# AGING EFFECTS ON PERCEPTION OF PARKINSONIAN AND NORMAL GERIATRIC SPEECH

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Bachelor of Science in Education

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2000

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
July 2015

AGING EFFECTS ON PERCEPTION OF PARKINSONIAN

AND NORMAL GERIATRIC SPEECH

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ACKNOWLEDGEMENTS

Writing this Master's thesis has provided me with not only a rich learning experience, but has also enabled me to interact with a number of wonderful and kind people that I otherwise would not have met. Thank you to all the speakers and listeners who graciously volunteered to participate in the study.

Specifically, I would like to acknowledge my supervisor, Dr. Sabiha Parveen, for encouraging me to pursue writing a Master's thesis. Thank you for your time, patience, encouragement and positive outlook during this process. Much gratitude is due to my husband, who supported me in this journey of graduate school and thesis writing. Thank you to my parents, sister, and in-laws who were willing to help in anyway they could. I am very appreciative of my friends, peers, and professors who were supportive and willing to volunteer their advice and time. Thank you to my committee members, Dr. Cheryl Giddens and Dr. Ramesh Kaipa, for your time and valued input. Thank you to Sarah Hammer and Ashley Webb for helping with data collection.

Name: ANNA SLATEN

Date of Degree: JULY 2015

Title of Study: AGING EFFECTS ON PERCEPTION OF PARKINSONIAN AND NORMAL GERIATRIC SPEECH

Major Field: COMMUNICATION SCIENCES AND DISORDERS

Abstract: Parkinson disease (PD) is frequently associated with speech and voice deficits, including changes in phonatory, articulatory, speech intelligibility, and prosodic aspects (Spencer, Sanchez, McAllen, & Weir, 2010). Prior studies have investigated listener perception of speech produced by speakers with PD using structured speech tasks such as word repetitions, sentence readings, and passage readings (i.e., Cheang & Pell, 2004; Dagenais, 2011). However, research has also indicated the need for studies with more naturalistic speech stimuli, including monologues, to determine perceptual abilities of different listener groups. Limited studies have examined perception by different listener groups for monologues produced by individuals with PD. The purpose of this study was to investigate aging effects among different listener groups during perception of monologues produced by individuals with PD and age- and gender-matched neurologically normal speakers (NS). The study included three listener groups (younger, middle-aged, older-aged adults). Speakers included five individuals with PD and five NS. All speakers produced a short monologue on a topic of interest. The three listener groups listened to the recorded monologues and completed a visual analog scale (VAS) to rate seven speech variables (including pitch, pitch variability, loudness, speech rate, pauses, understandability, and perception of effort) for the two speaker groups. Among the seven variables, results indicated that listener groups rated understandability and perception of effort significantly differently for individuals with PD and NS. All three listener groups rated the understandability for speakers with PD to be significantly lower than NS. However, the listener groups did not have any significantly different ratings for the remaining five variables including pitch, loudness, and speech rate. In addition, when the listener groups were compared amongst themselves, there were no significant aging effects among the groups for perception of monologues. Findings from the study provide evidence for similar perception among different aged normal listener groups for perception of monologues by individuals with PD and neurologically normal speakers.

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# CHAPTER I

## INTRODUCTION

Parkinson disease (PD) is a progressive neurological disorder affecting motor movements (Harel, Cannizzaro, Cohen, Reilly, & Snyder, 2004). Cardinal characteristics of PD include bradykinesia (slowness of movements), rigidity in movement and resting tremors (Harel et al., 2004; Miller, 2009). As a motor function, speech is often affected in PD. Due to decreased range of motion of motor movements, speech deficits resulting from PD are categorized under hypokinetic dysarthria (Duffy, 2005). Deficits of hypokinetic dysarthria can be seen in speech components such as respiration, phonation, articulation, prosody (Duffy, 2005; Harel et al., 2004) as well as resonance (Duffy, 2005). These deficits affect the range, amplitude, flexibility and speed of the speech components (Duffy, 2005). Integration of the speech components for output of "smooth, fluent speech" can be disrupted (Miller, 2009) and negatively affect speech production (Harel et al., 2004).

Several methods, subjective and objective, can be used in the assessment of normal and abnormal speech. The most common subjective method used to analyze normal and deviant speech is perceptual analysis (Ramig & Fox, 2012). Perceptual analysis involves listeners' judgment of speech variables such as pitch, loudness, vocal quality, articulation and speech intelligibility (Ramig & Fox, 2012; Sapir et al., 2002) and identification of the related physical behavior (Tjaden, 2000). Perceptual analysis is important in determining abnormal speech as it relates to everyday speech (Ho, Isanek, Marigliana, Bradshaw, & Gates, 1998). Decisions regarding the type, parameters and severity of speech deficits are influenced by listener perception of speech and are used to indicate type and goals of treatment. The purpose of the present study was to investigate age-related differences in listener perception of speakers with PD and normal geriatric speakers. The following sections discuss previous research that has examined listener perception of different speech aspects in individuals with PD.

# CHAPTER II

## REVIEW OF LITERATURE

### Phonation

Phonation has been defined as the production of voiced phonemes caused by vocal fold vibrations (Freed, 2012). Normal phonation requires adequate respiratory support as well as intact vocal fold function (Freed, 2012). Phonation in hypokinetic dysarthria is often disrupted and is perceived as soft, breathy and harsh (Holmes, Oates, Phyland, & Hughes, 2000; Miller, 2009). Ho et al. (1998) examined perception of speech impairment in individuals with PD. Participants included 200 individuals with PD and two trained raters. Raters listened to a two-minute recorded monologue given by the individual with PD and assessed voice features such as quality, volume, and intonation as well as fluency and articulation. Results of the study revealed that 73.5% of the participants had impaired speech that was characterized by voice dysfunction as both the initial symptom as well as the dominant issue. The authors concluded that voice dysfunction is a common speech impairment in individuals with PD and often presents before fluency and articulation impairments.

More recently, Dromey (2003) examined phonatory aspects of speech in individuals with PD. Participants included 10 males with PD and 10 age-matched neurologically normal males who served as speakers. Speaking tasks included sustained vowel, passage reading (The

Rainbow Passage; Fairbanks, 1960), and a 30-second monologue. Five speech-language pathology (SLP) graduate students (with little experience with dysarthric speech) served as raters. Results of the study revealed that raters perceived the speakers with PD to have more severe phonatory deficits compared to normal speakers. Dromey (2003) concluded that speakers with PD have perceptual features that differentiate them from normal speakers. In summary, results from prior studies show that phonatory deficits are common and are the most salient problems in PD related dysarthria. The previous studies suggest that phonatory deficits are commonly perceived by listeners.

**Perception of pitch by different listener groups.** Pitch is the perceptual correlate of fundamental frequency and is a subjective measurement of how high or low the voice sounds to the listener (Seikel, Drumright, & King, 2016). Deficits in pitch can include impaired level of pitch (too high or too low) as well as reduced variability of pitch (monotone quality). Previous research has reported individuals with PD to have reduced variability of pitch (Canter, 1963; Darley, Aronson, & Brown, 1969; Holmes et al., 2000) and impaired pitch level (Duffy, 2005). Previous findings regarding pitch in PD have been mixed with some studies indicating individuals with PD to have relatively higher pitch than control speakers (Canter, 1963; Duffy, 2005; Holmes et al., 2000) and others suggesting lower pitch in individuals with PD compared to the controls (Darley et al., 1969). Some of the existing studies of pitch in individuals with PD compared pitch perception using self-ratings by speakers with PD (Fox & Ramig, 1997) and proxy-ratings by other listener groups (e.g., Kozlosky, 2009; Parveen, 2013). The following sections discuss the findings from these studies.

Fox and Ramig (1997) explored self-perception of speech and voice in individuals with PD. Thirty individuals with PD and 14 healthy normal adults participated in the study. Participants were asked to complete a perceptual self-rating scale related to speech variables, such as pitch variability (monotone), based on how they perceived their speech to be most of the time. Results of the study showed that individuals with PD self-rated themselves as more impaired on all of the speech variables including pitch variability. The authors asserted that individuals with PD are perceptually aware of the changes and deficits in their own speech (Fox & Ramig, 1997).

In a more recent study, Kozlosky (2009) examined listener-related differences in speech perception of speakers with PD. Ten individuals with PD (mean age=65.8 years) participated as speakers and listeners in the study and their respective spouses participated as listeners. Additionally, six SLP graduate students served as trained listeners. Speech stimuli included a reading of the Rainbow Passage by the individuals with PD. After hearing the speech stimuli, all participants completed a perceptual rating scale of speech variables including pitch (too low/too high). Interestingly, while all three listener groups rated pitch as well as other speech variables as less than the ideal norm, results of the study revealed no significant differences in the rating scores between individuals with PD and their caregivers. Results indicated statistically significant differences between self-ratings by individuals with PD and ratings by trained raters as well as between proxy ratings by caregivers and corresponding ratings by the trained raters. Overall, the trained raters reported higher ratings (i.e., more favorable) for pitch compared to the PD and caregiver groups. The author concluded that while all three listener groups perceived pitch as deviating from normal, individuals with PD and their caregivers may not be accurate in their perception and therefore are not correctly estimating the true level of speech deficit.

In a different study, Parveen (2013) compared self-perception of speech by individuals with PD with proxy ratings by their caregivers as well as a trained rater. Twenty individuals with PD (mean age=66.7 years) and their respective communication partners (mean age=63.1 years) participated in the study. Individuals with PD served as speakers and listeners. Communication partners as well as a trained rater (CF-SLP with experience in motor speech disorders) served as listeners. Individuals with PD read the Rainbow Passage aloud in their habitual voice. Immediately following the reading task, all participants completed ratings on a visual analog scale (VAS) for seven identified speech characteristics including pitch level. Statistical analysis revealed no significant differences among listener groups for pitch level. Similar to Kozlosky (2009), pitch level was among speech features that received a rating below the ideal norm. Also consistent with Kozlosky (2009) individuals with PD and their caregivers had similar ratings that differentiated from the trained rater. However, in contrast with Kozlosky (2009), the trained listener rated pitch as further below the ideal norm than the individuals with PD. Parveen (2013) concluded that aging effects and/or familiarization with the speaker may influence the perceptual ratings of individuals with PD and their caregivers. In summary, findings from previous studies have shown that level of pitch in individuals with PD are perceived to be impaired as indicated by self-ratings of individuals with PD as well as by respective caregivers and trained SLP listeners.

**Perception of speech loudness by different listener groups.** Volume of speech is often perceived to be reduced (hypophonic) or to lack variability (monoloudness) in individuals with PD (Darley et al., 1969; Miller, Noble, Jones, & Burn, 2006). Several prior studies have reported individuals with PD to have impaired perception of their own loudness and have difficulty adjusting volume appropriately (Kwan & Whitehill, 2011). Among these studies, Ho, Bradshaw, and Iansek (2000) compared self-perceived speech volume of speakers with the actual speech intensity values. Fifteen individuals with PD who had hypophonic dysarthria and 15 age- and gender-matched healthy controls participated in the study. Speech tasks for the participants included reading the Rainbow Passage and holding a short conversation in three conditions: habitual volume or self-selected volume (no specific instructions on volume), quiet volume, and loud volume. After each speech task, the participants listened to a playback of their speech and were asked to indicate the volume they had just heard. Results of the study revealed that individuals with PD spoke more quietly in both the reading and conversational speech tasks than the control group. Yet individuals with PD consistently perceived their own volume as being louder compared to the control group's estimations of their volume. The authors concluded that discrepancies in volume perception indicated a possible defective sensorimotor integration in individuals with PD, leading to a mismatch between sensory judgment by individuals with PD and the actual speech amplitude (Ho et al., 2000).

More recently, a study conducted by Clark, Adams, Dykstra, Moodie, and Jog (2014) examined self-perception of loudness in individuals with PD. Seventeen individuals with PD and 25 healthy controls served as participants of the study. Participants completed three perceptual loudness tasks: magnitude estimation task, imitation task and magnitude production task. During the magnitude estimation task, participants were presented with a test sentence given a loudness value of 100 and then presented with the test sentence at different intensity levels. Participants were asked to provide a number they perceived proportional to the magnitude loudness. The imitation task involved imitating the presented volume of the test sentence. The magnitude production task involved reading a sentence at the participants normal intensity level (assigned a value of 100) followed by reading the sentence again at intensity levels proportional to the value of 100. Results of the study indicated that individuals with PD estimated the intensity of the presented stimulus differently than control participants during the magnitude estimation tasks, and had lower speech intensity in the imitation and magnitude production tasks in comparison to control participants. Clark et al. (2014) suggested possible sensory deficits in individuals with PD for perception of externally generated speech loudness and self-estimation of speech loudness. These findings of sensorimotor deficits in individuals with PD regarding perception of loudness are similar to Ho et al. (2000). Overall, prior research shows that individuals with PD have reduced speech loudness as well as impaired perception of internally and externally generated speech intensity.

