CERs. For example, they describe a patient who demonstrated a 90% intelligibility score, yet yielded a 0.35 CER. The intelligibility score shows a high amount information is being transferred; however, the CER score shows the information is being transmitted much less efficiently. Intelligibility is determined via the perceived clarity of individuals words, while CER incorporates the rate at which intelligible words are delivered over time.

Efficient communication is dependent upon a number of components, such as fluency and rate. If difficulties in initiation and excessive pauses within and between words are extant in an individual’s speech pattern, fluency and rate may be compromised, thereby affecting communication efficiency. In the previous example of the individual with high intelligibility and low CER, the resultant low CER score could be the product of an excessively slow or disturbed speech rate. Although exhibiting high intelligibility (90%), his rate showed low communication efficiency when his rate (67 WPM) was compared to a typical speaker’s rate (190 WPM). Yorkston and Beukelman (1981a) state that in cases where intelligibility is over 90%, effective communication may not be indicated solely in intelligibility scores. In these cases, modifications in functional communication may be better monitored by changes in CER. This issue is of particular
importance since four out of the five participants in the current research demonstrated pre-test intelligibility scores that exceeded 90%.

Participants 2, 3, 4, and 5 in the current research exhibited pre-test intelligibility scores that ranged from 97% to 99%. Participants 2 and 3 had consistently declining intelligibility scores across all testing time points with subsequent decreasing CER values. The combined results of declining intelligibility scores and decreasing CER values for these participants is indicative of a decline in speech quality over time. By contrast, Participant 4 had an increase in intelligibility from pre- to mid-test and maintained the same intelligibility score from mid- to post-test. For this participant, a decline in CER was observed from pre- to mid-test; however an increase in CER occurred from mid- to post-test despite an unchanged intelligibility value. These results suggest that Participant 4’s speech became more efficient over time. Participant 5 displayed no change in intelligibility scores across all testing time points, a decline in CER from pre- to mid-test, and no change in CER from mid- to post-test. These results indicate that even though his intelligibility score remained the same over time, at one point his speech became less efficient.

For Participants 2, 3, 4, and 5, intelligibility scores remained adequate over time, but communication efficiency was lacking. This finding relates to the issue previously described by Yorkston and Beukelman (1981a) showing that a high amount of information is being transferred, yet not in an efficient manner. Satisfactory communication efficiency results from the combination of the perceived clarity of individual words and the optimal rate at which those words are delivered. If speech rate is disturbed, communication efficiency is compromised.
Participant 1, who was severely affected (i.e., 65% pre-test intelligibility), exhibited the largest change in communication efficiency over time out of all participants. His intelligibility scores showed an increase from pre- to mid-test with an increased CER value. Although mid- to post-test results for Participant 1 showed a slight decline in intelligibility as well as CER value, pre- to post-test values for both constructs increased considerably. Anecdotal observations for Participant 1 revealed that pauses between and within words substantially declined across all testing time points. Additionally, speech initiation became less laborious and his fluency appeared to increase for both words and sentences. Participant 1’s CER value doubled from pre- to post-test, showing that his speech became noticeably more efficient over time. These results indicate that severely affected speakers are more likely to benefit from RSC treatments than patients who are mildly affected, in regard to communication efficiency.

**Research question 6.** Will participation in a RSC program influence the intelligibility of spontaneous speech in patients with PD? In the current research, intelligibility was previously discussed in the context of a sentence reading task (See Research Question 1). Additionally, the current research question addressed intelligibility by utilizing a picture description task (PDT). The PDT consisted of asking participants to formulate self-generated statements in response to viewing a photo. The purpose of this question was to distinguish between intelligibility using a sentence reading task and intelligibility using a task that required self-generated statements (i.e., spontaneous speech). The two tasks employ differing cognitive processes; therefore intelligibility may be affected in varying ways for each task. During the PDT, participants were provided with a color photo and then asked to speak three to five sentences regarding the scenario
presented in the photo. An example of one scenario is a woman who is grocery shopping with her children. This research question was measured in two ways: intelligible words score and content of speech score.

Recorded PDT speech samples were randomly assigned to two judges who evaluated them for intelligible words and content of speech via subjective global rating scales. The procedure for rating intelligible words entailed the judges providing a general estimate of the amount of intelligible words contained within each PDT sample. The rating scale for intelligible words ranged from 0 = “no words understood” to 4 = “all words understood.” The scores for intelligible words in regard to this question reflect intelligibility based on self-generated speech. This approach differs from percentage of intelligible speech which was previously observed via a reading task (See Research Question 1). Although an individual might speak several intelligible words, the words may not be connected in a way that forms a meaningful and coherent message (i.e., content of speech).

