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OROFACIAL SOMATOSENSORY CHANGES IN PARKINSON'S DISEASE

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ABSTRACT

There are a variety of sensory and motor deficits associated with Parkinson's disease (PD). One notable speech symptom is dystharia, which impacts the muscle coordination necessary for speech production. Currently, diagnosis and treatment largely focuses on the motor aspects of speech deficits and is lacking a full appreciation of somatosensory aspects. The purpose of this study is to identify changes in orofacial touch sensation in PD. The differences in sensation might influence the skills in speech and swallowing of people with PD. One 66-year-old participant with Parkinson's disease and one 67-year-old healthy control were recruited. Participants completed pure-tone hearing thresholds, self-reported basic health information, and provided a speech sample. They were assessed bilaterally on the lips and tongue using 2-point discrimination discs and Von Frey Hair monofilaments for detection and discrimination threshold estimates. The participant with PD displayed lower levels of sensation on all 3 tests, for all body locations tested. The only exception was 2-point discrimination on the right lip. These findings support the hypothesis of the study and can be used for further analysis of orofacial somatosensory changes associated with PD. Future research should focus on speech therapy techniques to accommodate individuals with decreased orofacial somatosensation in order to create a better quality of life for individuals with disease.

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Chapter 1

Introduction

Parkinson's Disease (PD) is a degenerative neurological disease that affects 1-2% of people over the age of 60. The neuropathological process of PD progresses throughout 6 stages and begins with the formation of Lewy bodies, which are abnormal aggregates of protein that invade nerve cells. As progression continues to stages 3-4 the forebrain and midbrain are affected, thus causing dysfunction to the substantia nigra and the beginning of symptoms. By the end stages (5-6) the neocortex is involved as higher order sensory and prefrontal processing becomes damaged. Due to the loss of dopaminergic cells within the basal ganglia, people with PD have irregular processing of sensory information. Consequently, the preparation and execution of voluntary movements are disturbed. The exact cause is currently unknown; however, research points to a variety of environmental and genetic influences (Sveinbjornsdottir, 2016).

Although PD itself does not directly cause death, there are a number of related physical symptoms that cause fatal complications such as thrombosis, pneumonia, and falls. The risks associated with the symptoms of PD result in a mortality rate that is 35-65% higher than healthy age and sex matched controls (Factor, 2008). The progression of the disease varies from individual to individual but the estimated advancement from one stage to the next is about 2-2.5 years. The approximated timeline is expected to be slower for properly treated patients (Factor, 2008). Although there is no cure for PD, there are numerous ways to alleviate the major symptoms and create a better quality of life for those affected.

PD causes many different sensory and motor disturbances, which can have negative impacts on daily living. A very common symptom of the disease is change in speech, however, research into the specific causes is lacking. Similarly, another symptom is reduced sensation, yet research focuses mainly on how changes in sensation may impact the motor issues associated with the disease. It is important to identify whether there are changes in orofacial touch sensation in people with PD. These changes might influence the skills in speech and swallowing people with PD, consequently therapy should be directed towards improving or compensating for the decrease in sensation.

This research used 2-point discrimination discs to obtain discrimination threshold estimates and Von Frey Hair Monofilaments to obtain tactile discrimination and detection threshold estimates. Testing was completed on the right and left lip and tongue on a patient with PD and the results are compared to a healthy age and sex-matched control. This paper will analyze the sensory changes associated with PD and contribute to the limited investigations on somatosensory orofacial changes.

Chapter 2

Literature Review

Symptoms

Many of the early symptoms of PD may go unnoticed and because of this imprecise onset, clinical diagnosis may be several years later. The time gap in conjunction with continuous improvements in health care and drug therapy make it difficult to ascertain an exact life expectancy rate. The most common physical symptoms that begin early in disease progression include tremors, fatigue, reduced energy, and joint stiffness. The patient may take longer to complete daily activities and engage in slower or more effortful movements. Other characteristics of early Parkinson's disease include hoarseness in the voice, sleep disruptions, and bladder disturbances (Factor, 2008).

The clinical symptoms assessed in diagnosis include a variety of motor and non-motor disturbances. Typically, the first noticeable changes are motor symptoms such as a shuffling gait, pill rolling with the thumb and pointer finger, a stooped posture, and rigidity. One defining feature of PD is a hypokinetic gait that causes the individual to lean forward, walk on the toes and forefeet, and shuffle with shorter steps (Factor, 2008). Due to bradykinesia, individuals with PD often have an expressionless face and smaller hand writing. Non-motor clinical symptoms include lack of motivation and emotional involvement, excessive daytime sleepiness, nighttime sleep disorders, and constipation. Furthermore, depression, anxiety, and dementia often become a larger burden to the patient than the motor issues (Sveinbjornsdottir, 2016). The distinctive sensory changes accompanying PD include deficits in olfaction, taste, body pain, and

restlessness. Oftentimes patients will describe vague, abnormal sensations inside the body and most typically in the limbs (Sveinbjornsdottir, 2016).

Many of the speech symptoms manifest in the earlier stages of PD. The main characteristics are reduced vocal loudness, breathy or hoarse voice, and hypokinetic articulation. Due to damage in the central nervous system, patients experience dysarthria, which results in disturbances such as incoordination and slowness in the muscular control of speech. Dysphagia also occurs throughout the progression of the disease and may cause weight loss or aspiration pneumonia. The patient's swallow is often disrupted at any or all stages, including bolus formation, initiation of the swallow, and decreased pharyngeal response. Despite great efforts to reduce motor disturbances associated with the disease, therapy to improve speech and swallowing disorders have been imprecise and inefficient (Factor, 2008). Typically, speech therapists focus on the motor aspects of speech deficits and overlook the direct impact of sensory changes, thus direct testing of somatosensory perception is limited.

