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Measures of Tongue Strength and Perceptual Characteristics of Speech in Parkinson Disease

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MEASURES OF TONGUE STRENGTH AND PERCEPTUAL CHARACTERISTICS OF

SPEECH IN PARKINSON DISEASE

By

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ABSTRACT

The present study examined tongue strength and speech characteristics in six individuals with Parkinson disease across two sessions of approximately 20 months. The Iowa Oral Performance Instrument was used to measure tongue strength. In addition, speech samples were recorded and rated for respiration, articulation, resonance, and phonation by five speech-language pathologists experienced in the assessment and treatment of dysarthria. A Wilcoxon signed ranks test was used to compare tongue strength measures across the sessions. Wilcoxon signed ranks tests were also conducted to compare the judges’ perceptual ratings over time. Results revealed a significant reduction in tongue strength at the second session. Perceptions of speech characteristics specifically, consonant imprecision, vowel imprecision, rate, and overall speech also demonstrated a consistent pattern of degradation over time, though those changes were not statistically significant.
INTRODUCTION

The tongue is an important structure for speech and non-speech tasks. In fact, with regard to speaking, the tongue has been described as the most important and active of the articulators (Zemlin, 1998). The importance is illustrated by the fact that the tongue modifies the shape of the oral cavity to influence resonance and inhibits airflow to produce articulatory sounds for speech (Zemlin, 1998). The tongue is able to achieve this because extrinsic and intrinsic muscles help move the tongue in a large range of motions (Ferrand, 2001). These movements, combined with a sound source from the larynx and airflow from the respiratory system, produce consonant and vowel sounds in speech. Specifically, tongue height, tension, and advancement create various vowel sounds (Ferrand, 2001). Likewise, tongue positioning in the oral cavity shapes consonant sounds in speech. For example, the fricative /s/, is made by narrowing the space between the tongue tip, tongue blade, and alveolar ridge and grooving the center of the tongue by holding the sides in place. For the production of glides and liquids the tongue must coordinate smoothly and quickly. These tasks require the tongue muscles to be strategically placed and controlled to produce speech sounds (Ferrand, 2001).

Because the tongue is important to speech, various measurement devices have been developed to study its function. One of the earliest instruments to measure tongue function was introduced by Sanders (1969). The instrument consisted of a force displacement transducer connected to a single channel direct writing, portable, recording system, and a specially designed tongue pressure disk, head stabilizer, and pressure unit holder. It required the subject to open their mouth as widely as they could and keep contact with dowels; one on the maxilla just below the nose and the other just above the mandible. The pressure unit holder was moved forward in the center slot base until the pressure disk was inside the subject’s dental arch of the mouth. Subjects were asked to “Press on the disk with your tongue as hard as you can”. To test reliability of the instrument’s measurements a group of 17 young adults were tested for maximal pressure on two separate occasions after at least a 24-hour time lapse. Four of the 17 participants tested showed significant difference in the amount of deviation between the two measures.

A similar instrument was used in a study by Dworkin (1978) to measure articulatory proficiency in children with frontal lisps. Forty-five school age children with frontal lisps and 45 school age control subjects participated in this study. The experimental group included 21 male
and 24 female subjects ranging from 7.6 to 12 years of age. All subjects had no history of neurological insult, physical impairments, hearing impairments, emotional instabilities, and/or craniofacial abnormalities. The instrument utilized was called the Lingual Force Scale. Like the original instrument, the Lingual Force Scale measured protrusion muscular force of the tongue. Experimental tasks required the participants to protrude their tongues for measures of tongue pressure. Although the apparatus used for the study was appropriate for the measures assessed, the device lacked portability.