**Prosody**

Prosody of speech is defined as the normal fluctuation of intensity, rhythm and pitch variability during speech production (Darley et al., 1969). Prosody is often affected in individuals with PD (Jaywant & Pell, 2010). Some of the observed changes in prosody include a loss of natural "melodic line" and timing which have been acoustically measured as changes in control of frequency, intensity, rate, and pause (Harel et al., 2004). Speakers with PD are found to have less pitch and loudness variability, which can worsen with progression of the disease (Holmes et al., 2000). Inadequate control of fundamental frequency results in disruption of prosody and is perceived as monoloudness and monopitch (Miller, 2009). Presence of prosodic deficits, including monotone quality and lack of loudness variability can affect listener perception of the meaning and emotion being conveyed (Jaywant & Pell, 2010).

**Perception of prosodic features by different listener groups.** Several prior studies have investigated perception of prosody in individuals with PD (e.g., Cheang & Pell, 2004; Jawyant & Pell, 2010; Tjaden, 2000). Among the existing studies, Cheang and Pell (2004) examined how normal listeners perceived prosody in sentences produced by speakers with PD. The study included 21 participants with idiopathic PD and 12 healthy controls. Additionally, six undergraduate students participated as raters. Speaker participants were recorded producing sentences of contrastive stress and phonemic stress. Raters completed two tasks: contrastive stress identification and phonemic stress identification. Identification of contrastive stress involved listening to speakers and choosing the word produced with the greatest stress. Identification of phonemic stress involved listening to a recorded phrase and choosing the picture that matched the meaning of the sentence they heard. Results of the study showed raters were less accurate and reliable in identifying contrastive stress and phonemic stress of sentences produced by speakers with PD. The authors concluded that healthy listeners perceive the linguistic-prosodic features of PD speech as aberrant and less efficient when compared to normal speakers.

A more recent study conducted by Jaywant and Pell (2010) explored the deeper implications that deficits in prosody may have on listener impressions of speakers with PD. The authors hypothesized that impaired prosody found in PD speech would negatively influence listener perception regarding the speaker's attitude. Eighteen individuals with PD and 17 healthy controls served as speakers. Thirty normal hearing adults served as listeners. Speakers were recorded performing a picture description speech task. For the perceptual task, listeners rated their impressions of eight different personality traits for each of the speech samples. Results showed that listeners identified speakers with PD as sounding less happy, friendly, interested, and involved in comparison to healthy speakers. The authors correlated these perceptual findings with results of acoustic analysis from the same recordings. The acoustic analysis revealed that speakers with PD had less intensity, longer pauses and more increased pause times. Jaywant and Pell (2010) concluded that listeners form negative impressions regarding certain aspects of personality in speakers with PD. The authors also indicated that future research should include more natural speaking situations.

Looking at a different feature of prosody, Tjaden (2000) compared articulatory rate of nine men with idiopathic PD and 10 healthy age-matched men. Speech stimuli included readings from the Farm Passage (Crystal & House, 1982) and spontaneous speech samples. Speakers were recorded reading the Farm Passage at three rates: habitual, twice as fast as habitual, and half as fast as habitual. The reading and speech samples were then segmented into speech runs (a run was defined as a stretch of speech bounded by pauses of at least 200 millisecond samples) before measuring articulatory rate. Listeners in the study included nine SLP graduate students. Listeners estimated the articulatory rate of recorded speech runs of the speakers using a magnitude estimation task. Results from this study showed that listeners perceived speakers with PD to have a faster rate of speech than control speakers. Results also showed that articulatory rate perception increased with severity of hypokinetic dysarthria. Tjaden (2000) explained that listeners experienced a "blurred acoustic contrast" leading to reduced speech clarity and perception of faster rate in speakers with PD. In summary, prior perceptual studies indicate presence of prosodic deficits including faster speech rate, lack of prosodic variability, decreased volume and inappropriate pauses in individuals with PD when compared to normal speakers.

## Speech Intelligibility

Intelligibility is a perceptual parameter of speech judged by the listener (Hustad, 2008). Tjaden and Wilding (2011) define intelligibility to be the degree to which the listener understands the speaker's acoustic signal. Intelligibility can be judged by using objective measures such as transcription or more subjective means such as rating scales (Dagenais, Adlington, & Evans, 2011). With disease progression, speech intelligibility may also decline in individuals with PD. Therefore, changes in intelligibility, in part, can be documented to track progress as well as to provide estimations of severity in relation to disease progression (Tjaden & Wilding, 2011).

**Prior studies related to speech intelligibility in individuals with PD.** Previous studies have reported that speech intelligibility is reduced in individuals with PD. A study conducted by McAuliffe, Ward, and Murdoch (2006) compared intelligibility between individuals with PD and neurologically normal control speakers. Participants in the study included nine individuals with PD and 15 neurologically normal control speakers divided into two groups (younger and older-aged adults). Two experienced SLPs served as raters. Speech stimuli involved speakers reading phrases aloud. Results of the study revealed that individuals with PD presented with significantly reduced intelligibility when compared to the other two speaker groups.

Another study by Kempler and Van Lancker (2002) also investigated speech intelligibility in speakers with PD. Participants in the study included one speaker with PD and 64 naïve listeners. Listeners transcribed speech samples (spontaneous speech, repetition, and reading tasks) recorded by the speaker with PD. Findings from the study revealed that listeners were able to understand 29% of the spontaneous utterances, 78% of read utterances, and 79% of repeated spoken utterances. Kempler and Van Lancker (2002) suggest that reading and repetition tasks may provided higher intelligibility scores due to the external cues provided by the type of speech task. Spontaneous speech, however, requires an internal model which may be impaired in individuals with PD and thus result in reduced intelligibility.

In addition, more recent studies have also found that speech intelligibility is reduced in individuals with PD (e.g., Feenaughty, Tjaden, & Sussman, 2014; Ma, Schneider, Hoffman, & Storch, 2015; Whitfield & Goberman, 2014). A study by Whitfield and Goberman (2014) investigated articulatory-acoustic vowel space and its effect on speech intelligibility in individuals with PD. Participants included 12 speakers with PD, 10 neurologically normal control speakers, and four listeners. Speech stimuli included recorded readings of the Rainbow Passage. Findings from the study revealed that speakers with PD were perceived to have less clear speech and to have a smaller articulatory-acoustic vowel space compared to control speakers. Another study conducted by Feenaughty et al. (2014) examined speech intelligibility and acoustic measures of speech in speakers with PD and healthy control speakers. Twelve individuals with PD and 12 healthy controls served as speakers. Fifty inexperienced listeners completed VAS on intelligibility of the speakers. Speech stimuli consisted of sentences recorded by the speakers. Additionally, acoustic measures of speech rate, articulatory rate, fundamental frequency, sound pressure level, and F2 interquartile range were obtained. Based on the perceptual ratings, speakers with PD were less intelligible than the control speakers. However, when the two speaker groups were compared based on acoustic measures, there were no statistically significant differences between the groups. The authors concluded that the lack of statistical difference between speakers with PD and control speakers for acoustic variables could possibly be attributed to variability within the individual speakers with PD.

In another recent study, Ma et al. (2015) explored the effects of speech stimuli on prosody and intelligibility in speakers with PD. Twenty-six speakers with PD, 12 healthy control speakers and three expert listeners participated in the study. Speech stimuli included sentences, passage reading, and a monologue. Findings from the study revealed that speakers with more severe dysarthria were less intelligible than speakers with mild dysarthria. Additionally, similar to Kempler and Van Lancker (2002), findings from Ma et al. (2015) suggested that monologues were less intelligible compared to sentence and passage reading tasks. Overall, previous studies indicate presence of speech intelligibility deficits in individuals with PD, which may vary based on the disease severity and type of speech tasks.

**Perception of speech intelligibility by different listener groups.** Previous studies have measured the intelligibility, acceptability, and comprehensibility of dysarthric speech by different listener groups. Among the existing studies, Miller et al. (2007) conducted a study to determine the prevalence of intelligibility changes in PD. Participants included 125 speakers diagnosed with PD and 97 healthy control speakers. The study included 99 naïve listeners who assessed the intelligibility of minimally paired words and then rated a recorded monologue produced by individuals with PD. Listeners rated the monologue using a five-point scale on "whether this person has a problem with spoken communication." Miller et al. (2007) also included self-assessments completed by the speakers with PD regarding their own speech. Results showed that over half of the listeners rated the PD speakers as "difficult to understand"

and 38% of the participants with PD revealed they saw speech difficulties as a major concern. Miller et al. (2007) concluded that intelligibility scores may not accurately describe the problem of speech in PD. Assessment of speech intelligibility does not account for all factors involved in conveying a message. Thus intelligibility scores may overestimate the problem of speech. However, speakers with PD may be able to provide a sample of their best speech production during a short period such as assessed in a clinical context, and therefore intelligibility may underrate the issue (Miller et al., 2007). Thus, further research is needed to study how intelligibility of individuals with PD is affected by other factors (Miller et al., 2007).

In an earlier study, Dagenais, Watts, Turnage and Kennedy (1999) examined speech intelligibility and acceptability (i.e., subjective rating of normalcy and naturalness of speech) of moderate dysarthric speech by normal listeners (including younger adults, older adults and SLPs). Speakers included two individuals with dysarthria and two age- and gender-matched controls. Listener groups consisted of 10 normal young adults (19-30 years), 10 normal hearing older adults (61-71 years), and 10 SLPs (with at least 2 years of experience with dysarthric speech). Speakers were recorded reading sentences from Assessment of Intelligibility of Dysarthric Speech (AIDS; Yorkston & Beukelman, 1981). Listeners were given two tasks: rating the speakers' acceptability on a scale from "terrible" through "excellent" and transcribing the speakers' sentences. Results from the study revealed that the SLPs provided significantly higher intelligibility scores than the other two listener groups who were more similar in intelligibility scores. Acceptability ratings among the three listener groups for speakers with dysarthria were similar, however, SLPs rated normal speakers with lower acceptability compared with the other listener groups. The authors speculated that SLPs, as trained listeners, have different expectations for acceptable speech compared to untrained listeners. Findings from the study also suggested a correlation between intelligibility and acceptability ratings for the speakers. As the impairment of speech increased, the connection between what listeners understand and what they deem acceptable is stronger. The authors concluded that further research is needed to assess the characteristics of speech that are less acceptable to listeners.

Continuing the research on perceptual measures in listening, Dagenais et al. (2011) explored listening differences of younger and older adults using intelligibility, comprehensibility (listener understanding of speech message), and acceptability as measures of dysarthric speech. Speakers included four men (22-39 years) with dysarthria resulting from traumatic brain injury and one control speaker. Listeners consisted of younger-aged listeners (19-30 years) and older-aged listeners (65 years and older). Listeners were presented sentences recorded by the speakers with dysarthria. For the intelligibility task, all listeners orthographically transcribed the sentences. The comprehensibility task involved listeners answering two questions per sentence. Acceptability was measured using a five-point scale from "totally unacceptable" to "totally acceptable." Results from the study showed that older listeners had lower scores of intelligibility than younger listeners. Comprehensibility scores were lower for the older listeners than the younger listeners, with the most significant difference on the speaker with severe dysarthria. The acceptability measure showed younger listeners gave consistently lower scores than the older listeners. Dagenais et al. (2011) explained that the older listeners' lower scores on intelligibility and comprehensibility may be due to age-related changes in perception of speech. The authors also suggested that the older listeners are less critical of speech in general, explaining the higher acceptability scores from the older listeners as compared to the younger listeners. The authors suggested that future studies should use naturalistic speech samples by speakers with dysarthria.

In a different study, Poole (2011) extended a previous line of research by Dagenais et al.

(1999, 2011) examining perception of dysarthric speech by different listener groups. Poole (2011) assessed the relationship of three perceptual measures: intelligibility, comprehensibility, and acceptability of dysarthric speech. Listeners consisted of two groups: a younger-aged group (19-35 years) and an older-aged group (55 years and older). Speakers consisted of four adults with dysarthria secondary to traumatic brain injury and one non-impaired control speaker. Listeners were presented with sentences (9-11 words in length) recorded by the speakers with dysarthria. Similar to methods in Dagenais et al. (2011), intelligibility was rated by the listeners' transcription of the sentences, comprehensibility was tested with questions regarding the recorded sentences, and acceptability was rated with a five-point scale. Results showed no significant differences between the two listener groups for the three measures. These results differed from prior reports from Dagenais et al. (2011) in which age-based differences were found. Poole (2011) discussed possible listener group differences as a basis for differences in her study and earlier studies by Dagenais et al. (2011). Poole (2011) included younger and older listeners who were cognitively matched, differing from the study by Dagenais et al. (2011), which did not account for cognitive abilities of listeners. Poole (2011) concluded that cognition may be a pertinent factor when considering differences between listeners of different ages.