In an effort to understand the specific pathophysiologic mechanisms affecting speech dysfunction in PD, numerous studies investigated specific areas of the orofacial system. For instance, phonetic analyses techniques revealed that as the disease became more severe, articulation and fluency issues increased (Ho, 1999). Electromyographic studies of orofacial movements demonstrated that patients reduced the size and speed of jaw movement during speech, which explains hypokinetic speech symptoms (Forrest, 1989). Prosaic abnormalities such as speaking at a rapid rate, stuttering, and palilalia have also been documented. One study found the resonant quality of patients' voices became altered and appeared to sound like a "foghorn" as a result of reduced velopharyngeal movement and atypical tongue posture (Hoodin, 1989). While many different factors impacting the speech symptoms in PD are acknowledged,

the functional changes that serve as the basis for understanding remain unclear. Future investigations are necessary to explore supplementary reasons such as reduced muscle activation, internal cueing, and deficits in somatosensory feedback (Factor, 2008). It is possible impaired somatosensation causes individuals to revert back to the "training" stages of speaking. The DIVA (Directions into Velocities of Articulators) Model explains how speech is learned when infants babble by organizing a speech sound map through the use of auditory and somatosensory feedback control systems (See Figure 1). Once a speech sound map is properly formulated, an individual can easily produce the sounds in which they have previously learned via their feed forward control system. When a disruption in the brain occurs, such as in a neurologic disease, the individual experiences an interruption in their feed forward control system and must relearn how to refine either speech planning, speech execution, or both in order to accurately produce speech. Similar to when infants learn to babble, the relearning for individuals with neurologic disease may also follow a similar pattern of combining auditory and somatosensory feedback into a speech sound map. By utilizing the DIVA Model for individuals with dysarthria, somatosensation plays a very prominent role in maintaining effective speech mechanisms (Tourville & Guenther, 2011).

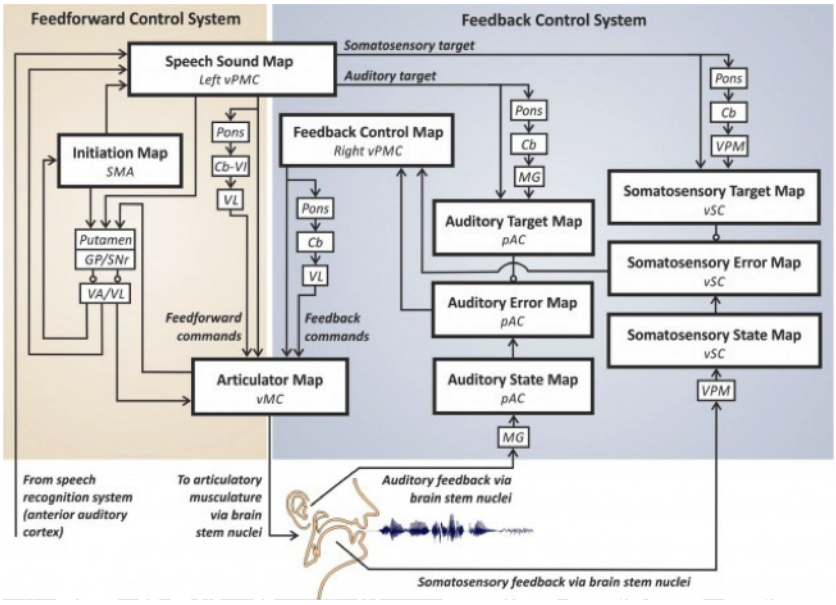


Figure 1. DIVA Model (Tourville & Guenther, 2011)

Somatosensation in Parkinson's Disease

In addition to speech symptoms, somatosensory changes associated with the disease also have unknown pathophysiological mechanisms. The sensory deficit that receives the most attention is loss of olfaction because it is the most notable symptom for patients with PD. Sobel and associates (2000) found that a sniffing impairment, rather than a smelling impairment is a main contributor to the overall olfaction deficits experienced by patients. Seeing that olfaction is a sensorimotor function, a common belief prior to this study was that the deficit occurred as a result of Lewy bodies permeating throughout the olfactory cortex. In Germany, The Department of Human Locomotion (2003) completed further research on sensation in differing parts of the body. They determined a decrease in sensitivity of the soles of the feet, which correlated with an increase in the motor disturbances of patients with PD (Pratorius). Similarly, Nolano and associates (2008) tested peripheral sensory nerves on the dorsum of the hand and foot to find a loss of epidermal nerve fibers, intrapapillary myelinated endings, and Meissner's Corpuscles in

patients with PD. The patients also experienced an increase in tactile and thermal thresholds as well as reduction in mechanical pain perception. Doty et. al (2014) sought to establish definitive documentation about the influences of PD on point pressure sensitivity (PPS). Prior investigations of PPS led to disparate discoveries, all of which used a less reliable model of non-forced choice threshold tests. Doty et. al's findings only further contributed to the controversial nature of sensitivity for patients with PD. Their results displayed stable relative threshold sensitivity throughout all locations for both the PD group and the control group.

The most detailed investigation into somatosensation in the orofacial region occurred in 1986 when Schneider et. al found that patients with PD performed significantly worse than controls in tasks assessing sensorimotor function. Somatosensory deficits were also observed with reach-to-eat tasks. The studies showed that because sensory control is altered in PD, individuals visually fixated for a longer period of time on an object they were reaching for when compared to the control group. As there was delay in recognition of grasping the object, there may also be a delay in recognition of an object touching the mouth or tongue (Sacrey, 2012). A study on laryngeal somatosensory changes showed that patients with PD had speech related deficits related to weak respiration and phonation abilities. These weakened abilities were a result of abnormal somatosensory function in their laryngeal mechanism (Hammer, 2009). Regardless of knowledge on speech disorders and sensation changes as a result of PD, there is still information lacking about the impact of orofacial sensory deficits on the speech and language of patients with PD. An important feature of guiding therapy for patients is to observe if there is a lack of sensation in the lips and tongue of patients with PD.