To account for content of speech, raters evaluated each PDT sample for the overall meaning of the message the speaker conveyed. The rating scale for content of speech ranged from 0 = “I have no idea what this person is describing” to 4 = “I understand perfectly what this person is describing.” The color photos that the speakers described were not provided to the raters during evaluation in order to assure the most accurate rating of each sample. The purpose of this task was to simulate how the participant might be understood in conversation. Results indicated that RSC did not have a statistically significant main effect on intelligible words score, but did have a statistically significant main effect on content of speech score. The most noteworthy
changes in scores for intelligible words and content of speech occurred from pre- to post-test, therefore only these results will be discussed.

Raw data revealed that all five participants either increased or maintained their scores for both intelligible words and content of speech from pre- to post-test. Participants 1 and 4 increased their pre- to post-test intelligible words scores while Participants 2, 3, and 5 showed no change in intelligible words between these testing time points. Participants 1, 2, 3, and 4 improved their content of speech scores from pre- to post-test, whereas Participant 5 demonstrated no change in content of speech scores over time. Participants 1 and 4 were the only participants to increase both their intelligible words and content of speech scores from pre- to post-test.

Analysis of data for content of speech scores achieved statistical significance and showed a large effect size. Attainment of statistical significance signifies the observed changes in content of speech scores are most likely a result of the RSC treatment, rather than chance. Practical significance denotes the magnitude or strength of the treatment effect. The values of both of these constructs indicate that the independent variable (i.e, RSC treatment) was reliably and greatly influential on the changes observed in the dependent variable (i.e., content of speech).

The data for intelligible words scores and content of speech scores are particularly critical to the current research. While the previous questions defined speech constructs by standardized means, the current question is concerned with the important perceptual aspect of speech. The speaker must be able to coherently relay a message to the listener, and the listener must perceive the message as intelligible and meaningful in order for functional communication to result. The process of delivering an intelligible message is
difficult for individuals with speech deficiencies associated with PD and therefore functional communication is affected. Results of this research question indicate skill transfer may occur with RSC and can impact production of spontaneous speech in individuals with speech deficiencies resulting from PD.

Limitations of the Study and Recommendations for Future Research

Certain limitations existed within the current RSC study, including problems with the screening procedure that resulted in an inaccurate assessment of speech deficiencies and a small sample size. Additionally, the protocol showed to be more challenging for the participants than originally anticipated. If the present research were to be reproduced, modifications in methodology would be necessary.

The present research required each participant and his/her primary caregiver to complete the “Speech Intelligibility Inventory: Self-Assessment Form” (Kent, 1994) prior to participation in this investigation. Completion of the assessment was done with the intention of identifying more severely affected speakers. As previously reported, all participant and caregiver scores on the screening assessment fell within the range of scores that suggested low intelligibility levels. The assessment revealed a severe level of impairment for Participants 2, 3, 4, and 5; however, these participants’ pre-test scores suggested they were only mildly affected. Self-assessment and pre-test scores showed Participant 1 was the only participant who demonstrated a severe speech impairment. Thus, the screening assessment was deemed ineffective in capturing an accurate estimate of the severity of speech impairments in all participants.

Anecdotal observations during the screening process revealed a few explanations to account for the ineffectiveness of the assessment. Some participants perceived their
speech deficiencies to be worse than what was evident, observed via conversation with the researcher, and graded themselves more critically on the assessment. Conversely, some caregivers deemed the speech deficiencies of their loved one to be more severe than what was evident and graded more unfavorably. With some participants, both of these scenarios occurred. Therefore, with the exception of Participant 1, the set of assessment scores for each participant and caregiver were dissimilar. For four out of five participants, scores were skewed to indicate speech impairments that were indicative of severe impairments.

The ineffectiveness of the screening assessment resulted in four out of five participants having mild speech deficiencies, not severe. Moreover, high pre-test intelligibility scores for these participants left little to no opportunity for improvement. Consequently, the RSC treatment may appear to be ineffective. If similar research is done in the future, researchers will need to utilize a more objective assessment which captures the level of speech impairment more accurately. Patient and caregiver assessments used in conjunction with an assessment completed by an outside observer would be ideal. The incorporation of a rating made by someone who is unfamiliar with the participants’ speech would offer a more objective and reliable rating for the severity of speech deficits. Another possibility to ensure an assessment tool will accurately reflect speech deficits is for a future researcher to pilot a potential intelligibility assessment.