To summarize, published research has found that intelligibility is reduced in speakers with dysarthria. In addition, with increased disease severity, the overall speech intelligibility of the speaker and acceptability of the speech signal by listeners deteriorates. With regard to listener differences in perception of intelligibility and acceptability, research shows that SLPs differ in their ratings of intelligibility in comparison to other listener groups. However, findings are mixed on whether there are age-related differences in perception of intelligibility and acceptability of dysarthric speech.

**Role of Speech Stimuli in Estimating Speech Intelligibility**

In assessing speech intelligibility many studies and diagnostics use more structured speech tasks such as reading sentences or a passage to judge intelligibility (Tjaden & Wilding, 2011). These structured speech tasks may or may not equally represent intelligibility in conversational speech (Ramig & Fox, 2012; Rosen, Kent, & Duffy, 2005). Few studies have investigated differences between structured and naturalistic speech tasks and their impact on assessment decisions. In their study, Tjaden and Wilding (2011) state that the majority of intelligibility assessments for dysarthria are at the word or sentence level with the exception of the Frenchay Dysarthria Assessment (FDA; Enderby & Palmer, 2008). Tjaden and Wilding (2011) compared intelligibility of a paragraph reading and a monologue task from speakers with PD. Participants included 12 speakers (six males and six females) diagnosed with PD and 70 naïve listeners. Three SLPs judged the dysarthria diagnosis, dysarthria severity and deviant perceptual characteristics of the participants' speech. Eleven of the 12 participants presented with hypokinetic dysarthria and one had hypo/hyperkinetic dysarthria. The dysarthria severity ranged from mild to moderate-severe. The participants were recorded reading the John Passage (Tjaden & Wilding, 2004) and during a two minute monologue. Results from the study revealed that scaled estimates of intelligibility for the passage reading and monologue recording were not significantly different. These findings were corroborated with results from Bunton and Keintz (2008), but differ from prior reports. Findings from Weismer (1984) and Kempler and Van Lancker (2002) showed that listeners perceived lower speech intelligibility for spontaneous speech than structured speech tasks (including reading) produced by individuals with PD. Tjaden and Wilding (2011) recommended use of structured speech tasks to measure intelligibility of conversational speech in individuals with hypokinetic dysarthria. Overall, these authors suggested that structured speech tasks may be used to estimate intelligibility of conversational speech. However, they caution that orthographic transcription may not represent a listener's ease in understanding conversational speech (Tjaden & Wilding, 2011).

The majority of existing studies on perception of dysarthric speech, including hypokinetic dysarthria found in individuals with PD, have included structured reading tasks at the word or sentence level. Production of speech in PD is not consistent across speaking tasks, but can vary depending on complexity, duration and setting of the speaking task (Ramig & Fox, 2012). Speech samples using word repetition and reading tasks may provide some information on a speaker's intelligibility, but the tasks are not as cognitively challenging as monologues and conversation and do not represent equal effort required to speak at length (Miller, 2009). Additionally, individuals with PD may perform at higher levels during a short structured speech task, but fatigue during longer speech tasks causing a decline in intelligibility (Miller, 2009). Prior perceptual studies have also used the "best" recorded speech samples during structured tasks (Dagenais et al., 2011; Hustad, 2006; Poole, 2011). However, use of "best" recordings on structured tasks may not be representative of speech in real-life situations (Dagenais et al., 2011). Speech samples such as monologues and conversational speech are more representative of typical speech performance in daily life (Dagenais et al., 2011). It is important to examine naturalistic speech recordings, including monologues, in order to determine how listeners perceive speakers with dysarthria in real-life situations.

**Age-Related Differences in Speech Perception in Normal Hearing Adults**

It is well understood that hearing loss is associated with normal aging, and that difficulties in speech perception and understanding are associated with hearing loss (Committee on Hearing, Bioacoustics and Biomechanics, 1988; Divenyi, Stark, & Haupt, 2005; Helfer & Freyman, 2014). However, as the present study was concerned with speech perception skills in normal hearing adults, it is important to consider age-related differences in speech perception that may occur despite normal hearing. The following section provides information on research related to age-related changes in speech understanding of normal hearing adults and other associated factors (i.e., listening conditions, cognitive functioning, and contextual information).

**Listening conditions.** Studies show that speech perception difficulties increase with age, more noticeably in adverse listening conditions than in quiet conditions (Gelfand, Piper, & Silman, 1986; Schneider, Daneman, & Pichora-Fuller, 2002). Several studies have investigated age-related changes affecting speech understanding in different listening conditions between younger and older adults. One such study conducted by Gelfand et al. (1986) examined age-related effects of consonant recognition in quiet and in noise in those with normal hearing. Participants in the study were divided into five groups according to their age (age range=21-68 years). Stimuli in the study consisted of nonsense syllables presented in three conditions: quiet and babble noise with a signal to noise ratio of +10 and +5 dB. Results of the study showed more decline in perception of nonsense syllables in both quiet and noisy conditions by older listeners when compared to younger listeners. The authors concluded that speech understanding declines with age even in adults with normal hearing acuity.

A more recent study conducted by Fullgrabe, Moore, and Stone (2015) also examined age-related differences in speech identification in quiet and in background noise for listeners with normal hearing acuity. Participants included 21 older adults (60-79 years) and nine young adults (18-27 years) matched for hearing ability, years of education and cognitive functioning (IQ). Participants completed a series of speech and cognitive tasks. Similarly to Gelfand et al. (1986), results showed that older adults had poorer consonant and sentence identification performance in noise than the younger aged group. Consistent with Gelfand et al. (1986) the authors concluded that speech in noise detection does decline with age, despite normal hearing. However, in contrast to the study by Gelfand et al. (1986), Fullgrabe et al. (2015) reported similar performance for speech identification tasks in quiet environment by younger and older listener groups.

Taking a different perspective, Helfer and Freyman (2014) investigated age-related differences in speech understanding using different types of competing speech. Participants were normal hearing adults divided into three groups: younger listeners (19-28 years), middle-aged listeners (45-59 years) and older-aged listeners (61-85 years). Results of the study revealed that of the differing types of competing speech, older-aged adults had more difficulty when the competing speech signal was a single masker of the same sex compared with younger listeners' performance. Middle-aged adults also had more difficulty when compared to younger listeners' performance. The authors concluded that difficulties in inhibiting the unwanted signal could explain the differences in age-related performance. Results from the above studies show that there is agreement in the literature regarding an age-related decline in speech understanding in noisy or adverse listening conditions. However, there are mixed results in attributing age-related decline in speech understanding in quiet conditions, possibly due to differences in methodology.

**Cognitive functioning.** Another aspect influencing speech perception and understanding may be age-related decline in cognitive functioning such as working memory, fluid intelligence (Meister et al., 2013), inhibitory skills (Helfer & Freyman, 2014), and information processing (Rajan & Cainer, 2008). Results of some studies have shown that cognitive abilities and working memory capacity have predicted performance in identifying speech in background noise and understanding degraded speech signals (Fullgrabe et al., 2015; Lee, Sung, & Sim, 2014). In an attempt to understand how cognitive functioning affects speech understanding in aging, several studies have included cognitive tasks in addition to speech perception tasks in noise.

In a study conducted by Rajan and Cainer (2008), the authors investigated age-related effects on understanding speech in noise in normal hearing adults given sentences requiring different demand levels. Thirty-one adults were divided into five groups based on age (age range=20-69 years). Speech stimuli consisted of recorded speech sentences (varying in length between four and six words per sentence) presented in two types of masking noise (speech weighted noise and babble noise) which participants were asked to repeat verbatim immediately following presentation of the sentence. Results revealed that participants performed similarly in the lower informational masker of speech-weighted noise. However an age-related decline in discriminating speech in noise was seen among the participants aged 60-69 years in the higher informational masker (babble noise). The authors concluded that age-related decline in speech discrimination in noise is due to cognitive functioning of auditory processing and phonetic cues needed to correctly identify sentences from noise.

In another study exploring cognitive factors and speech recognition, Meister et al. (2013) investigated age-related differences in speech recognition with a competing speaker that required selective and divided attention. Participants included 12 younger adult listeners (18-27 years) and 14 older adult listeners (58-79 years) all with normal hearing and normal cognitive functioning. Stimuli included sets of sentences that had low predictability (five word sentences) and sentences with high word predictability (three to seven word sentences). Results showed that older adults performed worse than the younger adults in repeating sentences with a single-talker masker. Additionally, older adults had poorer performance with divided attention tasks than the younger adult listeners. Analysis revealed that selective attention tasks correlated with working memory capacity and divided attention tasks correlated with fluid intelligence. The authors concluded that working memory and fluid intelligence affect speech recognition in listeners with normal hearing in competing speech (Meister et al., 2013).

In an effort to explain age-related changes related to both cognitive and perceptual factors affecting language comprehension, Schneider et al. (2002) conducted a series of listening tasks designed to assess comprehension in quiet and in more realistic conditions, such as in noise and with distractors. Participants included younger adults (under 30 years of age) and older-aged adults (over 65 years of age) with normal hearing. Results of the study showed that older-aged adults had lower scored performance in quiet. However, when the listeners were tested at equal levels of perceptual stress, performance between the two groups was nearly equal. The authors concluded that since performance between the two groups was not significantly different when the younger adults experienced the same perceptual stress in listening as older-aged adults, older listeners might have possible changes in listening skills due to different factors including sensory deficits and increased cognitive effort (Schneider et al., 2002).

In conclusion, studies of age-related cognitive factors in speech perception and understanding show that cognitive skills in normal hearing adults have an influence on speech recognition tasks in noise when the conditions are the same for all listener groups. However, when listening conditions were equalized by creating the same level of perceptual stress for all listener groups, age-related differences in performance disappeared (Schneider et al., 2002). This suggests that there may be sensory and perceptual differences in older adults with good hearing in comparison to younger adults and that these differences may also affect cognitive functioning by stressing the cognitive processing necessary for speech recognition (Pichora-Fuller, Schneider, & Daneman, 1995; Schneider et al., 2002).

**Contextual information.** The studies in the above sections demonstrated that there are age-related changes for listening in noise and in cognitive functioning among older-aged listeners with normal hearing. However, while some skills may decline for older-aged listeners, other skills, such as vocabulary have been shown to be stronger in older-aged adults (Pichora-Fuller, 2008). Older-aged adults have been shown to use context more efficiently than younger adults (Schneider et al., 2002). Therefore older-aged adults may compensate for a decline in other listening skills by utilizing vocabulary experience and contextual information in speech perception tasks.

A study conducted by Garcia and Hayden (1999) explored listener use of context in understanding of dysarthric speech. A 76-year old female diagnosed with mixed flaccid-spastic dysarthria participated as the speaker and 24 older adults (65-74 years) and 24 younger adults (18-35 years) comprised the listener participants. Listeners were assigned randomly to either a combination of audio and video or audio-only listening condition. The listeners transcribed sentences recorded by the speaker with dysarthria. Results indicated that younger listeners performed 14% better than the older listeners in understanding high predictive sentences. Garcia and Hayden (1999) concluded that younger listeners may use semantic information to understand less intelligible speech more proficiently than older listeners. The authors also suggested that older listeners may experience changes in auditory discrimination, semantic knowledge and information processing due to aging. These changes may diminish the use of contextual information. Overall, results from Garcia and Hayden (1999) highlight the changes age may have on language skills such as semantic knowledge and processing of information. These changes may affect understanding of less intelligible speech.

In a different study, Pichora-Fuller et al. (1995) investigated age-related differences in word recognition in noise. In comparing results from younger aged participants with normal hearing (22-29 years) with older-aged participants with near-normal hearing (65-77 years), the authors found that the older-aged participants received more assistance from context than their younger counterparts. However, Dubno, Ahlstrom, and Horwitz (2000) found different results than Pichora-Fuller et al. (1995). Dubno et al. (2000) used sentences with low and high context, and word recognition was measured in three conditions: quiet, +20dB masker, and +40dB masker. Signal-to-noise ratio was held constant for each individual listener. Participants of the study included eight younger adults (22-28 years) and eight older-aged adults (63-74 years) with normal hearing. Results of the study revealed that given equal speech audibility, no significant differences in how younger and older adult listeners use context were found.

In a more recent study, McAuliffe, Gibson, Kerr, Anderson, and LaShell (2013) examined whether age-related differences existed in understanding a degraded speech signal, specifically dysarthric speech. Sixteen younger (mean age=20.1 years) and 16 older-aged (mean age=64.8years) adults with normal hearing and cognitive functioning participated as listeners in the study. Stimuli included recorded speech samples (phrases varying from three to five words in length) from five speakers with hypokinetic dysarthria and five age- and gender-matched controls. Results showed that older listeners performed similarly to younger listeners. Additionally, a better receptive vocabulary correlated with better performance in understanding dysarthric speech. Results showed that while older listeners had diminished hearing acuity compared to the younger listeners, they had better vocabularies than the younger listeners. The authors concluded that listeners with a larger vocabulary are more adept at using lexical cues to understand dysarthric speech (McAuliffe et al., 2013).