Diagnosis and Therapy

Diagnosis of the disease typically occurs in 3 stages and begins by assessing motor disturbances such as slowness in initiating voluntary movements with a progressive reduction in speed of repetitive actions. Additionally, muscular rigidity and resting tremors are observed in the first stage of diagnosis. The second stage excludes the disturbances from having any other specific neuropathologic cause. Lastly, the disease is confirmed by three supportive criteria for PD such as unilateral onset of symptoms, persistent asymmetry affecting side of onset, or a strong response to Levodopa (Sveinbjornsdottir, 2008).

Medical treatment of PD involves the drug Levodopa, which is synthesized in the brain into dopamine and is proven to reduce many symptoms of PD. Exercise programs along with occupational, physical, and speech therapy have also been shown to alleviate symptoms. The most intensive speech therapy program in existence is the Lee Silverman Voice Treatment (LSVT). Patients undergo 60 minute, 4-day sessions for 4 consecutive weeks that incorporate 3 unique approaches. LSVT trains amplitude as a single motor control constraint, enforces high effort, and addresses multiple neurophysiological deficits typically seen in patients with PD. Profound improvements for speech and orofacial function are accomplished because the methods focus on recalibrating the motor and perceptual systems involved in speech production. For example, sensorimotor training teaches patients to use louder speech on a recording. When the audiotape is played back, patients recognize that what they consider to be louder speech is actually within normal limits. The discrepancy between perceived loudness and actual loudness illuminates abnormal sensory processing (Sapir, 2011). People with PD have abnormal sensory processing with hearing, taste and smell reception, and changes in vision, however, current therapy and diagnosis do not address somatosensory changes in the orofacial region.

The goal of speech therapy for patients with PD is to maintain communication throughout progression of the disease. Techniques focus on improvement in one or all of the 5 domains of speech: respiration, resonance, phonation, articulation, and prosody. The most notable parkinsonian speech changes result from hypokinetic dysarthria. Treatment for hypokinetic dysarthria includes rehabilitation of stress patterns (prosody), intonation (prosody), increasing vocal loudness and quality (phonation), and articulation drills (articulation) (Rolland, 2013). In 2012, Herd and colleagues compared 9 different speech therapy interventions for patients with PD. The interventions included LSVT, Articulation focused LSVT, Respiratory Therapy, Alphabet Board, Pacing Board, Altered Auditory Feedback, Traditional Rate Reduction Therapy, Prosodic Exercises with Cueing, and Prosodic Exercises Without Cueing. Herd et. al compared novel treatment approaches to alternative approaches, however, neither novel nor alternative approaches focus on sensation training or compensation. If orofacial somatosensory changes in PD prove to be prominent, then it is essential to incorporate sensory training into therapy, such as performing specific orofacial sensory tasks. An alternative solution to sensory training would be compensation, which focuses on utilizing skills of the other senses to improve speech due to a decrease in orofacial somatosensation.

Purpose of the Study

This study aims to compare orofacial touch sensation in a person with PD to a healthy age and sex-matched control. The differences in sensation might influence the skills in speech and swallowing of people with PD. Evaluations will be made using Von Frey Hair Monofilaments and Two-point Discrimination discs, which have yielded reliable and valid results in testing orofacial somatosensation in a healthy young population (Etter, 2014). It is

hypothesized people with PD experience changes in lip and tongue somatosensation that affect their voice, speech, and swallowing skills.

Chapter 3

Methods

Participants

One patient with Parkinson's disease was recruited for this study and his results were compared to a healthy age and sex matched control. The participant with PD (PPD) was a 66-year-old male and the control was a 67-year-old male. Prior to testing, participants completed screening information and were unaware of the specific assessment procedure. Through self-report, participants conveyed they were alert, able to consent, and met all the criteria for testing.

The screening information began with a 5-point scale to report current general health. Options included "poor, fair, good, very good, or excellent." The healthy aging control reported feeling "excellent" and the PPD reported feeling "good-very good." Pure tone hearing thresholds were completed at 500, 1000, and 2000, and 4000 Hz along with an average speech usage assessment using a 5-point scale with increasing levels of daily speech usage (Baylor, Yorkston, Eadie, Miller, & Amtmann, 2008).

A speech sample was obtained to assess the varying levels of speech and sounds within the participants' speech repertoire. Although data from the Speech Sample was taken, the results were not analyzed for this study. Beginning with sounds in isolation and working up to spontaneous storytelling, the speech sample protocol included: Sustained Vowel /a/ and /i/, Sequential Motion Rates /pa/, /ta/, /ka/, Alternating Motion Rates /pataka/, Automatics (count 1-20, days of the week, months of the year), Word Repetition, Words of Increasing Length, Repeated Trials/Multisyllabic Words, Sentences, Reading the "Grandfather Paragraph," and Storytelling. A detailed version of the Speech Sample protocol is provided in Appendix A**.**

Participants denied having any recent surgeries, anesthetics, and lesions to the orofacial region, or having a speech disorder. Participants confirmed or denied any history of smoking and any use of brass or woodwind instruments.

Testing Procedures

Three different tests were completed while patients sat upright in a comfortable position. All three assessments were completed in one session and test time was approximately 1-1.5 hours. Two-point discrimination threshold estimates were completed using discrimination discs and then tactile detection and discrimination estimates were completed using Von Frey Hair monofilaments. Four different locations of the orofacial region were chosen as the testing sites. Sensorimotor function of the right and left lower lip as well as the right and left sides of the tongue were assessed. The tongue was assessed at the lateral edge just posterior to the tongue tip. The right and left lower lip was assessed at the midpoint between the midline of the lip and the oral angle.