Further recommendations for a replication of this study would include a larger sample size. Five participants comprised the sample in the current study, which was insufficient to produce a normal distribution of the data. As previously stated, normality for the ANOVA was met to the degree that could be expected given the limitation of a
small sample size. Furthermore, as a result of small sample size, certain data may have lacked adequate power to achieve statistical significance. Consequently, some effects may have existed, but did not appear. This result was a likely occurrence, based on the large practical effect sizes ($\eta^2_p$) observed for six out of eight dependent variables. The small sample size may also create difficulties in the generalization of results. A larger sample size of speakers with severe speech impairments would be more appropriate when generalizing results to the entire population of individuals with severe speech deficiencies resulting from PD.

In reference to the treatment protocol, self-reports of the participants indicated that since acquiring PD, performing more than one task concurrently had become challenging. Treatment sessions were cognitively demanding for participants because of the simultaneous task performance involved in the protocol. Listening to a metronome cue, hand-tapping, and speaking at the same time was difficult for the participants. Frequent short breaks were taken during treatment sessions and even so, participants reported feeling “drained” at the end of sessions.

The participant self-reports are consistent with extant research that describes difficulties patients with PD exhibit while performing a dual task (Brown & Marsden, 1991). The cited research showed patients with PD displayed an impeded ability in the performance of a divided attention task when paired with a concurrent foot tapping task. Brown and Marsden (1991) state that the combined cognitive demands of two tasks outweighed the diminished cognitive resources of an individual with PD. Thus, the protocol for the current study may have been too arduous for participants and might have been reflected unfavorably in the results. If the participants were too drained by the
treatment protocol to fully partake in the sessions, they may not have acquired all the possible benefits from the treatment. Recommendations for replication of the current study would be to have more frequent, but shorter treatment sessions.

Additionally, since Participant 1 was more severely affected, he was in need of assistance with hand-tapping during treatment sessions. The researcher provided hand-over-hand assistance by tapping his hand for him which resulted in the participant still getting rhythmic input. The protocol may need to be altered for future research. For example, the researcher could provide tactile rhythmic input (i.e., tapping in the participant’s hand) for participants, especially for patients who are severely affected.

**Theoretical Implications**

Results of the present study provide theoretical insight as to how the auditory system interacts with and influences rhythmic behavior, specifically speech. The stabilization of participants’ speech rates that occurred after cuing at 60% of their HSR may reflect entrainment with a rhythmic auditory cue. Specifically for Participant 1, the metronome and hand-tapping cues appeared to provide a temporal patterning needed for accurate speech production, resulting in more efficient and effective motor planning. More efficient motor planning may have resulted from activation of internal oscillatory mechanisms or central pattern generators (i.e., CPGs).

Central pattern generators are complex connections of neurons that are implicated in the production of rhythmic motoric behaviors (i.e., speech and gait). These complex connections have been previously shown to change via sensory input (i.e., rhythm), thus modifying motor outcomes (Barlow, Finan, & Park, 2004). In the present study, auditory rhythm may have acted as an external timekeeper which re-set damaged internal
oscillators. Additionally, the hand-tapping may have facilitated a reinforcement of the rhythmic auditory cue and entrained the internal timing oscillators for speech. The result of these processes may have been an intersystemic reorganization which improved speaking when paired with a physical gesture (i.e., hand-tapping). Utilization of auditory rhythm in conjunction with a physical cue may have provided a strong signal which re-set CPGs for more fluent speech output.

**Clinical Implications**

The present study suggests that a long-term RSC protocol can be effective in the treatment of speech deficiencies that are associated with dysfluent and laborious speech in PD. Data from the current research indicates RSC with metered cuing appears to benefit patients with severe speech impairments more than those with milder speech deficits. Patients with severely affected speech may gain more fluency in speech over time as evidenced by improvements in specific speech constructs.

