

# Objective Measurement of Vocal Parameters in Older People With and Without Parkinson's Disease in Their Natural Environments: A Pilot Study

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**P**arkinson's disease (PD) is a progressive, neurodegenerative disease that has many debilitating effects on an individual's life (National Institute of Neurologic Diseases and Stroke, 2010; Spencer, Sanchez, McAllen, & Weir, 2010). The most common motor speech disorder observed in 70%–89% of individuals with PD is hypokinetic

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dysarthria (Duffy, 2012; Spencer et al., 2010), which is perceptually characterized as decreased volume, monopitch, monoloudness, prosodic insufficiency, consonantal imprecision, inappropriate silences, short rushes of speech, variable rate, and repeated phonemes (Darley, Aronson, & Brown, 1969; Duffy, 2012; Gamboa et al., 1997; Spencer et al., 2010).

Although the measurement of vocal parameters is standard in clinical and/or laboratory settings,

**ABSTRACT: Purpose:** The purpose of this study was to explore whether significant differences existed in mean amplitude and total phonation time between a group of older individuals with idiopathic Parkinson's disease (PD) and an age- and gender-matched control group (NO PD) in their natural environments, based on data collected by the ambulatory phonation monitor (APM; KayPENTAX).

**Method:** In this prospective, between-groups study, 5 individuals with PD and 5 NO PD controls wore the APM on 3 typical 8-hr days. The dependent variables included mean amplitude and total phonation time as measured by the APM. All of the participants also completed a self-estimated talk time log and an APM-use questionnaire. Data analysis included descriptive

statistics and a repeated measures analysis of variance.

**Results:** The NO PD group exhibited significantly higher mean amplitudes than the group with PD. The 2 groups did not differ in total phonation time. The group with PD significantly overestimated talk time compared to the NO PD group.

**Conclusion:** These preliminary data suggest that the APM may be used to objectively measure specific vocal parameters in a person's natural communication environment. However, larger sample sizes are needed to better understand the device's usefulness.

**KEY WORDS:** Parkinson's disease, phonation, treatment outcome measures, ICF participation

until recently, there has been no way to collect and objectively measure vocal parameters in a person's natural speaking environment (other than by a recording device). A recording device might cause a person to speak less freely, due to privacy concerns, than he or she would if content was not a concern (Hillman, Heaton, Masaki, Zeitels, & Cheyne, 2006; Ryu, Komiyama, Kannae, & Watanabe, 1983). Therefore, having a device that objectively measures vocal parameters without capturing content might provide a more valid measure of how an individual uses his or her voice in day-to-day communication.

Most assessments of motor speech disorders are conducted in clinical or laboratory settings because they require sophisticated instrumentation (e.g., acoustic and physiologic analyses). However, the results obtained in these settings may not be ecologically valid. Tupper and Cicerone (1990) defined ecological validity as how well the results that are obtained in controlled experimental conditions relate to results that are obtained in naturalistic environments. In the field of motor speech disorders, researchers have suggested that results that are gathered in a laboratory setting have questionable ecological validity (Beukelman, Mathy, & Yorkston, 1998; Kent, 2000). In fact, Adams and Dykstra (2009) suggested that

patients with PD may not use their habitual speech intensity levels in the unnatural context of the laboratory or speech clinic. Therefore, methods for obtaining acoustic measures of speech intensity outside of the clinical setting may need to be developed to establish valid estimates of hypophonia in PD. (p. 169)

The developers of the ambulatory phonation monitor (APM; Kay PENTAX) have suggested that it is an ecologically valid way to objectively measure vocal parameters during day-to-day communication in a person's environment (Hillman et al., 2006). The aim of this study was to determine whether differences exist between a group of older individuals who had been diagnosed with idiopathic PD and an age- and gender-matched control group (NO PD) on their amplitude of speech and total phonation time as measured by the APM. In the following paragraphs, we describe the APM and its functions and then move on to discuss what is known about the vocal parameters that the APM measures (for this study, amplitude and total phonation time) in aging and diseased populations.

## APM

The APM was designed to inconspicuously measure three vocal parameters<sup>1</sup>—mean fundamental frequency ( $f_0$ ), mean amplitude, and total phonation time—in a

speaker's natural environment (i.e., home, work, community) and to provide feedback to speakers about their voice use over a period of 8–10 hr. The APM works by collecting vibratory measures from a small accelerometer sensor that is placed above the sternal notch and is attached to the processor by a thin wire (Popolo, Svec, & Titze, 2005).

Vocal parameters that are measured by an accelerometer rather than a microphone may be more robust due to the way the accelerometer collects the data. First, because the accelerometer collects vibratory data rather than sound recordings, background noise is eliminated (Popolo et al., 2005). Second, an accelerometer can measure the exact timing of voiced speech, whereas a contact microphone cannot (Airo, Olkinuora, & Sala, 2000). Additionally, because an accelerometer does not capture message content, privacy issues are eliminated, which may allow a person to speak more freely and, perhaps, more often (Hillman et al., 2006; Ryu et al., 1983).