The three tests were completed in the same order for both participants with the two-point discrimination occurring first, followed by tactile detection, and then tactile discrimination. The presentation body location was randomized for each test and participants were asked to close their eyes to ensure that the patient could not see the type or timing of the presented stimuli. A blindfold was not used in order to avoid unnecessary distractions with excess facial stimulation. When testing the lips participants were instructed to relax their jaw with their mouth slightly open. When testing the tongue participants were instructed to slightly stick out their tongue so the researcher could use the probe to touch the tongue without touching other parts of the body. If needed, participants were instructed to close their mouth, swallow, or lick their lips throughout the testing. No feedback regarding correct or incorrect responses was given.

The testing involved three research investigators. The primary investigator trained two researchers for multiple sessions, which involved practicing the procedure on each other. Researchers also observed a data collection assessment prior to testing a research participant to ensure proper techniques were used. During testing, there were two investigators present, one to conduct the research and the other to record the data.

Two Point Discrimination Threshold Testing

By utilizing the Method of Limitations Approach (MoL), the two-point discrimination threshold was determined with a Baseline Discrim-A-Gon 2-point discrimination disc (Gescheider, 1997). The researcher held the disc at a perpendicular angle to the skin. The disc was pressed down on the area being tested in order to slightly indent the skin and was then removed. Based on the MoL approach, the starting stimulus was at the supramaximal level so the patient could easily identify two different pressure points on the testing location. For this test, the supramaximal level was 8mm. The researcher decreased the distance between the two points by 1mm each trial and asked participants when they were able to detect only one pressure point by raising a hand. The researcher then began with one point of pressure and increased distance between the two points by 1mm each trial. Participants were asked to inform the researcher when they were able to detect two different pressure points by raising a hand. The researcher randomly presented multiple single point stimuli (between 1 and 3 times) in order to eliminate a guessing pattern of the distances between all the pressure points along the disc. In total, the researcher completed 3 ascending and 3 descending trials and recorded the millimeter at which the participant was able to detect one or two pressure points, depending on the type of trial. Scoring was based on the average of all 6 testing trials in millimeters. Two-point discrimination took about 5 minutes to complete.

Tactile Detection Threshold Testing

Tactile detection thresholds were obtained by utilizing Von Frey Hair monofilaments. The filaments ranged from 0.008g up to 300g, however, we did not test detection above 15.0g for safety purposes. In order to determine threshold estimates, 0.008, 0.02, 0.04, 0.07, 0.16, 0.4, 0.6, 2.0, 4.0, 6.0, 8.0, 10.0, and 15.0g were used as the target forces. Using 15.0g ceiling from the manufacturer, the smallest intervals available were used for testing. The filament was held perpendicular to the area being tested and the tip was pressed onto the surface until the filament buckled.

During testing, the researcher began using the 2.0g monofilament. Participants were instructed to inform the researcher when they felt the tactile stimulus being presented following two sequential intervals. Threshold estimates were determined using a two-alternative forced choice (2-AFC) paradigm (Baylor, pg. 191-8). The researcher would say “trial one...trial two” as they randomly presented the stimulus in one of the two trials. Following trial two, participants would hold up one or two fingers to indicate which trial contained the stimulus. If participants were correct for three consecutive intervals, the researcher decreased the stimulus to the next lower target force level. If participants were incorrect once or if a missed response occurred, the researcher increased the stimulus to the next higher target force level. Thresholds were obtained after a participant had five crossings or reversals of a given monofilament. A participant’s stopping point was recorded after accurately determining a target force level five times. There was no minimum or maximum number of trials set prior to testing. The tactile detection thresholds took 15- 20 minutes to complete.

Tactile Discrimination Threshold Testing

Again, employing the Von Frey Hair Monofilaments, tactile discrimination threshold testing was similar to tactile detection testing. Participants were seated in a comfortable position and the lips, upper, and lower tongue were tested bilaterally. In this procedure, participants were informed that they would feel pressure in both trial one and trial two. They were asked to hold up one or two fingers to indicate which corresponding trial they felt a “stronger” or “higher” pressure from. The researcher began the discrimination trial with the monofilament that was three force target levels above their discrimination threshold estimate for that site. For example, if a participant's tactile detection threshold estimate was 0.4 g, the researcher began tactile discrimination with 4.0 g. As with detection estimates, the same rules applied for correct, incorrect, and stopping points. Discrimination testing took approximately 15-20 minutes to complete.

Chapter 4

Results

The healthy control participant had a pure tone average of 38.75dB in the right ear and 35dB threshold average in the left ear. The PPD had a pure tone average of 26.25dB in the right ear and 33.27dB in the left ear. Both participants denied any history of smoking and the PPD confirmed a short history of playing an instrument. The control indicated feeling "excellent" in terms of general daily health and the PPD indicated feeling "good-very good." Both participants identified average daily speech usage as a level 3, which is a moderate amount. Results can be found in table 1.