Participant 1, who was severely affected, demonstrated marked improvements in percentage of intelligible speech, rate of speech, IWPM, UWPM, and CER from pre- to post-test. His percentage of intelligible speech increased over time from 65% to 89%, which is a percentage that is comparable to typical speakers. Moreover, Participant 1’s speech sample duration decreased as his WPM increased across all testing time points. These findings show his speech rate stabilized as a result of cuing at 60% of his HSR, resulting from a possible entrainment effect. From pre- to post-test, Participant 1 also more than doubled his IWPM and reduced his UWPM by more than half. His CER increased from 0.14 to 0.28, showing his communication efficiency doubled from pre- to post-test. Finally, spontaneous speech samples via the PDT indicated that scores for both
intelligible words and content of speech increased for Participant 1 from pre- to post-test. Increases in intelligible words and content of speech scores are particularly important since they suggest skill transfer may have occurred into spontaneous speech. These results reflect an improvement in functional communication for patients with severe speech impairments resulting from PD.

Since the current study appears to be most beneficial to patients with severe speech deficiencies, the use of an effective assessment tool is critical to this protocol. As previously stated, clinicians will need to utilize an objective assessment which captures the severity of the speech impairment accurately. Patient and caregiver assessments may be used in conjunction with an assessment completed by an outside observer who is unfamiliar with the participants’ speech. This approach would offer a more objective rating of the severity of speech deficiencies and the reliability of the assessment would increase. Another possibility to ensure an assessment tool will accurately reflect speech deficits is for a clinician to pilot a potential intelligibility assessment.

Patients with severe speech deficits may also have difficulties in the simultaneous performance of tasks involved in the current treatment protocol since they may be in the later stages of the disease. Listening to a metronome cue, hand-tapping, and speaking at the same time can be challenging for patients with PD. To accommodate patients with more severe impairments, the researcher may provide hand-over-hand assistance by tapping the participant’s hand for him so that rhythmic input is still provided for the individual. The researcher could also provide tactile rhythmic input (i.e., tapping in the participant’s hand) for a severely affected participant. Additionally, shorter and more frequent treatment sessions are recommended in order to avoid participant fatigue. For
example, having five, 12-minute treatment sessions per week would equal the RSC treatment time in the current protocol and would be less demanding on the participants.

Clinicians may also consider using the current treatment protocol as a preventative measure. Due to the degenerative nature of the disease, individuals with PD will experience a consistent decline in speech intelligibility as the disease progresses. The current treatment protocol may help to delay the onset of more severe speech impairments if employed with individuals whose speech deficiencies are presently mild to moderate. Current data for the less severely affected participants indicated minor declines in certain aspects of speech; however, the treatment was not deemed particularly detrimental to any participant’s speech intelligibility. Clinicians would need to determine if an individual is able to engage in treatment without substantially impairing existing intelligibility levels and progress while in treatment would need to be monitored.

**Summary**

Parkinson’s disease is a progressive neurodegenerative disorder that is caused by a deterioration of the basal ganglia (Adams & Jog, 2009), causing a communication disorder known as hypokinetic dysarthria. An estimated 60% to 80% of PD patients develop speech deficiencies as the disease progresses (Adams & Dykstra, 2009), therefore effective treatment is necessary to maintain or improve functional speech in these individuals.

Previous research shows that the basal ganglia are implicated in the processes of speech production, rhythm perception, and rhythmic movement (Penhune et al., 1998; Kent, 2005; Grahn & Brett, 2007). Metered cuing, consisting of hand-tapping and a metronome cue, was previously shown to have a positive and immediate effect in
treatment of severely disturbed speech rate in comparison to other pacing conditions (Pilon et al., 1998; Thaut et al., 2001; Wambaugh & Martinez, 2000). The patients in the cited research presented with either mixed spastic ataxic dysarthria, hypokinetic dysarthria, or a combined diagnosis of apraxia and aphasia. Although these immediate results were promising, additional research was necessary to observe the outcome of long-term RSC treatment.

The purpose of the current study was to investigate the long-term effects of RSC on severe speech impairments resulting from PD. Five individuals diagnosed with idiopathic PD and self-reported diagnosis of speech deficiencies resulting from PD participated in the present research. Each participant received 12 treatment sessions of RSC over a 4-week period. Each 25-minute treatment session consisted of metered cuing with fading (for 20 minutes) and conversational speech (for 5 minutes). Data were collected during three testing sessions; pre-, mid-, and posttest. Each 20-minute testing session consisted of each participant speaking a total of 22 sentences (i.e., 220 words) from the Assessment of Intelligibility of Dysarthric Speech (AIDS) at their own preferred pace with no cuing. A picture description task (PDT) was also used, in which participants reported what they observed in a color photo depicting an everyday scenario. The dependent variables observed via the AIDS were percentage of intelligible speech, words per minute (WPM), intelligible words per minute (IWPM), unintelligible words per minute (UWPM) and communication efficiency ratio (CER). Additionally, intelligible words and content of speech were observed via the PDT.