More recent instrumentation was developed to increase reliability of tongue measurements excluding external factors such as the head and neck. Because the original instrumentation required specific head placement those factors may have influenced earlier instrumentation. Theodoros, Murdoch, & Stokes (1995) developed an instrument comprised of an air-filled rubber bulb connected by tubing to a pressure transducer to make their measurements of tongue function. The bulb was designed with a groove for teeth placement to ensure constant placement of the bulb on the anterior –two thirds of the tongue. To assure stability of jaw movement, participants were instructed to bite down on the groove. In a review of the literature pertaining to objective measurements of various physiological aspects of articulatory structure, Luschei (1991) discussed ways in which measures can become more standardized, eliminating intra-subject variability. Luschei (1991) suggested experimenting with the instructions for tasks to determine which set of instructions results in the least amount of variability. He also suggested future research in the area of speech motor control to include a technological instrument for measuring orofacial muscle function and a development of standardized protocols for measuring these tasks. Since then the Iowa Oral Performance Instrument (IOPI) was developed to measure physiological aspects of the tongue.

The Iowa Oral Performance Instrument (IOPI; Blaise), an instrument similar to that described in the Theodoros et al. (1994) study, has been utilized in studies to measure lingual strength and endurance (Solomon, Lorell, Robin, Rodnitzky, & Luschei, 1996; Stierwalt, Robin, Solomon, Weiss, & Max, 1996; Solomon, Robin, & Luschei, 2000; Clark, Henson, Barber, Stierwalt, & Sherrill, 2003). The IOPI is a hand-held, portable instrument that measures strength and endurance of the tongue and hand (Blaise, 2005). It consists of an air-filled bulb connected to a pressure transducer. Measurements are calculated in kilopascals (kPa) and digitally displayed on a liquid crystal display (LCD) screen. The IOPI measures strength of the tongue by
obtaining the maximum pressure an individual can produce in the tongue bulb by pressing the bulb against the roof of their mouth “as hard as they can”. Endurance has typically been measured by the individual sustaining 50% of their maximum effort. For instance, if an individual produced a strength measure of 60 kPa their endurance goal would be to sustain half of their strength measure, 30 kPa, for as long as possible.

Several studies report the reliability of the IOPI in measuring lingual strength and endurance for a variety of speech and nonspeech tasks (Clark et al., 2003; Robin, Goel, Somodi, & Luschei, 1992; Solomon, 2000; Youmans, Stierwalt, & Clark, 2002). Solomon (2000) analyzed the effects of tongue fatigue on normal speech. Fatigue tasks were implemented using the IOPI. Three female and five male normal speakers between the ages of 16 and 30 years participated in the study. The IOPI was used to measure maximum tongue strength and tongue fatigue. Baseline maximal pressures were obtained by participants pushing their tongue against the IOPI three times; the greatest pressure was obtained as baseline. Baseline speech measures were collected by participants completing three tasks: slow syllable repetitions (SSR) of /tu/, /su/, /shu/, fast syllable repetitions (FSR), and reading sentences aloud. Three trials of each speech task were given. During the speech tasks, subjects judged their perceptions of effort by marking a visual-analog scale (VAS) which indicated “no effort” and “extreme effort” on both ends. For fatigue tasks, the full LED display on the IOPI was set up to show maximal tongue strength. During these tasks, participants pushed the IOPI bulb against the roof of their mouth for 6 seconds as hard as they could and then rested for 4 seconds. This continued until they achieved 50% of their maximal pressure. After the criterion for termination of the fatigue task was met participants performed a maximum voluntary contraction with the tongue for a strength assessment. Immediately following, they completed one SSR trial of consonant vowel (CV) syllables. Participants then judged their effort on maximum voluntary contraction (MVC) with the VAS. The second phase of fatiguing exercises continued. This protocol continued through the remaining speech tasks with approximately 25 seconds between each fatigue phase.

Perceptions of the speech samples were rated by two groups of individuals, experienced and inexperienced, in three separate studies. Before rating the samples, listeners completed trial tasks to ensure they understood the task. The first study with experienced listeners consisted of eight speech-language pathologists with 7 to 35 years of professional experience. Twenty sentences of pre- and post fatigue speakers were paired and pre-selected by a consensus of three
informed listeners rated by the experienced group. The inexperienced group of raters of the second study comprised of thirty-one students aged 19-42 enrolled in their first communication disorders class. The second study judged baseline sentences and fatigue sentences. Sentences were selected in random order to ensure that no consecutive pairs of fatigue sentences and baseline sentences were from the same speaker. The listeners were instructed to select the sample in each pair that sounded “more precise” or to judge them as “equally precise”. The third study consisted of forty-one listeners’ ages 19 to 38 years, meeting similar criteria as the group in the second study. This group was instructed to judge one sentence across all trials from baseline to recovery, for imprecision.