Findings from these studies exploring age-related differences in using context for speech recognition in noise or given a degraded signal may differ due to variances in methodology. Overall, it is accepted that vocabulary skills are retained in older-aged adults and as some studies show, older-aged adults likely benefit from using their vocabulary knowledge and experience to compensate for age-related declines in other listening skills.

**Statement of the Problem**

Speech associated with PD is often characterized by phonatory deficits including impaired pitch level, reduced pitch variability, monoloudness and reduced speech loudness. Due to the intricate design of the laryngeal muscles, the voice is often the first indication of a neurological disorder as well as the progression of the disorder in severity (Duffy, 2005). According to Harel et al. (2004), acoustic analysis can be helpful in detecting changes in voice and overall speech changes before any overt symptoms are seen. More recently, Rusz, Cmeijla, Ruzickova, and Ruzicka (2011) reported that 78% of early-untreated individuals with PD present with vocal impairment. Rusz et al. (2011) also reported that while the majority of previous studies have found phonatory deficits followed by articulatory deficits to predominate, their findings suggested prosody to be more impaired in early, untreated PD. With this in mind, it is important that those, such as SLPs, who are evaluating voice are aware of possible listening effects and other aging effects for perception of dysarthric and normal speech. In addition, creating awareness among individuals with neurological disorders, as well as family members, regarding listening effects can be important to achieve better rehabilitation outcomes.

There is existing literature on how different listener groups perceive perceptual variables of parkinsonian speech, such as phonation, pitch, prosody, loudness, speech rate, acceptability and also more objective perception of intelligibility and comprehensibility. However, the literature is limited on findings that investigate speech perception of monologues by different aged listeners (younger, middle-aged and older-aged adults). The goal of the present study is therefore to examine aging effects in neurologically normal listeners for perception of monologues produced by individuals with PD and neurologically age- and gender-matched normal speakers (NS). The current study specifically examined perception of listener groups for seven speech variables including pitch, pitch variability, loudness, rate, pauses, understandability, and perception of effort of the two speaker groups (individuals with PD and NS). The specific research question of the study is as follows: Are there differences in speech perception of monologues produced by individuals with PD and NS by different aged listener groups (younger, middle-aged and older-aged adults)?

# CHAPTER III

# METHOD

The present study was approved by the institutional review board of Oklahoma State University (see Appendix A for the IRB Approval Forms including Adult Consent and Recruitment Forms). For this study, participants included five individuals with PD and five NS who served as speakers. Sixty normal hearing adults were recruited as listeners and divided into three age groups: younger adults (YA), middle-aged adults (MA) and older-aged adults (OA). The following sections describe the selection criteria and participant tasks.

## Selection Criteria

**Speakers with PD**. The present study included speakers with different severities of PD associated dysarthria, including mild, moderate, and severe. These speakers with PD (three males, two females; age range=55-80 years) were selected from recordings from a prior study conducted by Parveen (2013). All speakers with PD were assessed for dysarthria type and severity using Darley et al. (1969) criteria by an ASHA certified SLP. Out of the five speakers, two had mild hypokinetic dysarthria, two had moderate hypokinetic dysarthria, and one had severe hypokinetic dysarthria (Parveen, 2013). As identified in Parveen (2013), all speakers with PD met the following criteria: a diagnosis of idiopathic PD, no medical history of other neurological deficits, current usage of dopaminergic medication, no upper respiratory congestion at the time of recording, native speakers of American English, functional hearing levels for at least one ear as determined by passing a pure tone hearing screening test in three out of four tones (500, 1000, 2000, and 4000 Hz) or use of hearing aids at the time of recording, a score on the Dementia Rating Scale -2 (DRS-2; Mattis, 2004) above the cutoff of 123, and a reading level functional for paragraph length text.

**Normal speakers**. The present study included five neurologically normal speakers both age- and gender-matched with the five speakers with PD. Speakers with PD were age-matched with a difference of one year with neurologically normal speakers. Criteria for normal speakers included the following: no medical history of neurological deficits, no upper respiratory congestion at the time of recording, native speakers of American English, functional hearing levels for at least one ear as determined by passing a pure tone hearing screening test in three out of four tones (500, 1000, 2000, and 4000 Hz) or use of hearing aids at the time of recording, and a reading level functional for paragraph length text.

**Listeners**. The present study recruited listeners by convenience sampling. Listener participants included 60 adults in three age groups: 20 younger-aged listeners (18-35 years), 20 middle-aged listeners (36-64 years), and 20 older-aged listeners (65 years and older). Previous studies have used similar division of ages for listener groups (Dagenais et al., 2011; Fogerty, Kewley-Port, & Humes, 2012; Garcia & Hayden, 1999). Further rationale for ages of older adults is supported by ASHA's criteria for hearing screening changes for adults aged 65 and older (Roeser & Clark, 2007). Criteria for listener groups included the following: no medical history of neurological disorders affecting speech and language and functional hearing levels as determined by a hearing screening. Based on the criteria, five of the total recruited participants were eliminated (one YA had a history of neurological disorder, one YA did not pass the hearing screening, one OA was not a native speaker of American English, one OA wore hearing aids and did not have a recent audiological exam, and one OA had missing data on the DRS-2. For the current study, none of the included listeners were hearing aid users. In addition, all listeners completed a self-reported questionnaire about any possible cognitive deficits. None of the listeners self-reported deficits which might have interfered with tasks of the present study. Published literature reports that mild cognitive impairment has a 3% to 19% prevalence rate in the general elderly population (Gauthier et al., 2006). Listeners aged 65 and older were specifically assessed for any possible cognitive deficits by administrating the DRS-2 (range=130–144). The majority of recruited listeners were untrained in listening to parkinsonian speech. Out of the 60 listeners, two were trained as SLPs, two were undergraduate students in an SLP program, and 4 were graduate students in an SLP program. The remaining listeners were either students attending Oklahoma State University or adults living in the local community.

**Hearing Screening**

Hearing screenings for the speakers with dysarthria were performed at 25 dB HL (under 65 years) and 40 dB HL (65 years and older) at 500 Hz, 1 kHz, 2 kHz and 4 kHz (Parveen, 2013; Roeser & Clark, 2007). Four speakers with PD passed the hearing screening and the remaining participant with PD wore hearing aids at the time of recording. Hearing screenings were performed for normal speakers and listeners following the same procedures as Parveen (2013). The hearing screening form is attached as Appendix B.

## Demographic Questionnaire

Speakers with PD filled out a demographic questionnaire including information about medical history, last neurological visit, current medications, and disease duration. Similar to speakers with PD, all other participants including normal speakers and normal listeners filled out a demographic questionnaire at the beginning of the session (see Appendix C). The demographic questionnaire included information about participants' age, general health, neurological history, native language, and education level. The questionnaire also included questions regarding hearing, speech and language history as well as familiarity with speech produced by individuals with PD. Table 1 summarizes the demographic information of speakers with PD and NS. Table 2 summarizes the demographic information of listener groups.

Table 1
*Demographic Information of Speakers with Parkinson Disease (PD) and Neurologically Normal Aged- and Gender-Matched Speakers (NS)*

| List ID No. | Gender | Age | Severity and Dysarthria Type | Hearing Screening | DRS-2 Score |
|---|---|---|---|---|---|
| PD1 | Male | 67 | Moderate hypokinetic | * | 132 |
| PD2 | Male | 64 | Mild hypokinetic | Passed | 144 |
| PD3 | Female | 84 | Moderate hypokinetic | * | 135 |
| PD4 | Female | 62 | Mild hypokinetic | Passed | 141 |
| PD5 | Male | 55 | Severe hypokinetic | Passed | 128 |
| NS6 | Male | 55 | N/A | Passed | ------- |
| NS7 | Female | 85 | N/A | Passed | 119 |
| NS8 | Male | 66 | N/A | Passed | 136 |
| NS9 | Female | 63 | N/A | Passed | ------- |
| NS10 | Male | 63 | N/A | Passed | ------- |

*Note.* Columns include List of Recorded Speakers (List ID No.), Gender, Age (in Years), and Severity and Dysarthria Type. *Hearing Screening could not be completed for these participants as they wore hearing aids during the session. Participants aged 65 and older completed the Dementia Rating Scale 2 (DRS-2).

Table 2

*Demographic Information of Listener Groups*

| Listener Group | Number | Males | Females | Mean Age | Age Range |
|---|---|---|---|---|---|
| Young Adults (YA) | 20 | 5 | 15 | 22.2 | 18-31 |
| Middle-aged Adults (MA) | 20 | 4 | 16 | 48.35 | 36-64 |
| Older-aged Adults (OA) | 20 | 6 | 14 | 72.75 | 65-84 |

*Note.* Columns include Listener Groups, Total Number of Participants per Listener Group (Number), Total Number of Male Participants (Males) per Listener Group, Total Number of Female Participants (Females) per Listener Group, Mean Age (in Years) per Listener Group, Age Range (in Years) per Listener Group.

**Stimuli**

All speakers with PD were recorded at their respective homes using a table top microphone (Shure SM58) attached to a digital recorder (Marantz Professional Model PMD661MKII). All speakers produced a one to two minute monologue from a given choice of topics: job, favorite vacation, or hobby. Background noise level was measured in dB-A with a SLM (BK Precision Model 732) prior to recording. The ambient noise was monitored to be below 40 dBHL during all the recordings. The mouth-to-microphone distance was maintained at 15 cm during speech recordings for speakers with PD. Similar protocols were implemented for ambient noise and mouth-to-microphone distance during the recording of monologues by normal speakers. The monologue recordings were carried out either in a laboratory space or a location convenient to them.

## Rating Task

Listeners were presented with monologue stimuli using a laptop computer and headphone set (HD280-Professional). During the listening task, the background noise of the location was measured in dB-A using a Koolertron SL1361 Digital Sound Level Meter. The ambient noise level was below 40 dB (mean ambient noise level=35.56 dB) during the listening tasks. Listeners rated the monologue speech tasks using a VAS. Previous perceptual rating studies have used VAS to rate speech variables (Kozlosky, 2009; Parveen, 2013). Prior research (Grant et al., 1999) supports VAS as superior to fixed-point scales such as the Borg scale and Likert scale specifically for reproducibility and sensitivity to change. As described in the study by Parveen (2013), listeners in the present study placed an "X" on a 10 mm line for each speech variable corresponding to personal perception of the speech/voice presented. The seven speech variables included: pitch (too low/too high), pitch variability (monotone/excessive pitch variations), loudness (talking too quietly/talking too loudly), rate (too slow/too fast), pauses (too short or too few/too long or too many) speech understandability (not at all understandable/completely understandable) and perception of effort to speak (excessive effort/no effort). The present study included perception of effort as one of the speech variables based on research by Jacobson et al. (1997). These authors reported that individuals with greater speech impairments also self-reported greater effort. Therefore, perception of effort was included in this study to determine how different listener groups perceived this dimension for monologues produced by the two speaker groups. Definitions were provided for pitch, monotone, excessive pitch variations, loudness, rate, pause, and understandability (i.e., speech intelligibility). Before beginning the rating task, the researcher explained each variable. Definitions were also listed at the bottom of each rating page for the listener's reference. A copy of the perceptual rating form is attached as Appendix D.

To minimize order effects, speaker recordings were counterbalanced and randomized and two lists were generated (i.e., List 1 and List 2). Within each listener group, half of the listeners completed the rating task using List 1 and the other half completed the task using List 2. Both lists were compared and there was no statistically significant difference [$F(3,52)=1.899$, $p=0.089$, $\eta^2=0.204$].

**Reliability of Perceptual Ratings**

Scoring reliability (intra-reliability and inter-reliability) of VAS ratings was determined by having two experimenters rescore 20% of perceptual ratings (4 randomly selected listeners from each group for a total of 12). Pearson-Product Moment Correlation (PPMC) was used to analyze the reliability of scoring for the perceptual ratings. Reliability measurements were completed for each of the seven speech variables (i.e., pitch, pitch variability, loudness, rate, pauses, understandability, and perception of effort). Results of the PPMC indicated that reliability measurements were statistically significant for each speech variable at $p<.001$. Table 3 lists the reliability measurements.

Table 3

*Reliability Measures Including Pearson-Product Moment Correlation (PPMC) Coefficients for Intra-Score and Inter-Score Reliability Measures*

| Speech Variables | Intra-Score Reliability | Inter-Score Reliability |
|---|---|---|
| Pitch | 0.999 | 0.985 |
| Pitch Variability | 0.998 | 0.952 |
| Loudness | 1.000 | 0.995 |
| Rate | 0.999 | 0.885 |
| Pauses | 0.999 | 0.859 |
| Understandability | 0.846 | 0.908 |
| Effort | 1.000 | 0.826 |

*Note.* All values significant $p<.001$.