Table 1. Demographic Data

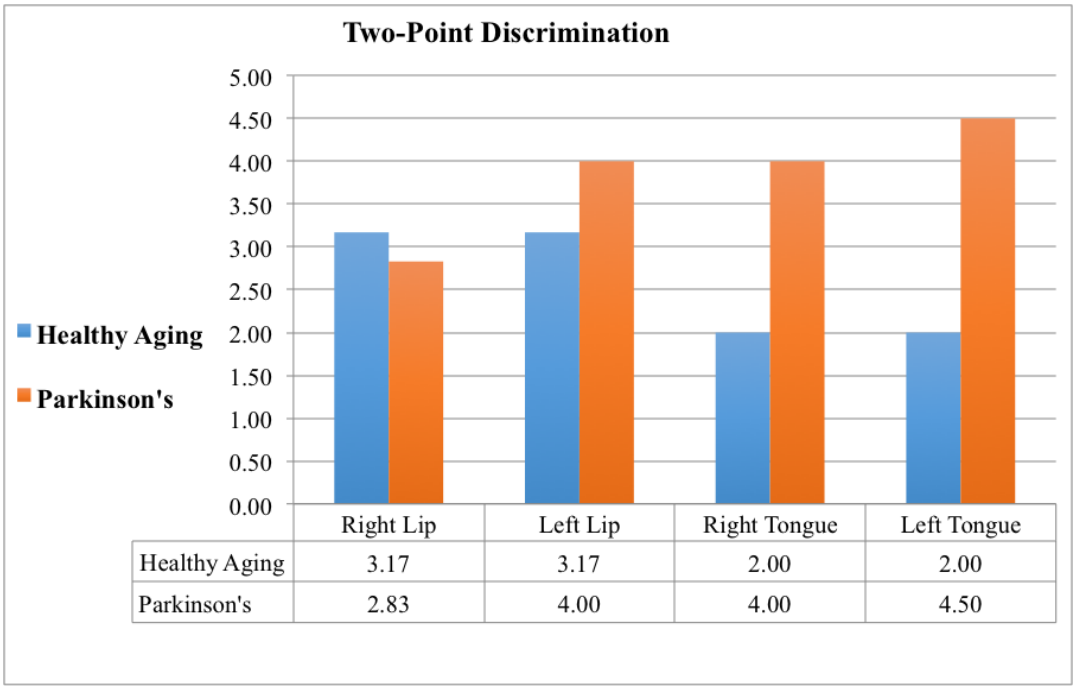
	Healthy Aging Control	Person with Parkinson's
Age	66	67
Sex	Male	Male
PTA-Right	38.75	26.25
PTA-Left	35dB	33.27dB
Smoker?	No	No
Musical?	No	Trumpet
Health	5 (excellent)	3.5 (good-very good)
Speech Usage	3	3

2-Point Discrimination Estimates

The results of the 2-point discrimination estimates were found using the 2-point discrimination discs (see appendix B) and can be found in Figure 2. The y-axis is measured in millimeters and represents the testing location. The results display estimates for the right and left lip and tongue. The data for the control on the right lip was a 3.17mm threshold estimate, which

was higher than the PPD who had 2.83mm threshold estimate. For the left lip, the control had lower thresholds with 3.17mm and the PPD had 4mm. The control was also lower on the right and left tongue with 2mm for each and the PPD had 4.00mm on the right tongue and 4.50mm on the left tongue. The majority of the locations tested support the hypothesis that PPD have less somatosensory sensitivity than healthy aging individuals.

Figure 2. Two-Point Discrimination Threshold Estimates



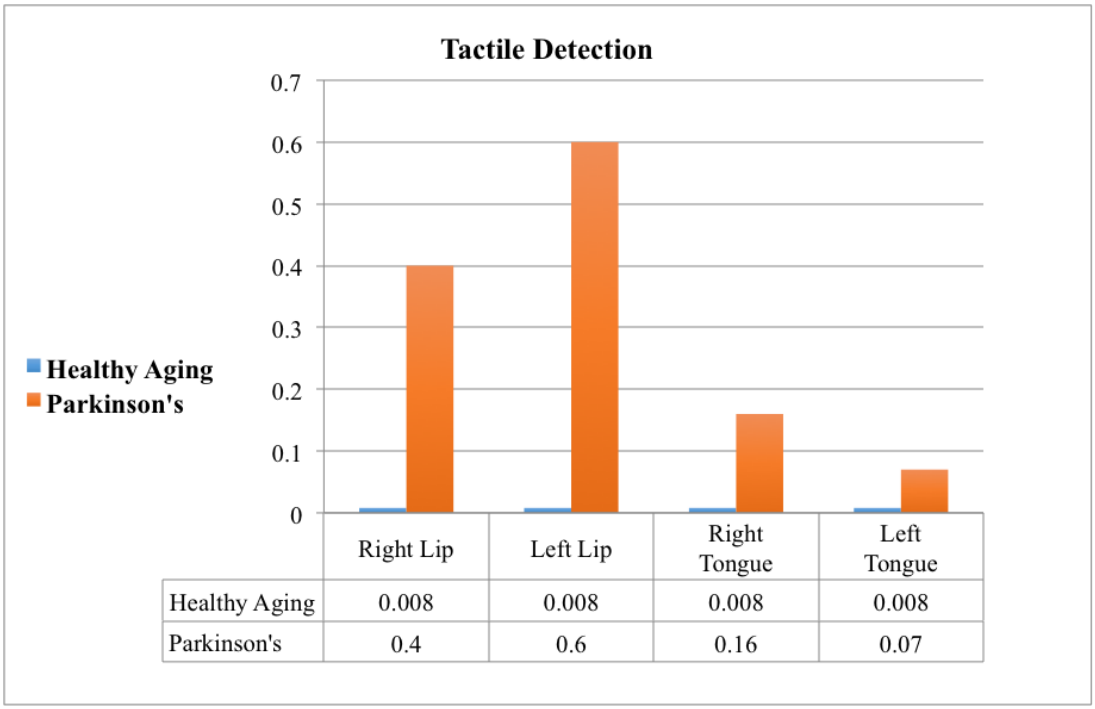
	Right Lip	Left Lip	Right Tongue	Left Tongue
Healthy Aging	3.17	3.17	2.00	2.00
Parkinson's	2.83	4.00	4.00	4.50

Tactile Detection Threshold Estimates

The data for the tactile threshold estimates can be found in Figure 3. Von Frey Hair Monofilaments (see appendix C) were used to obtain threshold estimates on the right and left lip and tongue. The y-axis is measured in tenths of grams and the x-axis shows the area of facial location testing. The control had a tactile detection estimate of 0.008g for the right lip, whereas the PPD had 0.4g. The control had a lower threshold, meaning he was much more sensitive to the pressure being applied. In comparison, the PPD had a threshold that was four levels higher. A

similar pattern continued for the rest of facial areas tested as the control had a threshold estimate of 0.008g for the left lip, right tongue, and left tongue. The PPD had a threshold estimate of 0.6g for the left lip, 0.16g for the right tongue, and 0.07g for the left tongue. At each location the control had lower thresholds than the PPD. For the left lip, the PPD was five levels higher, for the right tongue the PPD was 3 levels higher, and for the left tongue the PPD was two levels higher.