Results of the Solomon (2000) study revealed that perceptions of speech from raters were judged to be more precise before fatigue tasks than after speech tasks. In particular, alveolar consonants were perceived as more imprecise. Based on these results, muscle fatigue appears to be a factor that may influence articulation at least for individuals with normal function.

In addition to fatigue, age has been recognized as a factor in decreased lingual function (Crow & Ship, 1996; Youmans, Stierwalt, & Clark, 2002; McAuliffe, Ward, Murdoch, & Farrell, 2005). Crow and Ship examined age related changes in tongue musculature in healthy young and elderly individuals. Fifty-two males and 47 females ranging from ages 19 to 96 years were included in the study. The IOPI was used to measure participants’ hand and tongue strength and endurance. Strength and endurance measures followed the protocol utilized with the IOPI. Similarly, Youmans and colleagues used the IOPI to obtain objective measures of tongue function in healthy adults and to examine the relation of tongue function to gender and age. Participants in the study were 18 males and 59 females ages 19-91 with no reported history of tongue impairment and neurologic disorders. To analyze results participants were divided into 5 groups based on age. All participants in the study attained similar tongue strength and tongue endurance measures except for the group of individuals age 70 and above who scored significantly lower than the four younger groups.

There are several investigations that have sought to define the characteristics of tongue strength, endurance, and speech intelligibility in individuals with dysarthria secondary to degenerative neurological diseases. Dworkin et al. (1980) conducted a study in which tongue force, rate of syllable repetition, and judgment of articulatory precision in individuals with amyotrophic lateral sclerosis (ALS) were measured. The study included 19 individuals with
ALS and 125 normal individuals. Anterior and lateral tongue forces were assessed with a pressure transducer connected to a pen-writing device that recorded pressures. Diadochokinetic rates of /p^, t^, k^/ were audio recorded, transcribed, and counted. The study revealed that the individuals with ALS had significantly lower tongue measures than the normal controls. Syllable repetitions were judged to be slower in the group with dysarthria. Dworkin et al. concluded that there was a high correlation between severity of dysarthria and speech defectiveness. The study also revealed that syllable repetition tasks may be more sensitive to tongue instability in participants with dysarthria. However, a connected speech sample would better represent the dynamic characteristics of tongue movement and provide more functional information about the affects of tongue endurance on articulatory precision.

Solomon et al. (1996) also conducted an examination of tongue strength and endurance characteristics in individuals with Parkinson disease. To examine tongue function and its relation to speech precision, IOPI measures for strength and endurance were obtained and speech samples were recorded. Results of their investigation revealed that tongue strength measures of the participants with Parkinson’s were significantly lower when compared to the neurologically healthy controls; however, measures of tongue endurance were not. In addition, the group of participants with Parkinson disease had significantly greater articulatory imprecision.

In a more recent study Solomon et al. (2000) examined the same variables of strength and endurance in individuals with Parkinson disease. Similar to the earlier findings of Dworkin et al. (1980) the participants with Parkinson disease had reduced tongue strength and endurance (Solomon et al., 2000). However, a more functional approach to assessing speech intelligibility was measured with discourse samples generated from the “Cookie Theft” picture. Speech intelligibility was judged to be less precise in the experimental group than in the control group (Solomon et al., 2000). Also tongue endurance was less in the experimental group than normal controls; however, differences in tongue strength were not significant (Solomon et al., 2000). These results differ from results of the Solomon et al.’s 1996 study, which found a significant degree of reduced tongue strength in the Parkinson’s group, but not endurance.