**Statistics**

A multivariate repeated-measures analysis of variance (MANOVA) was performed to examine perceptual differences across the three listener groups (YA vs. MA vs. OA) for monologues produced by individuals with PD and NS on seven speech variables. The first independent variable was the listener group consisting of three levels (YA, MA, OA). The second independent variable was the speaker group consisting of two levels (individuals with PD and NS). The dependent variables were seven speech dimensions, including: pitch, pitch variability, loudness, rate, pauses, understandability, and perception of effort to speak. Alpha level for all statistical analysis in the present study was set at .05. Effect size ($\eta^2$) was reported in order to provide information regarding the magnitude of differences found in the results and the power of the findings (Sullivan & Feinn, 2012).

# CHAPTER IV

# RESULTS

To compare the listener ratings for monologues produced by two speaker groups, a multivariate ANOVA was completed with the independent variables of listener group (YA vs. MA vs. OA) and speaker group (PD vs. NS). No statistically significant listener X speaker interaction effects were found [$F(14,36)=.505$, $p=.915$, $\eta^2=.164$]. However, there was a significant speaker main effect [$F(7,18)=3.987$, $p=.008$, $\eta^2=.608$] and listener main effect [$F(14,36)=3.100$, $p=.003$, $\eta^2=.547$].

Univariate ANOVA statistics were then completed to determine the main effects for listener group and speaker group. Within the speaker group, significant univariate effects were found for only two of the seven dependent variables. These include understandability ratings [$F(1,24)=5.207$, $p=.032$, $\eta^2=.178$] and perception of effort ratings [$F(1, 24)=5.275$, $p= 031$, $\eta^2=.180$]. The remaining speech variables were not statistically significant. These include ratings for pitch [$F(1,24)=.308$, $p=.584$, $\eta^2=.013$], pitch variability [$F(1,24)=.266$, $p=.611$, $\eta^2=.011$], loudness [$F(1,24)=.004$, $p=.950$, $\eta^2=.000$], rate [$F(1,24)=.464$, $p=.502$, $\eta^2=.019$] and pauses [$F(1,24)=3.587$, $p=.070$, $\eta^2=.130$]. As there were only two speaker groups, no further post-hoc tests were completed for the two significant variables (understandability and perception of effort ratings). A separate set of independent samples t-test was instead completed to determine speaker group differences for understandability and perception of effort ratings.

Results indicated speakers with PD to have significantly lower understandability ratings than NS [$t(28)=-2.407$, $p=.026$]. In addition, speakers with PD had significantly higher perception of effort ratings compared to NS [$t(28)=-2.423$, $p=.023$]. When the mean ratings were examined descriptively, individuals with PD had lower understandability ratings (i.e., lower mean values) compared to NS. In addition, individuals with PD had significantly higher perception of effort ratings (i.e., lower mean values) compared to NS. Figure 1 includes graphical representation for speaker group differences for understandability and perception of effort. Table 4 summarizes the descriptive data of the perceptual speech ratings (mean and standard deviation) for the two speaker groups by the different listener groups.

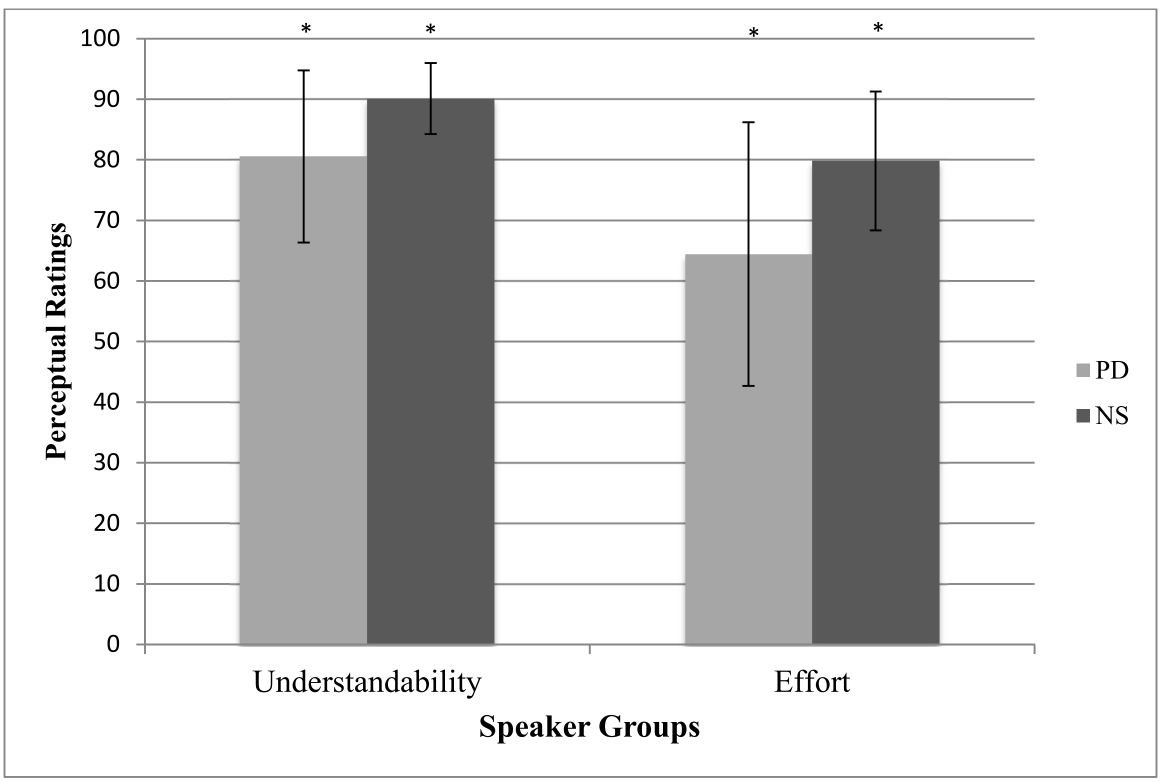


Figure 1. Differences for perceptual ratings of understandability and effort for speakers with Parkinson disease (PD) and neurologically normal age- and gender-matched speakers (NS) by listeners. *Values significant at $p<.05$. Error bars indicated the standard deviation.

Table 4

*Descriptive Data Including Mean (M) and Standard Deviation (SD) for Perceptual Speech Ratings of the Two Speaker Groups ((Individuals with PD (PD) and Normal Speakers (NS)) by Different Listener Groups: Young Adults (YA), Middle-aged Adults (MA), and Older-aged Adults (OA)*

| | | M | | SD | |
|---|---|---|---|---|---|
| Speaker ID | | PD | NS | PD | NS |
| Pitch[a] | | | | | |
| | YA | 47.270 | 44.090 | 9.485 | 8.103 |
| | MA | 44.630 | 43.300 | 9.760 | 5.234 |
| | OA | 45.540 | 44.980 | 7.963 | 8.731 |
| | Total | 45.813 | 44.123 | 8.504 | 6.991 |
| Pitch Variability[a] | | | | | |
| | YA | 38.860 | 37.275 | 10.972 | 11.138 |
| | MA | 40.070 | 39.600 | 9.739 | 8.478 |
| | OA | 39.360 | 38.465 | 11.192 | 9.924 |
| | Total | 39.430 | 38.447 | 9.877 | 9.607 |
| Loudness[a] | | | | | |
| | YA | 46.140 | 46.830 | 7.487 | 7.936 |
| | MA | 44.920 | 43.760 | 7.581 | 8.267 |
| | OA | 41.480 | 41.340 | 7.209 | 12.736 |
| | Total | 44.180 | 43.980 | 7.174 | 9.448 |
| Rate[a] | | | | | |
| | YA | 43.350 | 45.140 | 16.412 | 17.293 |
| | MA | 43.700 | 47.190 | 12.107 | 8.269 |
| | OA | 37.620 | 42.420 | 15.024 | 9.239 |
| | Total | 41.557 | 44.917 | 13.844 | 11.552 |
| Pauses[a] | | | | | |
| | YA | 60.880 | 55.710 | 12.513 | 16.174 |
| | MA | 59.710 | 51.960 | 9.731 | 7.685 |
| | OA | 57.580 | 48.600 | 8.467 | 4.994 |
| | Total | 59.390 | 52.090 | 9.709 | 10.381 |
| Understandability[b] | | | | | |
| | YA | 81.220 | 91.490 | 17.4339 | 5.239 |
| | MA | 81.370 | 92.490 | 15.242 | 4.627 |
| | OA | 79.050 | 85.900 | 12.845 | 6.129 |
| | Total | 80.547 | 90.093 | 14.197 | 5.870 |
| Effort[b] | | | | | |
| | YA | 65.930 | 79.320 | 23.857 | 16.466 |
| | MA | 69.060 | 82.880 | 21.045 | 10.255 |
| | OA | 58.300 | 77.230 | 23.816 | 7.888 |
| | Total | 64.430 | 79.810 | 21.758 | 11.451 |

*Note.* Speaker groups included individuals with Parkinson disease (PD) and normal age- and gender-matched speakers (NS). Listener groups included Young Adults (YA), Middle-aged Adults (MA), and Older-aged Adults (OA). [a]Speech variables with normal rating at 50. [b]Speech variables with normal rating at 100.

Specific to the listener groups, univariate ANOVA results indicated no statistically significant differences among the groups for any of the seven speech variables. These include ratings for pitch [$F(2,24)=.115$, $p=.892$, $\eta^2=.009$], pitch variability [$F(2,24)=.124$, $p=.884$, $\eta^2=.010$], loudness [$F(2,24)=.848$, $p=.441$, $\eta^2=.066$], rate [$F(2,24)=.445$, $p=.646$, $\eta^2=.036$], pauses [$F(2,24)=.608$, $p=.552$, $\eta^2=.048$], understandability [$F(2, 24)=.474$, $p=.628$, $\eta^2=.038$], and perception of effort [$F(2.24)=.506$, $p=.609$, $\eta^2=.040$]. Since no specific differences between the three listener groups were found to be significant, no further post-hoc tests were completed. Table 5 summarizes the descriptive data of the perceptual speech ratings (mean, standard deviation, and range) for speakers with PD by the different listener groups. Table 6 summarizes the descriptive data of the perceptual speech ratings for the normal speakers by the different listener groups.

**Additional analysis.** To the best of our knowledge, no other previous research has examined perception of effort among different listener groups for speakers with PD and NS. In order to better understand reasons for higher perception of effort among PD speakers, a correlational analysis was completed between the perception of effort and the remaining six dependent variables of the study (including pitch, loudness, rate, and understandability). Results indicated that perception of effort ratings had a positive correlation only with the understandability ratings ($p=.032$). The relationship between perception of effort and each of the remaining five variables (including pitch, pitch variability, loudness, rate, and pauses) was not statistically significant ($p > .05$)

Table 5

*Descriptive Data Including Mean (M), Standard Deviation (SD), and Range of Perceptual Speech Ratings of Speakers with Parkinson Disease (PD) by Different Listener Groups: Young Adults (YA), Middle-aged Adults (MA), and Older-aged Adults (OA)*