Figure 3: Tactile Detection Threshold Estimates



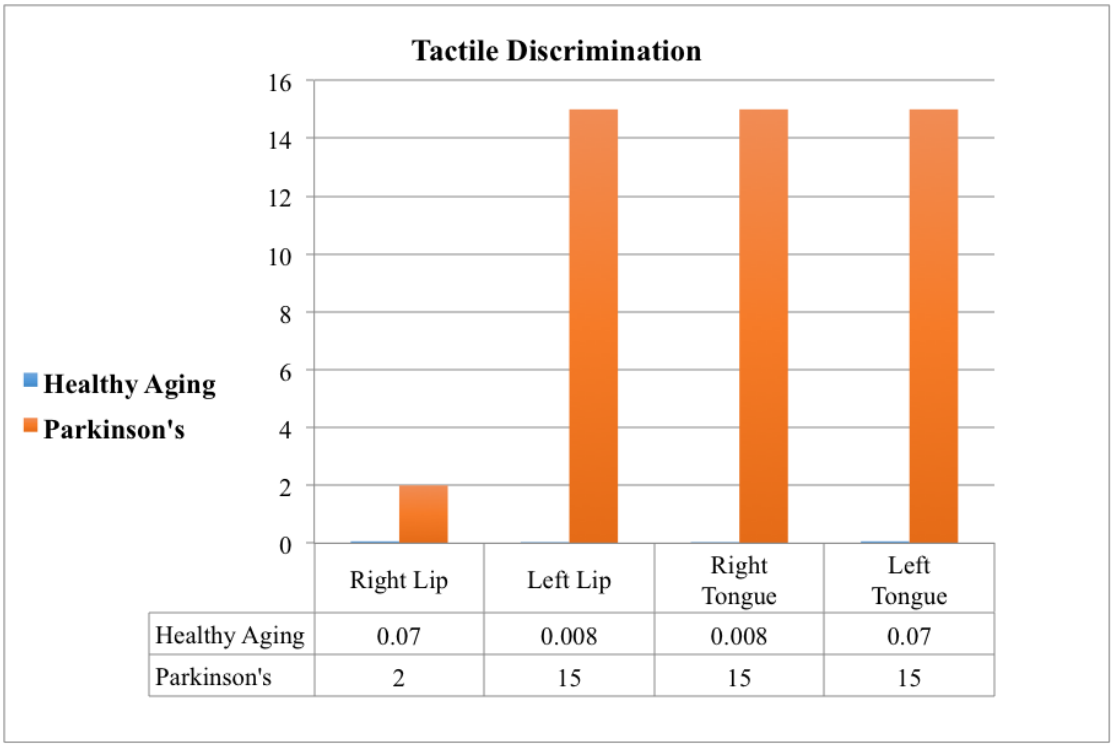
	Right Lip	Left Lip	Right Tongue	Left Tongue
Healthy Aging	0.008	0.008	0.008	0.008
Parkinson's	0.4	0.6	0.16	0.07

Tactile Discrimination Threshold Estimates

Figure 4 shows the data for tactile discrimination threshold estimates that were found using Von Frey Hair Monofilaments (see appendix C). The y-axis is measured in grams and the x-axis shows the facial region tested. The control had a tactile discrimination threshold estimate of 0.07g for the right lip and the PPD had 2.0g. The PPD had a threshold that was five levels higher than the control, thus he showed reduced sensitivity on the right lip. For the left lip the

control had a 0.008g threshold and the PPD had a 15g threshold, which is 13 levels higher. The control also had a 0.008g threshold and the PPD had a 15g threshold for the right tongue. For the left tongue the control had 0.07g and the PPD had 15g, which is 10 levels higher. The higher threshold estimates for the PPD shows that he had extremely reduced sensitivity in all four facial areas tested. This data supports the hypothesis that PPD have impaired somatosensation in the lips and tongue compared to healthy age and sex-matched controls.

Figure 4: Tactile Discrimination Threshold Estimates



	Right Lip	Left Lip	Right Tongue	Left Tongue
Healthy Aging	0.07	0.008	0.008	0.07
Parkinson's	2	15	15	15

Chapter 5

Discussion

The purpose of this study was to determine whether there are changes in orofacial touch sensation in patients with Parkinson's disease. Based on the data collected, the results indicate that the PPD has reduced sensitivity in the orofacial region when compared to the healthy age and sex-matched control. Two-point discrimination discs and Von Frey hair monofilaments assessed detection and discrimination threshold estimates on the right and left lip and tongue. Participants included one patient with PD (66 year-old-male) and one healthy control (67 year-old-male). The 2-point discrimination testing revealed decreased sensation for the PPD in all orofacial regions, with the exception of the right lip. Tactile detection and tactile discrimination both revealed a decrease in threshold estimates, revealing a decrease in somatosensation for the PPD in all four orofacial regions. The PPD was many levels higher than the control and as the levels get higher, this shows the ability to detect pressure is lower and sensitivity is reduced.

The results of this study illuminate the importance of identifying and quantifying somatosensory deficits. Due to the decreased sensitivity on the lips and tongue of the PPD, it is likely that he would not benefit from traditional speech therapy that requires taking in and processing orofacial somatosensory instructions (i.e. "touch your tongue to the ridge on the roof of your mouth"). Without adequate sensation on the lips and tongue, the patient will not be able to feel the precise movements for proper speech output. When the necessary movements are not adequately felt, it is also harder for the patient to recognize errors and correct them. As previously discussed, the inability to correct errors relates to the DIVA model that connects the neuromotor processes of speech to the sensory processes needed for speech production. Using the DIVA model, therapists can help PPD recalibrate their speech output system in order to

correct the somatosensory feedback system that has been damaged due to changes in the brain. Therapy for patients with PD should require further instruction or visual feedback in order to compensate for the lack of touch sensation.