Additional investigations have sought to define the differences in tongue function between elderly individuals and those with neurologic conditions. McAuliffe and colleagues (2005) investigated the tongue strength, and endurance of individuals with Parkinson disease compared to neurologically normal individuals, which included older adults. The study
consisted of thirteen men and one woman with Parkinson’s ranging from ages 56 to 83 years. Experimental participants were included in the study if they exhibited a perceptible speech disorder as perceived by two speech-language pathologists. The experimental group was compared to two healthy groups: an older group (OC) consisting of eleven men and two women aged 58-79 years and younger group (YC) of nine men and six women ranging from ages 20 -31. The control group’s speech was judged by a speech-language pathologist to be normal.

Oral motor function was assessed and rated with the Frenchay Dysarthria Assessment (Enderby, 1983). Participants were also asked read a standard reading passage. Qualified speech pathologists listened to the passage and rated precision of consonants, length of phonemes and precision of vowels using a perceptual rating scale of 1 indicating no impairment and 4 indicating severe impairment. A tongue pressure transducer was utilized to specifically assess tongue function in each participant. The instrument consisted of an “air-filled rubber bulb connected to a pressure transducer” (McAuliffe et al., 2005, p. 668). Each participant was provided with instructions on the operation of the device for the measures collected. Nonspeech tasks included: maximal tongue pressure, fine tongue pressure control, repetition of maximal tongue pressure, fast rate of repetitions, and sustained sub maximal tongue pressure. Results of nonspeech tongue tasks revealed PD and OC groups demonstrated significantly reduced numbers of repetitions and tongue pressures on the fast rate task and significantly reduced endurance compared to the YC (McAuliffe et al., 2005). The analyses further indicated no significant differences in tongue function among the participants in the PD group, although judgments of their speech varied from mild to severe. Analyses from the perceptual judgments of the speech tasks revealed that the PD group demonstrated a mild to moderate degree of consonant imprecision (McAuliffe et al., 2005). Speech characteristics that were deviant in the PD group included length of phonemes and precision of vowels.

The majority of studies that have examined the relation of tongue function and speech measures in individuals with Parkinson disease have done so in a static manner with measures that were made in a single point in time in the course of the disease process. It would be of interest, given the progressive nature of Parkinson disease, to investigate these measures in a longitudinal manner to further examine the interrelation of measures of tongue function and speech.
Therefore, the purpose of the current study was to extend research on tongue function in Parkinson disease by exploring longitudinal affects of Parkinson disease on tongue strength. In addition, speech was examined to further understand the nature of the tongue strength measures relative to speech through the progression of the disease. It is expected that tongue strength will decrease in the second session and that speech perceptual measures will show a similar pattern.
METHODS

Participants

Participants in this study were six adults with Parkinson disease (Table 1). These adults were enrolled in a larger study examining longitudinal effects of Parkinson disease on cognitive and oral motor function. Aside from the diagnosis of Parkinson disease, the participants reported no history of additional neurological, psychiatric conditions, or any current or previous difficulty with oral motor function.

Table 1

<table>
<thead>
<tr>
<th>Participant</th>
<th>Gender</th>
<th>Age</th>
<th>Hoehn-Yahr</th>
<th>Time between testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>-</td>
<td>-</td>
<td>20 months</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>59</td>
<td>Stage 2</td>
<td>22 months</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>-</td>
<td>-</td>
<td>21 months</td>
</tr>
<tr>
<td>4</td>
<td>W</td>
<td>74</td>
<td>Stage 2</td>
<td>21 months</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>90</td>
<td>Stage 3-4</td>
<td>21 months</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>62</td>
<td>Stage 3</td>
<td>21 months</td>
</tr>
</tbody>
</table>

Instrumentation

The instrument utilized in this study was the Iowa Oral Performance Instrument (IOPI; See Figure 1). The IOPI is a portable instrument that has been adopted in a number of studies to examine tongue strength and endurance (Robin, Goel, Somodi, & Luschei, 1992; Robin, Somodi, & Luschei, 1992; Solomon et al., 2000; Solomon, Robin, Lorell, Rodnitzky, & Luschei, 1994; Solomon Robin, Mitchinson, VanDaele, & Luschei, 1996; Stierwalt et al. 1996). These studies have established the IOPI as a reliable device to measure tongue strength and endurance with intrajudge reliability reported at .97 and interjudge reliability reported to be .95 (Clark, Henson, Barber, Stierwalt, & Sherrill, 2003).
Figure 1. The Iowa Oral Performance Instrument (IOPI).