| | M | | | | | SD | | | | | Range (0-100) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Speaker ID | PD01 | PD02 | PD03 | PD04 | PD05 | PD01 | PD02 | PD03 | PD04 | PD05 | PD01 | PD02 | PD03 | PD04 | PD05 |
| Pitch[a] | | | | | | | | | | | | | | | |
| YA | 44.70 | 48.90 | 53.00 | 57.25 | 32.50 | 12.33 | 10.29 | 16.25 | 12.69 | 14.89 | 50 | 45 | 68 | 52 | 54 |
| MA | 42.35 | 46.75 | 48.70 | 55.85 | 29.50 | 15.43 | 5.96 | 12.17 | 13.40 | 13.94 | 69 | 28 | 53 | 58 | 44 |
| OA | 43.35 | 49.85 | 43.70 | 56.05 | 34.75 | 16.09 | 12.59 | 13.25 | 12.64 | 12.36 | 80 | 64 | 54 | 44 | 44 |
| Pitch Variability[a] | | | | | | | | | | | | | | | |
| YA | 36.05 | 39.30 | 45.65 | 51.10 | 22.20 | 16.60 | 18.67 | 20.12 | 19.29 | 20.15 | 56 | 69 | 85 | 80 | 90 |
| MA | 38.55 | 46.80 | 44.25 | 47.00 | 23.75 | 10.14 | 8.57 | 20.39 | 6.04 | 16.92 | 35 | 41 | 92 | 22 | 66 |
| OA | 34.55 | 46.45 | 39.45 | 52.75 | 23.60 | 14.82 | 9.18 | 14.26 | 9.88 | 10.91 | 73 | 40 | 53 | 33 | 33 |
| Loudness[a] | | | | | | | | | | | | | | | |
| YA | 41.65 | 46.8 | 54.40 | 51.85 | 36.00 | 12.05 | 12.22 | 19.67 | 20.95 | 13.82 | 47 | 66 | 74 | 98 | 48 |
| MA | 36.50 | 48.70 | 50.90 | 51.60 | 36.90 | 13.90 | 9.43 | 14.76 | 10.66 | 13.20 | 59 | 47 | 75 | 47 | 49 |
| OA | 32.25 | 47.80 | 46.00 | 46.20 | 35.15 | 13.68 | 9.21 | 13.49 | 10.75 | 14.76 | 48 | 38 | 53 | 52 | 50 |
| Rate[a] | | | | | | | | | | | | | | | |
| YA | 49.20 | 42.05 | 46.70 | 61.75 | 17.05 | 23.58 | 14.83 | 11.24 | 15.91 | 12.17 | 87 | 66 | 42 | 60 | 38 |
| MA | 39.90 | 51.65 | 43.50 | 57.55 | 25.90 | 17.34 | 11.80 | 14.88 | 11.45 | 18.53 | 69 | 53 | 60 | 38 | 79 |
| OA | 30.25 | 47.80 | 34.25 | 57.05 | 18.75 | 12.63 | 11.69 | 16.46 | 13.88 | 9.57 | 49 | 54 | 58 | 58 | 37 |
| Pauses[a] | | | | | | | | | | | | | | | |
| YA | 69.60 | 61.90 | 58.35 | 41.20 | 73.35 | 20.24 | 18.66 | 20.85 | 16.90 | 25.20 | 68 | 75 | 79 | 63 | 95 |
| MA | 67.20 | 58.50 | 60.25 | 44.10 | 68.50 | 20.50 | 16.88 | 15.64 | 10.52 | 19.70 | 79 | 72 | 55 | 33 | 75 |
| OA | 64.20 | 50.15 | 58.30 | 47.95 | 67.30 | 24.68 | 16.62 | 18.76 | 9.93 | 26.33 | 80 | 78 | 70 | 37 | 87 |
| Understandability[b] | | | | | | | | | | | | | | | |
| YA | 80.70 | 96.65 | 82.05 | 94.00 | 52.70 | 21.30 | 4.82 | 18.92 | 9.02 | 27.11 | 67 | 21 | 58 | 32 | 98 |
| MA | 81.65 | 93.80 | 81.80 | 93.35 | 56.25 | 21.92 | 13.54 | 19.61 | 10.67 | 22.91 | 73 | 63 | 76 | 48 | 82 |
| OA | 76.40 | 94.00 | 78.20 | 86.80 | 59.85 | 20.21 | 5.59 | 19.40 | 14.28 | 27.21 | 66 | 24 | 57 | 51 | 79 |
| Effort[b] | | | | | | | | | | | | | | | |
| YA | 60.75 | 82.85 | 60.20 | 93.85 | 32.00 | 25.72 | 24.59 | 25.66 | 5.77 | 24.31 | 94 | 78 | 83 | 20 | 78 |
| MA | 64.25 | 87.10 | 63.45 | 91.35 | 39.15 | 28.13 | 13.22 | 22.87 | 12.65 | 21.50 | 93 | 53 | 70 | 58 | 77 |
| OA | 51.40 | 83.45 | 52.90 | 79.05 | 24.70 | 27.34 | 13.89 | 24.84 | 21.45 | 17.00 | 96 | 54 | 82 | 62 | 57 |

*Note.* Listener groups included Young Adults (YA), Middle-aged Adults (MA), and Older-aged Adults (OA). [a]Speech variables with normal rating at 50. [b]Speech variables with normal rating at 100.

Table 6

*Descriptive Data Including Mean (M), Standard Deviation (SD), and Range of Perceptual Speech Ratings of Neurologically Normal Age- and Gender-Matched Speakers (NS) by Different Listener Groups: Young Adults (YA), Middle-aged Adults (MA), and Older-aged Adults (OA).*

| | M | | | | | SD | | | | | Range (0-100) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Speaker ID | NS06 | NS07 | NS08 | NS09 | NS10 | NS06 | NS07 | NS08 | NS09 | NS10 | NS06 | NS07 | NS08 | NS09 | NS10 |
| Pitch[a] | | | | | | | | | | | | | | | |
| YA | 50.85 | 45.55 | 32.60 | 51.95 | 39.50 | 6.12 | 11.32 | 15.36 | 11.65 | 14.45 | 28 | 49 | 51 | 60 | 55 |
| MA | 44.95 | 45.50 | 41.45 | 49.25 | 35.35 | 13.96 | 10.15 | 7.83 | 4.38 | 15.35 | 67 | 44 | 26 | 19 | 49 |
| OA | 49.15 | 50.65 | 42.30 | 51.95 | 30.85 | 6.78 | 14.03 | 10.20 | 7.40 | 18.26 | 23 | 58 | 39 | 24 | 49 |
| Pitch Variability[a] | | | | | | | | | | | | | | | |
| YA | 45.75 | 37.70 | 20.10 | 48.75 | 26.15 | 13.96 | 18.70 | 14.41 | 9.20 | 15.42 | 63 | 66 | 53 | 37 | 55 |
| MA | 40.80 | 42.50 | 33.70 | 49.85 | 28.80 | 14.37 | 15.75 | 13.55 | 6.78 | 15.60 | 54 | 59 | 54 | 34 | 52 |
| OA | 41.55 | 32.70 | 34.00 | 52.35 | 27.25 | 12.55 | 17.29 | 12.40 | 11.83 | 17.27 | 53 | 52 | 49 | 51 | 75 |
| Loudness[a] | | | | | | | | | | | | | | | |
| YA | 49.15 | 51.95 | 38.60 | 55.95 | 38.50 | 5.66 | 7.86 | 13.88 | 12.96 | 13.65 | 26 | 34 | 41 | 56 | 57 |
| MA | 48.45 | 46.55 | 40.90 | 52.05 | 30.85 | 5.22 | 9.30 | 12.59 | 6.55 | 17.18 | 22 | 37 | 55 | 24 | 53 |
| OA | 47.55 | 43.10 | 44.15 | 52.40 | 19.50 | 7.41 | 9.55 | 9.43 | 9.79 | 16.47 | 32 | 37 | 34 | 44 | 56 |
| Rate[a] | | | | | | | | | | | | | | | |
| YA | 39.80 | 66.20 | 21.05 | 56.70 | 41.95 | 14.58 | 20.04 | 12.38 | 14.23 | 10.21 | 59 | 77 | 42 | 60 | 40 |
| MA | 42.90 | 58.65 | 37.40 | 52.00 | 45.00 | 15.78 | 14.27 | 12.04 | 5.67 | 13.24 | 67 | 52 | 54 | 22 | 59 |
| OA | 37.80 | 54.70 | 31.35 | 48.65 | 39.60 | 11.24 | 20.33 | 11.63 | 8.72 | 14.15 | 39 | 73 | 46 | 38 | 47 |
| Pauses[a] | | | | | | | | | | | | | | | |
| YA | 66.65 | 33.50 | 75.60 | 51.95 | 50.85 | 18.19 | 15.94 | 16.51 | 16.50 | 11.40 | 72 | 54 | 56 | 74 | 55 |
| MA | 59.75 | 40.35 | 57.75 | 52.60 | 49.35 | 12.71 | 16.15 | 16.00 | 7.47 | 11.19 | 46 | 46 | 64 | 34 | 56 |
| OA | 53.05 | 40.45 | 51.50 | 47.45 | 50.55 | 20.86 | 16.61 | 17.92 | 8.54 | 14.79 | 83 | 61 | 72 | 35 | 63 |
| Understandability[b] | | | | | | | | | | | | | | | |
| YA | 96.15 | 86.25 | 86.15 | 97.15 | 91.75 | 5.76 | 17.34 | 17.09 | 2.92 | 13.96 | 25 | 75 | 56 | 12 | 63 |
| MA | 96.80 | 85.85 | 92.15 | 97.35 | 92.30 | 3.17 | 15.17 | 11.27 | 2.55 | 8.98 | 10 | 59 | 46 | 9 | 29 |
| OA | 87.65 | 84.85 | 88.00 | 92.80 | 76.20 | 12.87 | 17.09 | 13.33 | 11.74 | 25.12 | 41 | 60 | 54 | 53 | 92 |
| Effort[b] | | | | | | | | | | | | | | | |
| YA | 78.55 | 78.60 | 53.05 | 95.20 | 91.20 | 19.30 | 23.82 | 27.63 | 5.25 | 9.54 | 58 | 73 | 94 | 19 | 30 |
| MA | 90.95 | 71.00 | 72.40 | 91.15 | 88.90 | 8.62 | 25.10 | 28.13 | 14.30 | 10.03 | 28 | 99 | 99 | 54 | 42 |
| OA | 80.00 | 70.50 | 68.20 | 87.60 | 79.85 | 24.15 | 25.67 | 25.16 | 17.21 | 16.15 | 73 | 77 | 83 | 68 | 57 |

*Note.* Listener groups included Young Adults (YA), Middle-aged Adults (MA), and Older-aged Adults (OA). [a]Speech variables with normal rating at 50. [b]Speech variables with normal rating at 100.

# CHAPTER V

# DISCUSSION

The purpose of this study was to examine age-related differences in perception by three different aged listener groups (i.e., younger, middle-aged, and older-aged) for monologues produced by individuals with PD and neurologically normal adults. When listener ratings were analyzed based on two speaker groups (PD vs. NS), significant effects were found for only two of the seven variables. Specifically, speakers with PD were rated significantly lower on understandability than NS by all three listener groups. In addition, all listener groups rated significantly higher perception of effort by speakers with PD compared to NS. Further, when the listener groups were compared amongst themselves, there were no significant aging effects. The following sections discuss the above findings.

The present study's findings of reduced understandability ratings for individuals with PD by listeners is consistent with previous research (e.g., McAuliffe et al., 2006; Miller, 2007). The present study defined understandability as intelligibility or understandability of speech. McAuliffe et al. (2006) had previously examined perception of speech intelligibility of PD speakers during reading tasks by two SLPs. These authors concluded that the two SLP listeners perceived speakers with PD to have imprecise consonant production characterized by articulation errors. A later study by Miller (2007) also concluded normal listeners to perceive reduced speech intelligibility among speakers with PD compared to control speakers during word repetition and monologue tasks.

Some of the recent studies (i.e., Feenaughty et al., 2014; Ma, et al., 2015; Whitfield & Goberman, 2014) have examined the reasons behind reduced speech intelligibility in individuals with PD. Whitfield and Goberman (2014) compared speech intelligibility of speakers with PD to healthy control speakers during a paragraph reading task. The authors also measured articulatory-acoustic vowel space of the two speaker groups. The results of this study revealed that speakers with PD were perceived to have less clear speech, and also found to have smaller articulatory-acoustic vowel space when compared to normal speakers. Whitfield and Goberman (2014) concluded that speakers with PD had decreased articulatory range of motion compared to control speakers. Speech intelligibility has also been reported to decline with disease progression in individuals with PD (Ma et al., 2015). The study by Ma et al. (2015) found that speakers with moderate-severe dysarthria had significantly lower intelligibility ratings compared to speakers with mild dysarthria. These authors concluded that speech intelligibility declines with progression of dysarthria. Previous studies have also concluded that the intelligibility of the speaker is also influenced by the speech task with monologues being less intelligible than structured reading tasks (Kempler & Van Lancker, 2002; Ma et al., 2015).

In conclusion, the present study provides evidence for reduced speech understandability in speakers with PD during monologue tasks compared to age-and-gender matched NS. Although the present study did not include acoustic measures for the speakers with PD, it is possible that imprecise consonant production, smaller articulatory-acoustic vowel space of speakers with PD, and prosodic features (changes in rate, more pauses) as described by published studies may account for the perceived reduced speech understandability among the speakers with

PD.  Future studies can examine the relationship between acoustic measures and perceptual measures for the same set of speakers to determine the factors influencing the perception of speech intelligibility.

In addition to understandability ratings, the listeners in the present study rated speakers with PD to have put in more speech effort during the monologue task compared to normal speakers.  This is in agreement with findings by Jacobson et al. (1997) about increased perception of effort in speakers with greater speech deficits.  Only one prior study (Parveen, 2013) has investigated perception of effort as a speech variable by listeners.  This study included only participants with PD as speakers and thus no comparisons were made with other speaker groups.  Based on the additional analysis completed between perception of effort and other dependent variables (including pitch, loudness, rate and understandability), the perception of effort only had a significant positive correlation with understandability ratings in the present study.  It is possible that listeners in the present study associated higher perception of effort (i.e., lower effort scores on VAS) among PD speakers with significantly lower understandability (i.e., lower understandability scores on VAS) compared to NS.  Additional studies are needed in order to determine the relationship between perception of effort and other speech variables by different listener groups.

None of the other five speech variables (pitch, pitch variability, loudness, rate, pauses) examined in the present study were found to be significantly different for speaker groups (PD vs. NS) when rated by listeners.  Several factors may account for the findings of no significant differences between the two speaker groups for these five variables.  These factors include inexperience of listeners, variability among speakers with PD, small sample size of different severity ratings of dysarthria, and nature of the VAS task.