Patients with Parkinson's disease undergo a slow development of disruptions throughout the disease's progression. The most notable disruptions are motor changes, followed by speech and overall sensation changes. Despite current speech therapy techniques, the diagnosis and therapy of speech disorders associated with PD overlooks the impact of sensation on the entire speech mechanism. Due to damage in the basal ganglia, patients with PD experience a decline in somatosensory processing. Previous research focuses on the decline of processing in regards to motor issues and is lacking in regards to speech issues. Additionally, the research that does focus on somatosensation in the orofacial region is incongruent and fails to identify the direct impact on speech and language. The current research supports the hypothesis that there is a decrease in orofacial somatosensation in patients with PD. Decline in sensory processing of the specific areas necessary for speech production will have a negative impact on producing speech.

Limitations

The data collected supports the hypothesis that individuals with PD may have decreased orofacial somatosensation, however, further testing is necessary to find a larger number of participants. A large obstacle was recruiting PPD and finding healthy age and sex matched controls. This study did not analyze disease progression as a factor; however, it is possible that patients with PD experience varying amounts of somatosensory changes depending on his or her individual course of the disease. Disease progression can also be impacted by the amount of therapy the patient receives as well as medications, which this study did not compare. However, this is most similar to future clinical testing and was not controlled for in the original reliability

study (Etter et al, 2017). Another concern is that the researcher tested approximately the same area on the lips and tongue but there was no way to ensure the exact same spot was tested with every trial. Although the shortcomings of this experiment are due to time constraints, the results highlight the need for more research to specify if orofacial somatosensory changes are associated with PD and what significance they may have for future interventions in speech and swallowing.

Future Directions

The next step in this research is to continue testing participants to obtain a larger sample size. The speech sample should also be analyzed in detail to discover which sounds are most impacted by the changes in orofacial somatosensation. Development of specific therapy techniques for individuals with decreased orofacial somatosensation is the culmination of the results from this research.

Overall, the patient with PD demonstrated significant decreases in orofacial somatosensory capability that coincide with significant decreases in speech skills. Touch sensation on the lips and tongue should not be overlooked when treating patients with PD due to the necessity of somatosensation during speech production. The evidence of somatosensory changes noted from this study, along with greater support by obtaining a larger sample size can influence the speech and language therapies delivered for patients with PD.

Appendix A

Speech Sample Protocol

What:	Example:
Sustained /a/ x3	/a/
Sustained /i/ x3	/i/
AMRs	Pa Ta Ka
SMRs	PaTaKa
Automatics	1-20 Days of Week Months of Year
Word Repetition	Mom, Bib, Nine, Coke, Peep, Sis, Shush, Roar
Words of Increasing length	Emotion, Emotional, Emotionally
Repeated Trials	Flashlight, Flashlight, Flashlight
Sentences	We saw several wild animals My physician wrote out a prescription The municipal judge sentenced the criminal
Grandfather Passage	"Here is a short passage that seems a little silly. It was written to include most of the sounds in the English language. Please read the paragraph to me."
Story Telling	Tell me about a vacation you've taken