Procedure
Participants for the study were evaluated in their home, at their physician’s office, or at a university speech and hearing clinic. After obtaining informed consent, participants were asked to complete a number of oral motor function tasks.

**Measures of tongue function.** Tongue strength was measured as the maximum pressure that a person could exert on the IOPI device. The IOPI was configured to display peak pressure and the participants were told to begin the task when they were ready. Participants were instructed to place the bulb on the center of their tongue and press the bulb against the roof of their mouth as hard as possible. The digital screen on the IOPI was within view of the participants as visual reinforcement when they applied pressure to the tongue bulb. Participants also received verbal encouragement to achieve maximum pressure during the trials. Participants completed this procedure three times with a brief break between each trial while the examiner recorded the peak pressure. The highest pressure achieved of the three trials was recorded as the individual’s maximum pressure.

**Measures of speaking performance.** Two speech samples were collected for this study. Each of the participants wore a headset microphone which placed the microphone at a uniform distance for each of the recordings. The samples were collected on a Sony digital audiotape recorder model TCD-D100.

The first sample consisted of a group of 10 sentences ranging from five to ten words per sentence. The sentences were selected from the Assessment of Intelligibility of Dysarthric Speech, (Yorkston & Beukelman, 1984) which is carefully balanced for articulatory complexity and other factors that may influence overall intelligibility. The second speech sample was a
standard reading passage, written at the fifth grade level to account for differences in education across participants. The reading passage was selected from the Gray Silent reading Test (GSRT, Wiederholt & Blalock, 2000) reading test.

**Perceptual Speech Measures.** A group of five speech-language pathologists, experienced in working with individuals with dysarthric speech, rated the samples according to five components of speech execution: respiration, phonation, resonance, articulation; and overall speech defectiveness. Each component of speech execution included subcomponents and their definitions (see Appendix A). A numeric rating scale was developed to describe the severity of each of the speech systems and their subcomponents. The rating scale ranged from 1 to 5, with one indicating normal, 2 indicating a slight difference, 3 indicating a noticeable difference, 4 indicating a markedly noticeable difference, and 5 indicating a severe difference.

Five speech-language pathologists, all having obtained the certificate of clinical competence (CCC), rated the speech samples. Each rater had 3 or more years experience in diagnosing and treating the dysarthrias. Table 2 further describes the raters’ years of holding clinical competence, years experience in dysarthrias, and current settings in which they work.

<table>
<thead>
<tr>
<th>Raters</th>
<th>Years holding CCC</th>
<th>Years experience with dysarthria</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>Acute Care</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>3</td>
<td>University</td>
</tr>
<tr>
<td>3</td>
<td>17</td>
<td>9</td>
<td>Rehabilitation</td>
</tr>
<tr>
<td>4</td>
<td>9</td>
<td>9</td>
<td>Rehabilitation</td>
</tr>
<tr>
<td>5</td>
<td>9</td>
<td>9</td>
<td>Rehabilitation</td>
</tr>
</tbody>
</table>

Prior to making perceptual judgments, raters were instructed on the rating system, provided time to review the definitions of the subcomponents, and questions on the rating system were addressed. None of the raters had heard the samples before, nor did they have any familiarity with the purpose of the study other than the information provided in the consent form. Each rater received the necessary number of rating sheets for the participants examined in this study. They were told to “listen to the following samples in which some would sound more different than others”. Rating sessions took place in a rehabilitation treatment room, hospital
office, university office, or home. Samples were played on a laptop computer and amplified with desktop speakers. Participants rated the samples for approximately one hour and 30 minutes in one sitting. Recordings were replayed once, only as requested during rating sessions. Analysis