One possible reason for perceived differences in understandability and effort ratings and not the other five speech variables, may be lack of training and/or familiarity among the listener groups regarding speech aspects of PD associated dysarthria. The majority of listeners in the present study were untrained listeners. While listeners were provided with a verbal explanation and written definition for each of the speech variables, they were not provided with audio examples of typical and PD associated dysarthric speech. Therefore, it is possible that these untrained listeners were not perceptive in listening for deviant speech characteristics including changes in pitch, pitch variability, changes in loudness, and changes in speech rate.

In addition, published studies provide evidence for variability between speakers with PD (i.e., Feenaughty et al., 2014; Metter & Hanson, 1986). As found in Feenaughty et al. (2014), speakers with PD were perceived to have reduced intelligibility compared to control speakers. However, the authors reported no statistically significant speaker group differences based on acoustic measures. Feenaughty et al. (2014) concluded that lack of group differences based on acoustic measures could be attributed to possible variability within the speakers with PD. In addition, these authors recommended careful interpretation of results from group analyses due to possible variability within the PD speakers.

Additionally, the dysarthria severity of the speakers in the present study may have contributed to lack of differences for ratings of five variables including pitch, loudness, and rate. Previous studies have concluded that speech deficits associated with dysarthria in PD are not always apparent in mild to moderate dysarthria, but become more obvious in severe to profound dysarthria (i.e., Holmes et al., 2000; Logemann, Fisher, Boshes, & Blonsky, 1978; Tjaden, 2000). Both Ma et al. (2015) and Metter and Hansen (1987) have observed that speakers with mild and moderate PD may not have marked speech differences compared to healthy control speakers. Specific to speech rate, Metter and Hanson (1986) found that PD speakers with mild or moderate PD associated dysarthria may have relatively normal speech rates compared to those with severe PD associated dysarthria. These findings are also similar to results from Tjaden (2000) in which articulatory rates of speakers with mild and moderate dysarthria did not differ, but rates for speakers with severe dysarthria were perceived to grow more rapidly. Multiple studies have concluded that the degree of severity of the dysarthria is an important factor in explaining the variety of observed perceptual and acoustic measures. As the majority of speakers with PD (four out of five) in the present study had a rating of mild or moderate PD associated dysarthria, it is possible that these speakers did not differ from NS in some of the speech variables.

Finally, the nature of the VAS task could have influenced the perceptual ratings. Listeners were provided with instructions and shown the VAS form prior to listening to any recorded monologues. However, while listening to the monologues, listeners did not have the VAS form in front of them for reference or to mark as they listened. After each monologue, the listeners were given the VAS form to complete for the speaker they just heard. Therefore, it is possible that relying on memory for the more specific speech variables such as pitch, pitch variability, loudness, rate and pauses was more difficult than rating the overall understandability and perception of effort of the monologue. In conclusion, different factors including specific speaker related characteristics, lack of training or familiarity among listeners, and the nature of the task could be possible reasons for lack of differences for speech variables including pitch, pitch variability, loudness, rate, and pauses.

Specific to the listener groups, results from the present study indicated no age-related differences among the three groups for rating monologues produced by individuals with PD and

NS. These findings are similar to Poole (2011) in which younger and older-aged adults did not have age-related differences in ratings of speech for intelligibility, comprehensibility, and acceptability. Possible reasons for finding no age-related differences in perception between listener groups in the present study may be due to the following factors: contextual support of monologues, quiet listening conditions, and normal cognitive functioning of participants.

It is possible that contextual information provided in the monologues benefited listeners and reduced age-related differences. Published findings have shown that both younger and older listeners utilize semantic information, receptive skills, and contextual information to aid in speech understanding (i.e., Garcia & Hayden, 1999; McAuliffe et al., 2013; Schneider et al., 2002). Therefore, it is possible that the nature of the speech stimuli used in the current study diminished differences among the listener groups.

Another factor that may have contributed to similar perceptual ratings among listener groups is the listening condition of the study. The present study was conducted in a quiet environment (mean ambient noise=35.56 dB) and during the listening task, listeners wore closed-ear headphones designed to attenuate outside noise. The present study's findings of similar performance between older and younger adults in quiet conditions are consistent with findings from Fullgrabe et al. (2015). The prior study concluded that both younger and older adults had nearly equal performance on an identification task for consonants and sentences produced by normal speakers in quiet conditions.

In addition, normal cognitive functioning of all listener participants may explain presence of similar performance by different listener groups in the present study. All listeners in the study self-reported no neurological and/or cognitive deficits that might have affected their performance on the presented listening tasks. Findings from previous research (i.e., Poole, 2011) suggest that matched cognitive levels in older and younger listeners may account for similar performance in listener perception of dysarthric speech. Therefore, normal cognitive function in listener participants in this study may account for similar perceptual ratings and lack of age-related differences among listener groups.

## Limitations of the Study

**Nature of the listening task**. The present study focused on overall speech perception of speakers rather than the content or comprehensibility of the presented stimuli. This is in contrast to prior studies that have found age-related differences among listener groups during different speech tasks. In particular, Schneider et al. (2002) examined perception of speech stimuli by different listener groups based on comprehension tasks. These authors concluded older listeners to have poorer comprehension scores in quiet conditions when compared to younger adults. It is possible that the listening task in the present study may not have been challenging enough to parse out specific age-related differences among the different listener groups as was previously found in studies that included transcription tasks and comprehensibility tasks (i.e., Dagenais et al., 2011; Schneider et al., 2002).

**Lack of external reference.** The majority of listeners in the present study were not trained in perception of dysarthric speech. Therefore, it is possible that these listeners were not experienced enough to perceive the differences among the different speech aspects. Listeners were provided with only verbal instructions and written definitions for the speech variables. No audio files were presented to the listeners as external references for normal versus disordered speech including PD associated dysarthria. Thus, listeners may have lacked a strong internal reference in which to accurately rate the perceptual features per speaker group. Future studies may include training sessions and presentation of audio examples to elicit more accurate performance by listeners to differentiate between normal and disordered speech.

**Age ranges of listener groups.** The present study included listeners divided into three age ranges: younger adults (18-35), middle-aged adults (36-64), and older-aged adults (65 and older). Division of age groups in the present study was based on prior studies using similar age ranges. However, other researchers have used different divisions of age in comparing age-related differences. Thus, it is possible that the age ranges included for each group in the current study could be a confounding factor. Perhaps using different age ranges would have resulted in more significant differences between age groups.

**Familiarity with speakers.** Another limitation of this study may be due to the recruitment sample of speakers and listeners. A small proportion of listeners (10/60) were acquainted personally with two of the NS. Although all of the listeners were blinded to the speakers' identity and presence or absence of a diagnosis of PD, it is possible that some of the listeners might have been influenced in their ratings by recognizing voices of two of the NS during the listening task.

**Listener familiarity with PD.** While the majority of listeners recruited for this study were not trained in perception of parkinsonian or dysarthric speech, approximately half of the listeners did know someone personally who had PD. Of the listeners who answered yes to knowing someone with PD, only 14 were in contact with the individual with PD on a regular basis. Familiarity with speakers with PD was not a variable controlled for in this study, and therefore it may be seen as a possible limitation.

**Characteristics of PD speakers.** Two further possible limitations of the current study may be due to characteristics of the recruited speakers with PD. Recruited speakers with PD in the present study included two with mild severity (one female, one male), two with moderate severity (one female, one male), and only one male speaker with severe degree of hypokinetic dysarthria. As discussed in earlier sections, speakers with mild and moderate dysarthria may not demonstrate apparent speech deficits that differentiate them from NS. Therefore, the small sample size of different severities of dysarthria may account for the lack of statistical differences between listener groups and among speech variables. Another limitation may be due to possible gender effects. Ratings of male and female speakers with PD were combined in the present study. Other research (i.e. Skodda, Visser, & Schlegel, 2011) has indicated that there are gender-related differences in the patterns of prosodic disturbance in speakers with PD. Therefore the combined analysis of both male and female speakers with PD in the current study may be a confounding factor. Future studies could examine gender differences within the PD speakers.

## Conclusions and Future Directions

In conclusion, the present study investigated age-related differences between listener perception of monologues produced by individuals with PD and NS. Overall, no significant age-related differences were found among the three listener groups. However, significant speaker-related differences were found for two of the speech variables (understandability and perception of effort). All listener groups rated individuals with PD to have significantly lower speech understandability compared to NS.

Findings from the present study suggest multiple future directions. Researchers may consider recruiting a larger sample size of speakers with PD with different disease severities in order to better examine perceptual abilities by different listener groups. The majority of listeners in the current study were untrained, so future studies could also investigate effects of training and/or listener familiarity for perception of parkinsonian speech and other neurogenic speakers. In addition, there are currently limited studies regarding age-related differences in speech perception of features such as pitch, pitch variability, loudness, speech rate, pauses, understandability and perception of effort. Future studies could further investigate these speech variables within the same set of participants. Researchers could also focus on examining age-related differences of these perceptual features using realistic speech stimuli (monologues and conversation) and under different conditions (i.e., quiet and typical background noise) in order to establish if age-related differences exist for these measures in different listening conditions. Additionally, studies may include both perception of speech features (i.e., pitch, pitch variability, loudness, speech rate, and pauses) and objective listening tasks such as transcription and comprehension to discover if there are age-related differences in performance on subjective and objective tasks between listener groups of different ages. Finally, future studies could include multiple monologue samples per speaker and determine listener rating changes based on the content of the speaker.

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# APPENDICES

## APPENDIX A: IRB APPROVAL FORM

### Oklahoma State University Institutional Review Board

| | | | |
|---|---|---|---|
| Date: | Thursday, November 13, 2014 | **Protocol Expires:** | **10/28/2015** |
| IRB Application No: | AS14121 | | |
| Proposal Title: | Perception of Individuals with Parkinson Disease and Normal Speakers by Different Listener Groups | | |
| Reviewed and Processed as: | Expedited<br>**Modification** | | |

Status Recommended by Reviewer(s) **Approved**

Principal Investigator(s):

Sabiha Parveen
042 Murray
Stillwater, OK 74078

Anna Slaten
700 N Greenwood Ave
Tulsa, OK 74106

---

The requested modification to this IRB protocol has been approved. Please note that the original expiration date of the protocol has not changed. The IRB office MUST be notified in writing when a project is complete. All approved projects are subject to monitoring by the IRB.

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

The reviewer(s) had these comments:

Modification to 1)administer the DRS-2 to normal participants aged 65 + and to all PD participants and 2) add demographic questions for PD participants.

Signature:

Hugh Crethar, Chair, Institutional Review Board

Thursday, November 13, 2014
Date

**ADULT CONSENT FORM**

Perception of Speech by Individuals with

Parkinson Disease and Normal Speakers

**PROJECT TITLE:** Perception of Speech by Individuals with Parkinson Disease and Normal Speakers

**INVESTIGATORS:**

Sabiha Parveen, Ph.D. Oklahoma State University

Anna Slaten, B.S. Oklahoma State University

**PURPOSE:**

The purpose of the study is to examine effects of aging and familiarity on perception of speech produced by individuals with Parkinson disease (PD) and neurologically normal speakers of different age groups (18 years and older). It is possible you are being contacted because of previous interest or participation in research. The results of this study will be used to learn more about how listeners perceive the speech produced by individuals with Parkinson disease (PD) and normal speakers.

**PROCEDURES**

The study will include one or two sessions in a laboratory space or another location convenient to you. Your participation will start with filling out a series of questionnaires and a hearing screening. The maximum time commitment for each session is approximately 45-60 minutes. All normal participants aged 65 years and above are going to complete a test of thinking before the speaking and/or listening tasks.

☐ Speakers (normal participants): You will be asked to perform speech tasks.

☐ Listeners (normal participants): You will be asked to listen to live and recorded speech samples, and answer some questions.

☐ Listeners (individuals with PD): You will complete a test of thinking and a movement test (Section III of Unified Parkinson Disease Rating Scale) before completing the listening tasks. The movement test will be administered to determine the severity of PD. In addition, you will be asked to listen to live and recorded speech samples, and answer some questions.

**RISKS OF PARTICIPATION:**

There are no known risks beyond those that you would normally encounter in your daily life. However, the movement test for participants with PD does involve standing, walking, and balance. Participation in this research is voluntary. You will be given the option to skip any piece of the test that you might feel unsafe with. No funds have been set aside by Oklahoma State University to compensate you in the event of illness or injury.

You may benefit by learning more about perception of speech produced by individuals with Parkinson disease and neurologically normal speakers.

**BENEFITS OF PARTICIPATION:**

The study will help us to identify the factors that listeners utilize to perceive speech of individuals with and without neurological diagnoses. Findings from study can be then incorporated in treatment aspects of individuals with neurological disorders. In case you are interested, we will send you a copy of the results of the study when it is finished.