The results showed that RSC had a statistically significant main effect on content of speech scores. Although only one dependent variable achieved statistical significance,
six out of eight dependent variables generated large effect sizes, thus indicating practical significance. Statistical significance was most likely not reached for these six dependent variables due to a small and varied sample which may have lacked sufficient power to show some effects. Additionally, findings revealed that the current RSC treatment protocol was most effective in the treatment of individuals with severe speech deficiencies.

Participant 1, who was severely affected, demonstrated marked improvements in all dependent variables observed in the current research. His percentage of intelligible speech increased from 65% to 89%, which is a percentage that is comparable to typical speakers. Moreover, Participant 1’s speech sample duration decreased as his WPM increased across all testing time points. From pre- to post-test, Participant 1 also more than doubled his IWPM and reduced his UWPM by more than half. His CER increased from 0.14 to 0.28, showing his communication efficiency doubled from pre- to post-test. Finally, spontaneous speech samples via the PDT indicated that both scores for intelligible words and content of speech increased for Participant 1 from pre- to post-test. Increases in intelligible words and content of speech scores are of particular importance since they suggest skill transfer may have occurred with RSC into spontaneous speech.

The present RSC study provides theoretical insight to how the auditory system interacts with and influences rhythmic behavior, such as speech. The combined metronome and hand-tapping cues may have provided a temporal patterning needed for more accurate speech production and may have resulted in more effective and efficient motor planning. More efficient motor planning may have resulted from activation of neural connections that are implicated in the production of rhythmic motoric behaviors.
These connections were potentially modified by the rhythmic cuing, which may be indicative of an entrainment effect. The data from the current study demonstrate that within a one month RSC protocol, patients with severe speech impairments resulting from PD can maintain or improve functional speech.
References


Dear Patient,

You are invited to be part of a special research project for individuals with Parkinson’s disease that is being done at the University of Miami. The project is designed to examine the influence of rhythm on speech intelligibility in patients with Parkinson’s disease. If you have Parkinson’s disease and difficulty speaking, you may be eligible for this project.

You will participate in testing and treatment sessions over a 4-week period. Three testing sessions will take place, one at the beginning of the 4 weeks, one in the middle, and one at the end. Each testing session will last no longer than an hour. Treatment sessions will take place three times per week over the 4-week period, for a total of 12 sessions. In these sessions, you will learn how to use rhythm to cue your speech. Each treatment will last no longer than 30 minutes. Upon your participation in this project, you will complete an informed consent form. Ultimately, the results of this project should help determine if rhythm can enhance speech intelligibility with patients with Parkinson’s disease.

If you would like to participate in this project, please either call me at 305.xxx.xxx, or e-mail me at Joy_Fairfield@xxxxxx.com. You will need to be able to speak, read, and write English to be part of this project. In addition, you must be able to follow simple directions. You will be required to be on medication for the symptoms of Parkinson’s disease and not expect to have any change of medication during the course of this project. Additionally, you will be required to be free of any other diagnoses of mental disorders (i.e., dementia).

Testing and treatment sessions will take place either in your home, or in room 201-B of the McKnight Building which is located on the south end of the University of Miami Coral Gables campus. Please see the back of this page for driving directions and parking information. If you drive to your appointments, you will receive a free parking permit.

If you would like to participate in this study, please contact me by phone or by e-mail. Your participation in this project is completely voluntary. I look forward to meeting you!

Sincerely,

Joy Fairfield
Master’s Degree Student, Music Therapy

Call me at: 305.xxx.xxx
E-mail me at: Joy_Fairfield@xxxxxx.com

****ENGLISH SPEAKING ONLY****
Driving and Parking Directions to the McKnight Building

The McKnight Building is easy to find from either US 1, or Red Road.