To our knowledge, the supposition that people will talk more if content is not being recorded has not been tested. However, three studies have investigated the performance effect (also called the microphone effect) on speech intelligibility when microphones were introduced to record the speech of individuals with PD and dysarthria (Bunton, K., & Keintz, C. K., 2008; Goberman, Recker, & Parveen, 2010; Keintz, Bunton, & Hoit, 2007). Goberman et al. (2010) did not find a performance effect in individuals with PD when a microphone was introduced into the experiment. Conversely, Keintz et al. (2007) reported that individuals with PD and dysarthria demonstrated increased speech intelligibility during clinical testing compared to conversations. The performance effect was further confirmed in a study that compared the vocal parameters of individuals with PD during recorded single- and dual-task monologue production to spontaneous conversations in which the participants did not know they were being recorded. The results indicated that when people with PD did not know they were being recorded, or had their attention divided between speaking and performing a simple motor task, they performed less well than

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<sup>1</sup>The authors recognize that motor speech deficits encompass more than measures of vocal parameters, particularly articulation, which heavily influences reduced speech intelligibility (Duffy, 2012). The APM only measures selected phonatory aspects of three vocal parameters— $f_0$ , amplitude, and total phonation time. We chose to study amplitude and total phonation time because these two parameters are represented frequently in the PD literature. Reduced loudness is one of the most frequently cited concerns of individuals with PD and their communication partners (Duffy, 2012), and individuals with PD and dysarthria typically report that they do not talk as much as they did because it requires increased effort (Miller, Noble, Jones, & Burn, 2006).

when they knew they were being recorded during the single-task monologue (Bunton, K., & Keintz, C. K., 2008; Keintz et al., 2007).

In addition to collecting and measuring vocal parameters, the APM can collect data continuously for up to 10 hr. This is an advantage for researchers and clinicians who are trying to understand changes in vocal behaviors over the course of a day or from day to day. Recently, investigators demonstrated the need to measure phonation time over extended durations in order to obtain a thorough estimation of voice use and misuse (Mehta et al., 2012; Nacci et al., 2013). For example, by measuring amplitude across a day, researchers and/or clinicians are able to observe specific points in time when an individual's vocal intensity was optimal or when it failed to meet target levels. Although not part of this study, one of the uses of the AMP is its ability to monitor amplitude and cue the wearer when it is greater or less than the target.

## Amplitude

Changes in vocal intensity due to aging have been documented (Colton, Casper, & Leonard, 2006). Although the results are inconclusive, amplitude generally decreases with age due to decreased strength in the respiratory musculature, lung volume, and glottal resistance (Hodge, Colton, & Kelley, 2001). Older men and women do not differ significantly in measures of maximum sound pressure level (SPL) during vowel prolongation: 100.5 dB (range 88–110, *SD* = 5.9) for geriatric men and 98.6 dB (range 90–104, *SD* = 4.5) for geriatric women (Ptacek, Sander, Malone, & Jackson, 1966). Two studies comparing the conversational intensity measured during paragraph reading in younger adults (Gelfer & Young, 1997; Izadi, Mohseni, Daneshi, & Sandughdar, 2012) found that there were no statistically significant differences in mean vocal intensity produced between young men and women: Gelfer and Young (1997) reported intensities of 70.42 dB and 68.15 dB, respectively; Izadi et al. (2012) reported intensities of 77.24 dB and 76.8 dB, respectively. Comparable studies investigating the conversational intensity measures in geriatric adults could not be found.

As discussed earlier, reduced vocal intensity is one hallmark of hypokinetic dysarthria that is typically demonstrated by individuals with PD (Duffy, 2012; Stewart et al., 1995). In fact, research has demonstrated that individuals with PD as well as their families, clinicians, and researchers consider reduced loudness to be the major speech deficit associated with PD. One study reported that decreased loudness was typically noted by the person with PD as well as

his or her family and close friends before the disease was diagnosed by a physician (Tetrud, 1991).

Fox and Ramig (1997) suspected that the inability to produce loud phonation resulted from perceptual deficits in individuals with PD because they demonstrated an average 2-dB to 4-dB reduction across vowel prolongation, sentence reading, and paragraph reading (Fox & Ramig, 1997). Other researchers have suggested that individuals with PD may have impaired perception of their own vocal abilities related to impairment in self-monitoring abilities during specific motor speech tasks, even without hearing loss (Bodis-Wollner, 2003; Solomon, Robin, Lorell, Rodnitzky, & Luschei, 1994). People with PD have reported that they feel they have to expend more effort than NO PD people to talk louder (Donovan, Kendall, Young, & Rosenbek, 2008). However, there is no known evidence that individuals with PD reduce the length of time they talk in order to conserve energy or that increased vocal intensity leads to reduced phonation time.