To examine longitudinal effects of Parkinson disease on tongue strength, maximum pressures obtained on the IOPI in session one and session two were compared with a nonparametric Wilcoxon signed ranks test. The Wilcoxon was also conducted to examine perceptual judgments of speech across the two sessions. Although perceptual judgments were made across a variety of speech components, the ratings selected as dependent measures to indicate tongue function for the purposes of this investigation were consonant imprecision, vowel imprecision, rate, and overall speech defectiveness.
RESULTS

Table 3 contains the IOPI measures obtained from the participants for each testing session. A comparison was conducted using the one-tailed Wilcoxon signed rank test. The statistic obtained was $Z = 2.201$, with a probability of 0.0156. Figure 2 displays the average IOPI for the group across sessions.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Session #1</th>
<th>Session #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>42 kPa</td>
<td>30 kPa</td>
</tr>
<tr>
<td>2</td>
<td>51 kPa</td>
<td>48 kPa</td>
</tr>
<tr>
<td>3</td>
<td>66 kPa</td>
<td>27 kPa</td>
</tr>
<tr>
<td>4</td>
<td>35 kPa</td>
<td>33 kPa</td>
</tr>
<tr>
<td>5</td>
<td>67 kPa</td>
<td>63 kPa</td>
</tr>
<tr>
<td>6</td>
<td>56 kPa</td>
<td>47 kPa</td>
</tr>
</tbody>
</table>
To explore whether perceptual judgments changed across the two testing sessions, additional one-tailed Wilcoxon tests were performed. Those tests revealed the following results, $Z_{1,5} = -0.949; p = 0.343$, $Z_{1,5} = -1.134; p = 0.257$, $Z_{1,5} = -0.647; p = 0.518$, and $Z_{1,5} = -1.16; p = 0.244$ for consonant imprecision as shown in Figure 3, vowel imprecision as shown in Figure 4, rate as shown in Figure 5, and overall speech defectiveness respectively as shown in Figure 6. Figures 3-6 display the average ratings of the judges for each testing period.

Figure 2. Average tongue strength measures means and (Standard Deviations) obtained by the six subjects for the first and second sessions.
Figure 3. Judge’s perception of subjects’ consonant imprecision (Means and Standard Deviations) for the first and second sessions.

Figure 4. Judge’s perception of subjects’ vowel imprecision (Mean and Standard Deviations) for the first and second sessions.
Figure 5. Judge’s perception of subjects’ rate (Means and Standard Deviations) for the first and second sessions.

Figure 6. Judge’s perception of subjects’ overall speech defectiveness including respiration, phonation, articulation, and resonance.
DISCUSSION

The purpose of this study was to examine longitudinal measures of tongue strength in individuals with Parkinson disease. In addition, speech was examined to further understand the nature of the tongue strength measures relative to speech through the progression of the disease.

The results indicated that for this group of six individuals with Parkinson disease, tongue strength significantly declined as time progressed. While the group average from the first session was within the normal range, the second measure indicated reduced tongue strength (Youmans & Stierwalt, 2006). The finding of reduced strength for the second testing session in this study support some of the earlier reports of Solomon et al. (1995), Solomon et al. (2000), and McAuliffe (2005). Solomon et al. (1995) examined 19 individuals with mild to moderate Parkinson disease and neurologically normal individuals. Their results indicated that tongue strength measures for the group with Parkinson disease was significantly lower than normal controls. These findings are not compatible, however, with Solomon et al. (2000) which examined tongue strength, endurance, and hand function in 16 adults with Parkinson’s. Using the IOPI to measure these functions they did not find significantly reduced tongue strength. The different results between the two studies may be the inclusion of individuals with greater severity of Parkinson’s in the former study.