From the North: (if you are coming from north of SW 64th Street)

- Take US 1 south to Red Road (SW 57th Ave) and turn right, so you are heading north.
- Take an immediate right turn again, so that you are on Ponce de Leon Blvd.
- The first light you come to will be San Amaro Dr. When you reach this light, the McKnight Building will be on your left.
- You can turn right into the parking lot at this light (under the Metro-rail) and park there. Or, you can turn left and park in the parking lot behind the McKnight Building.
- When you arrive, call me at 305.xxx.xxxx from your cell phone. I will meet you in the parking lot to escort you into the building. If you do not have a cell phone, simply enter the front door of the McKnight Building and come up to the second floor. An elevator is available. I will be in room 201-B.

From the South: (if you are coming from south of SW 64th Street)

- Take US 1 north to Red Road (SW 57th Ave) and turn left, so you are heading north.
- Take an immediate right turn, so that you are on Ponce de Leon Blvd.
- The first light you come to will be San Amaro Dr. When you reach this light, the McKnight Building will be on your left.
- You can turn right into the parking lot at this light (under the Metro-rail) and park there. Or, you can turn left and park in the parking lot behind the McKnight Building.
- When you arrive, call me at 305.xxx.xxxx from your cell phone. I will meet you in the parking lot to escort you into the building. If you do not have a cell phone, simply enter the front door of the McKnight Building and come up to the second floor. An elevator is available. I will be in room 201-B.

IF YOU BECOME LOST AT ANY POINT, PLEASE CALL ME AT 305.xxx.xxxx
### Appendix B

#### Speech Intelligibility Inventory: Self-Assessment Form

*Item 2.75. Speech Intelligibility Inventory: Self-Assessment Form*

<table>
<thead>
<tr>
<th>Name of person completing form:</th>
<th>If not client, relationship to client:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date:</td>
<td>Diagnosis:</td>
</tr>
</tbody>
</table>

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

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

On the whole, people find it hard to understand my speech

- (all of the time) (most of the time) (sometimes) (seldom) (never)

What do you do to improve your speech?
Appendix C
Picture Description Task (PDT) Photos

Pre-test Photo
Mid-test Photo
Appendix D

The Effect of a Rhythmic Speech Cuing Protocol on Speech Intelligibility in Patients with Parkinson’s Disease

INFORMED CONSENT FORM

PURPOSE: You are being asked to participate in a research study on the effect of rhythmic cuing on speech in patients with Parkinson’s disease. The purpose of this study is to investigate if a Rhythmic Speech Cuing protocol changes speech intelligibility in individuals with Parkinson’s disease. Ultimately, the results should help determine a therapeutic technique to treat speech problems in patients with Parkinson’s disease.

PROCEDURES: You will participate in testing and treatment sessions over a 4-week period. Three testing sessions will take place, one at the beginning of the 4 weeks, one in the middle, and one at the end. Each testing session will last no longer than an hour. Treatment sessions will take place three times per week over the 4-week period, for a total of 12 sessions. In these sessions, you will learn how to use rhythm to cue your speech. Each treatment will last no longer than 30 minutes. You will make an appointment for each testing and treatment session. All testing and treatment sessions will take place in your home, or in room 201-B of the McKnight Building located at the University of Miami Coral Gables campus. For appointments scheduled at the university, you will receive a free parking permit. During the initial appointment, you will complete an audio consent form.

During testing sessions, your voice will be recorded while you read a list of sentences out loud. Additionally, you will be asked to describe what you see on a color photograph.

During treatment sessions, you will speak a series of sentences with the researcher, then eventually without the researcher. The procedure for Rhythmic Speech Cuing (RSC) used in treatment will consist of the following steps. First, the researcher will read through each sentence out loud one time with hand-tapping and a steady auditory beat provided by a metronome in order to model what is expected. You will watch, listen, and tap along without speaking. Second, you will join the researcher in reading each sentence out loud one time with hand-tapping and the metronome cue. Then, you will speak the sentence with the metronome cue and hand-tapping without modeling. Next, you will speak each sentence one time with metronome cuing. The cue will be eventually faded. You will then speak each sentence one time with no cuing. Additionally, you will be presented with a list of topics and asked to choose a topic. You will be asked to speak on the topic for 3 to 5 minutes.

RISKS: No foreseeable risks or discomforts are anticipated for you by participating in this study.
BENEFITS: No direct benefit can be promised to you for taking part in this study; however, you may learn new ways to improve your speech intelligibility and fluency in communication with others.