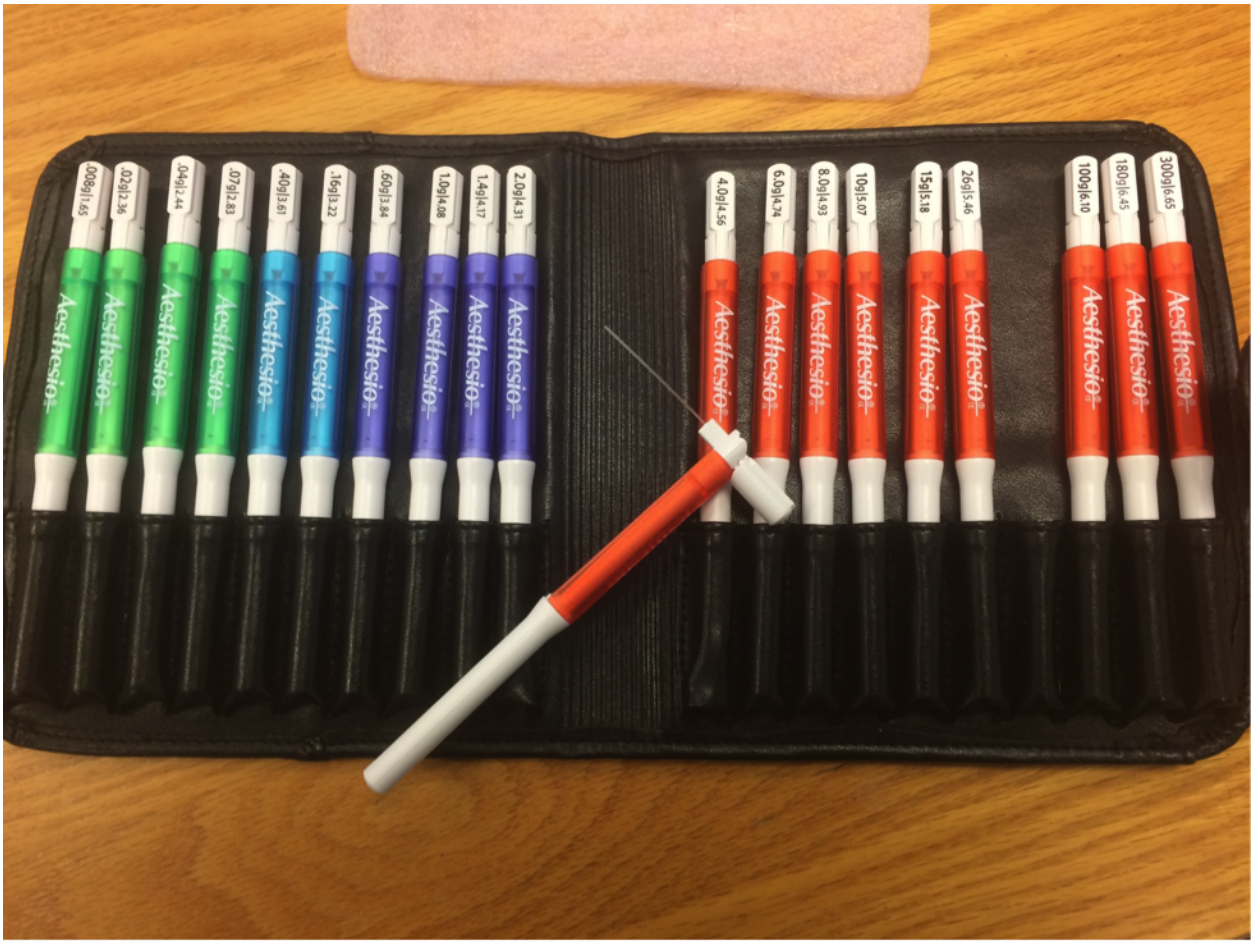
Appendix B

Two-Point Discrimination Discs

Baseline Discrim-A-Gon ™

Appendix C

Von Frey Hair MonoFilaments



Aesthesio ® Danmic Global

BIBLIOGRAPHY

Baylor, C., Yorkston, K., Eadie, T., Miller, R., & Amtmann, D. (2008). Levels of Speech Usage: A Self-Report Scale for Describing How People Use Speech. *Journal of Medical Speech-Language Pathology*, *16*(4), 191–198.

Doty, R. L., Gandhi, S. S., Osman, A., Hurtig, H. I., Pawasarat, I., Beals, E., . . . Leon-Sarmiento, F. E. (2015). Point pressure sensitivity in early stage Parkinsons disease. *Physiology & Behavior,138*, 21-27. doi:10.1016/j.physbeh.2014.09.015

Factor, S. A., & Weiner, W. J. (2008). *Parkinsons disease: diagnosis and clinical management*. New York: Demos Medical Publishing.

Forrest, K., Weismer, G., & Turner, G. S. (1989). Kinematic, acoustic, and perceptual analyses of connected speech produced by parkinsonian and normal geriatric adults. *The Journal of the Acoustical Society of America, 85*(6), 2608-2622. doi:10.1121/1.397755

Gescheider, G.A. (1997). *Psychophysics : the fundamentals* (3rd ed.) Mahwah, N.J.: L. Erlbaum Associates.

Hammer, M. J., & Barlow, S. M. (2009). Laryngeal somatosensory deficits in Parkinson's disease: implications for speech respiratory and phonatory control. *Experimental Brain Research,201*(3), 401-409. doi:10.1007/s00221-009-2048-2

Herd, C., Tomlinson, C., Deane, K., Brady, M., Smith, C., Sackley, C., & Clarke, C. (2012). Comparison of speech and language therapy techniques for speech problems in parkinson's disease. *Cochrane Database of Systematic Reviews,* (8), CD002814. doi:10.1002/14651858.CD002814.pub2

Ho, A. K., Iansek, R., Marigliani, C., Bradshaw, J. L., & Gates, S. (1999). Speech Impairment in a Large Sample of Patients with Parkinson's Disease. *Behavioural Neurology, 11*(3), 131-137. doi:10.1155/1999/327643

Hoodin, R. B., & Gilbert, H. R. (1989). Nasal airflows in parkinsonian speakers. *Journal of Communication Disorders, 22*(3), 169-180. doi:10.1016/0021-9924(89)90014-2

Nolano, M., Provitera, V., Estraneo, A., Selim, M. M., Caporaso, G., Stancanelli, A., . . . Santoro, L. (2008). Sensory deficit in Parkinsons disease: evidence of a cutaneous denervation. *Brain,131*(7), 1903-1911. doi:10.1093/brain/awn102

Prätorius, B., Kimmeskamp, S., & Milani, T. (2003). The sensitivity of the sole of the foot in patients with Morbus Parkinson. *Neuroscience Letters,346*(3), 173-176. doi:10.1016/s0304-3940(03)00582-2

Rolland-Monnoury, V. (2013). Parkinson's disease and speech therapy. *Annals of Physical and Rehabilitation Medicine, 56*, e258. doi:10.1016/j.rehab.2013.07.672

Sacrey, L. R., & Whishaw, I. Q. (2012). Subsystems of sensory attention for skilled reaching: Vision for transport and pre-shaping and somatosensation for grasping, withdrawal and release. *Behavioural Brain Research,231*(2), 356-365. doi:10.1016/j.bbr.2011.07.031

Sapir, S., Ramig, L. O., & Fox, C. M. (2011). Intensive voice treatment in Parkinson's disease: Lee Silverman Voice Treatment. *Expert Review of Neurotherapeutics,11*(6), 815-830. doi:10.1586/ern.11.43

Schneider, J. S., Diamond, S. G., & Markham, C. H. (1986). Deficits in orofacial sensorimotor function in Parkinsons disease. *Annals of Neurology,19*(3), 275-282. doi:10.1002/ana.410190309

Sobel, N., Thomason, M. E., Stappen, I., Tanner, C. M., Tetrud, J. W., Bower, J. M., . . . Gabrieli, J. D. (2001). An impairment in sniffing contributes to the olfactory impairment in Parkinsons

disease. *Proceedings of the National Academy of Sciences,98*(7), 4154-4159. doi:10.1073/pnas.071061598

Sveinbjornsdottir, S. (2016). The clinical symptoms of Parkinsons disease. *Journal of Neurochemistry,139*, 318-324. doi:10.1111/jnc.13691

Tourville, J. A., & Guenther, F. H. (2011). The DIVA model: A neural theory of speech acquisition and production. *Language and Cognitive Processes*, *26*(7), 952–981. http://doi.org/10.1080/01690960903498424

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