**CONFIDENTIALITY:**

All records related to this research will be maintained in a locked laboratory and will be available only to those assisting with the project. The recordings will be maintained after the study is complete for future research/ continuation of this study. You will be assigned a participant number and this will be used in place of your name. The investigators will not reveal any identities if they publish or present the results of this study.

**COMPENSATION/ EXTRA COURSE CREDIT:**

Participants recruited through the SONA database: You will receive one unit of course credit for completing the entire session. There are no partial credits available for participation. You can withdraw at any point during the study without penalty. In case you withdraw without completing the entire session, please check with your course instructor for other alternatives to earn available extra course credits.

All other participants will receive a $10/session for participation.

**CONTACTS:**

You may contact any of the researchers at the following addresses and phone numbers, should you desire to discuss your participation in the study and/or request information about the results of the study: Sabiha Parveen, Ph.D., 016 Murray Hall, Dept. of Communication Sciences and Disorders, Oklahoma State University, Stillwater, OK 74078, (405) 744-5116. If you have questions about your rights as a research volunteer, you may contact the IRB Office at 219 Cordell North, Stillwater, OK 74078, 405-744-3377 or irb@okstate.edu

**PARTICIPANT RIGHTS:**

I understand that my participation is voluntary, that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at any time, without penalty.

**CONSENT DOCUMENTATION:**

I have been fully informed about the procedures listed here. I am aware of what I will be asked to do and of the benefits of my participation. I also understand the following statements:

I affirm that I am 18 years of age or older.

*Preface the signature lines with the following statement (expand if appropriate):*

I have read and fully understand this consent form. I sign it freely and voluntarily. A copy of this form will be given to me. I hereby give permission for my participation in this study.

______________________________ ________________

Signature of Participant Date

Please also initial here if you give consent for your anonymous data to be used for educational purposes:

I certify that I have personally explained this document before requesting that the participant sign it.

______________________________ ________________

Signature of Researcher Date

**RECRUITMENT SCRIPT**
Perception of Speech by Individuals with
Parkinson Disease and Normal Speakers

**Introduction**: You are being invited to participate in a study of perception of speech recordings. It is possible you are being contacted because of previous interest or participation in research. The results of this study will be used to learn more about how listeners perceive the speech produced by individuals with Parkinson disease (PD) and normal speakers. The study will be conducted by Sabiha Parveen and Anna Slaten with the Department of Communication Sciences and Disorders at Oklahoma State University.

**Eligibility**: You are eligible to participate if you are over 18 years of age, a native speaker of standard American English, and if you pass a hearing screening procedure.

**Procedures for speakers and listeners**: The study will include one or two sessions in a laboratory space or another location convenient to you. Your participation will start with filling out a series of questionnaires and a hearing screening. The maximum time commitment for each session is approximately 45-60 minutes. All normal participants aged 65 years and above are going to complete a test of thinking before the speaking and/or listening tasks.

- Speakers (normal participants): You will be asked to perform speech tasks.
- Listeners (normal participants and individuals with PD): You will be asked to listen to live and recorded speech samples, and answer some questions.
- Listeners (individuals with PD): You will complete a test of thinking and a movement test (Section III of Unified Parkinson Disease Rating Scale) before completing the listening tasks. The movement test will be administered to determine the severity of PD. In addition, you will be asked to listen to live and recorded speech samples, and answer some questions.

**Payment / Costs**:

Participants recruited through the SONA database: You will receive one unit of course credit for your participation. Please check with your course instructor for other alternatives to earn available extra course credits. All participants will be informed that they can withdraw at any point during the study without penalty. This means that the student will still receive credit even after withdrawing from a session that has already begun.

All other participants will receive a $10/hour for participation.

**Risks and Benefits**: There are no known risks beyond those that you would normally encounter in your daily life. The movement test for participants with PD does involve standing, walking,and balance. You will be given the option to skip any piece of the test that you might feel unsafe with. No funds have been set aside by Oklahoma State University to compensate you in the event of illness or injury.

You may benefit by learning more about perception of speech produced by individuals with Parkinson disease and neurologically normal speakers.

**Confidentiality**: All records related to this research will be maintained in a locked laboratory and will be available only to those assisting with the project. The recordings will be maintained after the study is complete for future research/ continuation of this study. You will be assigned a participant number and this will be used in place of your name. The investigators will not reveal any identities if they publish or present the results of this study.

**Questions**: You may contact any of the researchers at the following addresses and phone numbers, should you desire to discuss your participation in the study and/or request information about the results of the study: Sabiha Parveen, Ph.D., 016 Murray Hall, Dept. of Communication Sciences and Disorders, Oklahoma State University, Stillwater, OK 74078, (405) 744-5116 or Anna Slaten, B.S., at 419-372-4320 (anna.slaten@okstate.edu). If you have questions about your rights as a research volunteer, you may contact the IRB Office at 219 Cordell North, Stillwater, OK 74078, 405-744-3377 or irb@okstate.edu

**HANDWRITTEN FORMS WILL NOT BE ACCEPTED**
**Application for Review of Human Subjects Research**
**Appendix A**

# Request for OSU System Email Addresses for Human Subject Research Recruitment Purposes

The purpose of this form is to obtain approval to access OSU-System faculty, staff or student email addresses for purposes of recruitment to human subject research conducted by Oklahoma State University researchers. **Please include a copy of this completed and signed form with your IRB application.**

| | |
|---|---|
| **Protocol Title:** | Perception of individuals with Parkinson disease and normal speakers by different listener groups |

## SECTION 1 – Principal Investigator/Advisor Information

| | | | |
|---|---|---|---|
| Primary PI Name:<br>SABIHA PARVEEN | | Advisor Name (If PI is a student): | |
| Department:<br>COMMUNICATION SCIENCES AND DISORDERS | E-Mail:<br>sabiha.parveen@okstate.edu | Department: | E-mail: |

## SECTION 2 – Study Description

Purpose of Research: The purpose of the study is to examine effects of aging and familiarity on perception of speech produced by individuals with Parkinson disease (PD) and neurologically normal speakers of different age groups (18 years and older).

Description of Research: (A brief description of what participants will be expected to do and or types of information to be requested) **Please note that due to the many requests for research and the large volume of email to university users, OSU Communications/IT allows only one follow-up email to be sent after the initial recruitment email. Any request for additional emails will be handled on a case-by-case basis and should be directed to the Office of University Research Compliance.**

(i) All participants (speakers and listeners) will complete a general questionnaire (including demographic information, past medical history).
(ii) All participants will complete a hearing screening. Listeners will be eligible to participate in the study only if they pass the hearing screening.
(iii) Listeners will then listen to recorded monologues produced by speakers (individuals with PD and normal individuals) and complete some listening-related tasks based on different recordings.

**All participants will complete a hearing screening. Listeners will be eligible to participate in the study only if they pass the hearing screening.**

## SECTION 3 – Sample Population Description

| | |
|---|---|
| Indicate which campuses of the OSU System Population you wish to sample:<br>☐X OSU-Stillwater Campus<br>☐X OSU-Tulsa Campus | Indicate which segments of the population you wish to sample:<br>☐X Faculty<br>☐X Undergraduate Students<br>☐X Graduate Students<br>☐X Staff |
| Total Sample Size Requested: 800<br>Expected Response Rate: 100<br>Total Number of Responses Needed: 60 | Please specify any sample inclusion and/or exclusion criteria (e.g. junior and seniors only) and how the sample should be distributed (e.g. proportionately, specified numbers, etc.) Please note that OSU Communications/IT not allow more than one follow-up email to be sent after the initial recruitment email. |

Okla. S[illegible]
Approved 10-29-1[illegible]
Expires 10-28-1[illegible]
IRB# AS-14-121

Oklahoma State University Institutional Review Board
219 Cordell North, Stillwater, OK 74078
405-744-3377

Version 05/2011

**SECTION 4 – Approval Signatures**

Obtain the signature of your department head first then submit the form to OSU Communications Services for review and signature. **A copy of the fully signed form should be submitted with your IRB application.**

| PI 's Department Head: | Date: | OSU Communication Services: | Date: |
|---|---|---|---|
| [signature] | 10-22-14 | [signature] | 10/23/14 |
| | | | |

Okla. State Univ.
IRB
Approved 10-29-14
Expires 10-28-15
IRB# AS-14-121

**Oklahoma State University Institutional Review Board**
219 Cordell North, Stillwater, OK 74078
405-744-3377

Version 05/2011

## APPENDIX B: HEARING SCREENING FORM

Participant's Name: ______________________________________________________

Participant ID: _____________________ Date: _______________

Hearing Screening Right ear: Pass/ Fail Left ear: Pass/ Fail

| Frequency | Comments | Comments |
|---|---|---|
| 500 Hz | | |
| 1000 Hz | | |
| 2000 Hz | | |

Hearing Aid (if applicable) Right ear Left ear

Last visit to Audiologist:

Other comments:

## APPENDIX C: GENERAL QUESTIONNAIRE (For all participants)

**Partic #__________** **Date: ___________**

1. Age: _________________ Date of birth: ___________________
2. Sex: _________________
3. General Health: □ Good □ Fair □ Poor □ Bad
4. Health in past week: □ Very sick □ Sick □ Moderate □ Healthy □ Very Healthy
5. Are you taking any medications (either prescribed or over-the-counter) that may affect your speech/ language/ hearing? □ Yes □ No

   If yes, please list medications: ________________________________________

   ________________________________________________________________
6. Do you have any neurological diagnoses/diseases that may affect speech/ language/ hearing?

   □ Yes □ No

   If yes, please explain: ________________________________________________

   ________________________________________________________________

   ________________________________________________________________
7. Do you have any medical diagnoses/ diseases that may affect speech/ language/ hearing?

   □ Yes □ No

   If yes, please explain: ________________________________________________

   ________________________________________________________________
8. Is English your first language? □ Yes □ No

   If not, how old were you when you began learning English? ___________
9. Highest level of education obtained:

   □ Elementary level □ High School □ College □ Graduate School

**SPEECH/ LANGUAGE/ HEARING HISTORY**

10. Do you have any: a. Visual deficits: □ Yes □ No

    b. Hearing deficits: □ Yes □ No

    If yes, do you use hearing aids? □ Yes □ No

    □ Right □ Left □ Both

    When was your last visit to an audiologist? Please describe.

    ______________________________________________

    ______________________________________________
11. Have you had any neurological injuries (including concussion, stroke, head injury)

    during childhood? □ Yes □ No

    as an adult? □ Yes □ No

    If yes to either please describe: ________________________________________

    ________________________________________________________________
12. Have you ever been enrolled in therapy with a Speech-Language Pathologist?

    □ Yes □ No
13. Have you participated in speech, language, or hearing studies before: □ Yes □ No

    If yes, please describe: ______________________________________________

    ______________________________________________________________
14. Do you know anyone personally who has Parkinson disease (PD)? □ Yes □ No

    If yes, please describe how frequently do you communicate with the individual(s)?

    ______________________________________________________________

## APPENDIX D: SPEECH RATING FORM

**Speaker # ___________**

**Partic #_________** **Date: ____________ Time: __________**

Place an X along each line to indicate your perception of your speech/ voice used during monologue recording. Use the definitions if needed.

| | | |
|---|---|---|
| Pitch too Low | ______________________________ | Pitch too High |
| Monotone | ______________________________ | Excessive Pitch Variations |
| Talking too Quiet | ______________________________ | Talking too Loud |
| Rate too Slow | ______________________________ | Rate too Fast |
| Pauses too short / too few | ______________________________ | Pauses too long / too many |
| Not at all understandable | ______________________________ | Completely understandable |
| Excessive effort to speak | ______________________________ | No effort to speak |

**DEFINITIONS:**
**Pitch**= Highness or lowness of voice
**Monopitch**= Voice lacks normal pitch and inflections
**Excessive pitch variations**= Too many ups and downs in speech
**Loudness**= Voice is insufficiently or excessively loud
**Rate**= Rate of actual speech is abnormally slow or rapid
**Pause**= Intervals in between words (filled or silent)
**Speech intelligibility**= Intelligibility or understandability of speech

Does the speaker have Parkinson Disease? YES_________ NO______________

VITA

Anna Slaten

Candidate for the Degree of

Master of Science

Thesis: AGING EFFECTS ON PERCEPTION OF PARKINSONIAN AND NORMAL GERIATRIC SPEECH

Major Field: Communication Sciences and Disorders

Biographical:

Education:

Completed the requirements for the Master of Science in Communication Sciences and Disorders at Oklahoma State University, Tulsa, Oklahoma in July, 2015.

Completed the requirements for the Bachelor of Science in English Education at John Brown University, Siloam Springs, Arkansas, 2000.

Experience:

GTA Position, Fall 2013 - Spring 2014, Dr. Sabiha Parveen

Conferences Attended:

OSHA Conference, October 2014

Inez Conference on Communication Sciences and Disorders, April 2014