When individual data are viewed from the current investigation, it is notable that some participants showed more decline in tongue pressures than other participants. In particular, one subject depicted minimal decline in the second session whereas another subject showed a large decrease in strength. Although age related changes in strength measures have been documented, (Youmans & Stierwalt, 2006) that is clearly not the influencing factor in this group of participants. Reports of age related changes in tongue strength measures include declining strength with increasing age. Interestingly, our oldest subject had the greatest tongue strength measures. Individual variability across subjects in this group creates a certain degree of obscurity in the results. However, the results point to an overall trend of declining tongue strength with some definite outliers with regard to the extent of change.

In addition to significant differences in tongue measures across time, perceptual judgments of the subjects’ speech changed between the two testing sessions. As with the strength measures the trend was reduced performance in the second session, evidenced in this
study by lower ratings in the first session than the second session. While the differences in ratings across time did not reach statistical significance, they do demonstrate a consistent change in perceptual characteristics of speech across time in individuals with Parkinson disease. Solomon et al. (1996) detected no overall speech defectiveness in their group with Parkinson disease but they did detect a significant correlation between measures of tongue strength and articulatory imprecision. The mean strength measures obtained in the Solomon study were higher than the one obtained by the group in the current study, thus, the greater measure of tongue strength may have been reflected in greater impressions of their overall speech. However, the correlation to articulatory ability is of interest. In our study consonant and vowel imprecision both showed change over time. That observation coupled with declining tongue strength suggests a relationship between the measured parameters. Such a relation is intuitive given the tongue’s role in articulatory placement and vowel definition (Ferrand, 2001).

Perceptual judgments for the current study were greater (indicating greater impairment) for consonant imprecision, vowel imprecision, rate, and overall speech in the second session, yet not statistically significant. These findings support the results of McAuliffe and colleagues (2005) who also found differences in the speech of participants with Parkinson disease that were only mildly and moderately deviant; specifically, consonant imprecision and vowel imprecision. Consonant imprecision was rated as “just noticeable” to “moderate” impairment. Similarly, vowel imprecision was evident; however, in seven of the 14 PD participants, the parameter was rated as just noticeable.

Although tongue function and measures of speech perception were showed to deteriorate over time in the current study, the relationship between the two remains unclear. Unlike their earlier study, Solomon et al. (2000) found no significant correlation between tongue measures and ratings of speech precision. Similarly, McAuliffe and colleagues, suggest that there may not be a relationship between tongue function and perception of speech integrity. An analysis of PD participants’ speech impairment and measures of tongue tasks in the latter study revealed that participants, despite severity of speech impairment, had similar tongue function measures (McAuliffe et al., 2005). Their finding suggested that tongue measures may not be viable indicators of severity of speech impairment.

It can also be postulated that the severity of the disorder may determine the overall speech defectiveness (Solomon, 1996). Solomon discovered that tongue strength was
statistically significant to severity of disease in that tongue strength tended to be negatively correlated with overall speech defectiveness and articulatory imprecision; even if speech was perceived as normal or mildly defective. This trend is likely to have occurred in the present study as tongue strength and overall speech perception deteriorated. It is possible the severity of the disorder may have caused a decline in tongue strength, thus overall speech perception. However, if the relationship between severity of the disorder and speech perception exists, then the notion that tongue strength directly effects speech is additionally supported by the present study. The fact that the current investigation studied function over time and that deterioration, though variable, was consistent across participants makes a stronger statement about the relation than a single measure could make. Additional study is warranted that incorporates a larger sample size and additional sampling sessions to support this preliminary evidence.
CONCLUSION

In our group of individuals with Parkinson disease we found that tongue strength declines significantly over time. The decline in tongue strength parallels deterioration in speech resulting in consonant imprecision, vowel imprecision, altered rate of speech and overall speech defectiveness. While these findings are preliminary and based on a small group of participants they suggest a relation that warrants further examination.
APPENDIX A: PERCEPTUAL RATING SHEETS

Florida State University
Neurocognitive, Neurocommunication Laboratory
Perceptual Speech Analysis

Sample_________________________
Date___________________________

Scale

Components of Speech Execution

Respiration
Breath support
Intensity – ( loud soft variable )
Intensity – decay over utterance
Stress pattern ( excess equal variable )