CONFIDENTIALITY: The researcher will consider your records and audio recordings confidential to the extent permitted by law. The records and audio recordings will not be identified as pertaining to you in any publication without your expressed permission. The U.S. Department of Health and Human Services (DHHS) may request to review and obtain copies of these records. Your records may also be reviewed for audit purposes by authorized University employees or other agents who will be bound by the same provisions of confidentiality. The collected data will not contain any information that could be used to identify you. All data will be identified by an assigned code, not by your name. All paper and electronic records will be stored in a locked file cabinet to which the investigator, Joy Fairfield, will have the only access. All records will be kept in this locked location for a period of seven years. After that time, all data will be destroyed.

RIGHT TO WITHDRAW: Your participation is voluntary; you have the right to withdraw from the study. During the study, you may stop participating at any time. You have the right to not participate and nothing will happen to you as a result. If you do not want to participate or do not follow procedures, the researcher can also remove you from the study without your consent.

OTHER PERTINENT INFORMATION: Joy Fairfield (305.xxx.xxxx) or Dr. Shannon de l’Etoile (305.xxx.xxxx) will gladly answer any questions you may have concerning the purpose, procedures or outcome of this project. If you have any questions concerning the study, your participation in the study, please do not hesitate to contact Joy or Dr. de l’Etoile. If you have questions about your rights as a research participant in this project, you may contact the University of Miami’s Human Subjects Research Office at 305.xxx.xxxx.
PARTICIPANT AGREEMENT:
I have read the information in this consent form and agree to participate. I have had the chance to ask any questions I have about this study, and they have been answered for me. I am entitled to a copy of this form after it has been read and signed.

Participant’s Name

Participant’s Signature

Date

Signature of Person Obtaining Consent

Date
**Authorization for Audio/Video/Photography Recording in a Research Study**

I hereby authorize the University of Miami, Department of Music Education/Music Therapy, to take still photographs, videotapes, and/or sound recordings of me/ (my child).

I authorize the University to use in any manner said photographs, film, video or tape recordings, in whole or in part as follows:

- For the purpose of teaching, research, scientific meetings and scientific publications, including professional journals or medical books;
- For research purposes only.

I agree that the University of Miami, its Trustees, officers, employees, faculty and agents will not be responsible for any claims arising in any way out of the taking and use as described above of such photographs and/or recordings. I understand that I will not have an opportunity to inspect and approve such photographs or recordings prior to their use.

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<thead>
<tr>
<th>Signature of Participant:</th>
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<th>Signature of Witness:</th>
<th>Printed Name of Witness:</th>
<th>Date:</th>
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<tr>
<th>Signature of Parent (if applicable):</th>
<th>Printed Name of Parent (if applicable):</th>
<th>Date:</th>
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Appendix F
Demographics Questionnaire

1. Participant: _______

2. Sex (Circle One):  M       F

3. Age: _______

4. Age of Diagnosis: _______

5. Side of Onset (Circle One):  Left    Right

6. Side More Affected (Circle One):  Left    Right    Both

7. What medications are you currently taking to manage the symptoms of Parkinson’s disease?

8. How long have you been on medication for Parkinson’s disease?

9. What time of day do you typically take medication?

10. What time of day is your medication most effective?

11. What hand do you write with?
Appendix G
Assessment of Intelligibility of Dysarthric Speech (AIDS) Scoring Sheet

<table>
<thead>
<tr>
<th>Speaker</th>
<th>Date</th>
<th>Duration</th>
<th>Intelligibility (%)</th>
<th># of Intelligible Words</th>
<th># of Inintelligible Words</th>
<th>Comment</th>
<th>Efficiency Ratio (WPM: 100)</th>
<th>WPM:</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

**Key**:
- 1A
- 2A
- 3A
- 4A
- 5A
- 6A
- 7A
- 8A
- 9A
- 10A
- 11A
- 12A
- 13A
- 14A
- 15A

**Total Correct**: 

---

This form may be duplicated.
Appendix H
Global Rating Scales for Picture Description Task (PDT)

Number of words I can understand as spoken by this person (circle the number that applies):

0 – No words
1 – Very few words
2 – Some words
3 – Most words
4 – All words

Choose one of the statements below to most accurately describe the content of this person’s speech:

0 – I have no idea what this person is describing.
1 – I’m struggling to understand what this person is describing. For example, I can detect certain words, but I don’t know how they are related.
2 – I have a basic idea of what this person is saying, but I need more details in order to put the words together in a context.
3 – I have a good idea of what this person is describing, but additional details would help form a more clear idea.
4 – I understand perfectly what this person is describing.