Phonation
Pitch – ( high low variable )
Pitch variation
Breathiness
Hoarseness
Strained-strangled
Wet/gurgly

Resonance
Nasality
Hypernasality
Hyponasality

Articulation
Consonant imprecision
Vowel imprecision
Rate – ( fast slow variable )

Overall Speech Defectiveness
APPENDIX B: PERCEPTUAL SCALE DEFINITIONS

Perceptual scale  
Definitions

Respiration
  **Breath support:** Enough to support normal breath groups, without excessive pausing to breathe while talking.
  **Intensity:** Loudness should be suitable for the environment.
  **Intensity:** Loudness should be maintained throughout an utterance.
  **Stress Pattern:** Syllable / word stress should fall within the boundaries of normal prosody. There are instances where the stress pattern may include both excess and equal qualities.

Phonation
  **Pitch:** Considering the age and gender of the individual, the pitch is within the normal range.
  **Pitch variation:** There is normal variation of pitch to account for prosodic information.
  **Breathiness:** The voice contains a breathy quality without other noticeable problems.
  **Hoarseness:** The voice contains some breathiness combined with a low pitch and hard onset.
  **Strained-strangled:** The voice sounds very pressed and tight throughout an utterance.
  **Wet/gurgly:** The voice has a wet, or gurgly quality as if there is liquid on the vocal folds.

Resonance
  **Hypernasality:** Too much nasal resonance results in a “nasal” quality, air escaping from the nose and difficulty making consonants.
  **Hyponasality:** Too little nasal resonance sounds as though someone has a bad head cold.

Articulation
  **Consonant precision:** The speech sounds are produced crisply and are easily discernable.
  **Vowel precision:** Vowels are produced without prolongation or distortion.
  **Rate:** The rate of production is suitable for the situation without abnormal fluctuation.

Overall Speech Defectiveness The speech produced, overall is intelligible and free of obvious distracting qualities.
APPENDIX C: FSU HUMAN SUBJECTS COMMITTEE APPROVAL LETTER

Office of the Vice President For Research
Human Subjects Committee
Tallahassee, Florida 32306-2763
(850) 644-8633 . FAX (850) 644-4392

APPROVAL MEMORANDUM

Date: 11/3/2005

To: Julie Stierwalt
Mc 1200
Dept.: COMMUNICATION DISORDERS

From: Thomas L. Jacobson, Chair

Re: Use of Human Subjects in Research
Perceptual characteristics of speech in individuals with progressive neurological conditions

The forms that you submitted to this office in regard to the use of human subjects in the proposal referenced above have been reviewed by the Human Subjects Committee at its meeting on 10/12/2005. Your project was approved by the Committee.

The Human Subjects Committee has not evaluated your proposal for scientific merit, except to weigh the risk to the human participants and the aspects of the proposal related to potential risk and benefit. This approval does not replace any departmental or other approvals which may be required.

If the project has not been completed by 10/11/2006 you must request renewed approval for continuation of the project.

You are advised that any change in protocol in this project must be approved by resubmission of the project to the Committee for approval. The principal investigator must promptly report, in writing, any unexpected problems causing risks to research subjects or others.

By copy of this memorandum, the chairman of your department and/or your major professor is reminded that he/she is responsible for being informed concerning research projects involving human subjects in the department, and should review protocols of such investigations as often as needed to insure that the project is being conducted in compliance with our institution and with DHHS regulations.

This institution has an Assurance on file with the Office for Protection from Research Risks. The Assurance Number is IRB00000446.

cc: Tamika Prendergast
HSC No. 2005.796
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BIOGRAPHICAL SKETCH

Tamika Prendergast is a graduate student in the Department of Communication Disorders. She received her Bachelor of Science degree in Communication Disorders at Florida State University. Her clinical and educational experiences include dysphagia, aphasia, cognitive-linguistic disorders, speech disorders, and child language and articulation disorders. She is a member of the National Society of Collegiate Scholars and National Student Speech-Language and Hearing Association.