## Phonation Time

In fact, other than the literature investigating occupational vocal use (Hunter & Titze, 2010), there is very limited information pertaining to total phonation time across a full day for any population. Some researchers have speculated that it is a difficult variable to measure given the extensive variability among individuals' personalities, vocations, or education. The few reports that have attempted to quantify phonation time across the day were conducted for individuals who are at risk for voice overuse, such as teachers. Evidence has shown that teachers and speech-language pathologists tend to overestimate the amount of talking they do in a given day compared to microphone-recorded data (Ohlsson, Brink, & Lofqvist, 1989). In another study, the average speaking time collected for 11 participants in various professions (i.e., bus drivers, physicians, pediatric nurses, and clerks) amounted to 110 min a day (Ryu et al., 1983). In a third study, investigators examined the average speaking times of 20 study participants: three doctors, five nurses, four company employees, four housewives, and four medical students. The mean speaking time across all of the occupations was 6 min and 25 s per hour ( $\pm 1$  min and 36 s; Watanabe, Shin, Oda, Fukaura, & Komiyama, 1987).

For researchers and clinicians who are interested in developing new treatments that address communicative participation for people with PD (such as improving communicative effectiveness in the workplace), being able to objectively measure total phonation time over 8–10 hr could provide useful information for program planning and goal attainment.

In a pilot study that was conducted in our laboratory, two older community-dwelling participants with PD and dysarthria wore the APM for 8 hr each. Their phonation time over the 8 hr averaged just 11.25 min (approximately 1.5 min per hour), which is substantially lower than the phonation time results cited earlier (Ryu et al., 1983; Watanabe et al., 1987). The very low total phonation time served as the impetus for the current study to compare the total phonation time of individuals with PD and a control group across an 8-hr day.

## Study Aims

We designed this study to explore whether differences in mean amplitude and total phonation time (measured by the APM) existed between a group of older individuals who had been diagnosed with idiopathic PD and dysarthria compared to an age- and gender-matched control group. Based on the extant literature, we hypothesized that the PD group would have lower mean amplitude and reduced total talk time in comparison to the control group.

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## METHOD

### Design

This study was a prospective, between-group study that was designed to determine whether differences exist in mean amplitude and total phonation time as measured by the APM across three 8-hr days between a convenience sample of two groups: individuals with idiopathic PD and dysarthria and an age- and gender-matched control group. The dependent variables included mean amplitude as measured in dB SPL, and mean total phonation time measured in hours, minutes, and seconds. To examine data reliability, we collected vocal parameter measures three separate times. The Louisiana State University's (LSU's) Institutional Review Board for the Protection of Human Subjects approved this study. Informed consent was provided by all participants before data collection.

### Participants

This study included 10 Caucasian participants (5 with PD and dysarthria and 5 controls) who were recruited from local PD support groups; the LSU speech, language, and hearing clinic; or word of mouth. Inclusion criteria included community dwelling, no history or active neurologic or neurodegenerative disease other than PD, no active cognitive deficits based on

a Mini-Mental State Examination (Folstein, Folstein, & McHugh, 1975) score greater than 24, no apathy based on an Apathy Scale (Starkstein et al., 1992) rating greater than 14 or depression based on a Geriatric Depression Scale Short Form (Sheikh & Yesavage, 1986) score of greater than 10, and adequate hearing based on patient report. Individuals in the group with PD met four additional inclusion criteria: PD diagnosed by neurologist, Hoehn and Yahr PD functional impairment rating of 1–4 (Hoehn & Yahr, 1967), dysarthria severity rating of 1–4 (Donovan et al., 2008), and not receiving speech treatment while participating in the study. Participants in the two groups ranged in age from 67 to 85 years. Each group included three males and two females. Years with PD diagnosis ranged from 2.5 to 8.0 years and of mild to mild-moderate severity based on Hoehn and Yahr ratings ( $M = 1.6$ ,  $SD = .5$ ). Likewise, dysarthria was in the mild to mild-moderate severity based on the dysarthria severity rating ( $M = 1.8$ ,  $SD = .4$ ). Table 1 displays the participants' descriptive characteristics.

### Procedure

Because the APM's accelerometer will not activate without adequate phonation, we conducted preliminary measures. To ensure that neither group included individuals with an excessively breathy voice quality, we assessed breathy voice quality by comparing the amplitudes of the first harmonic amplitude (H1) and second harmonic amplitude (H2) of vowels according to procedures established by Kreiman, Gerratt, Precoda, and Berke (1992). Each participant was asked to read two sentences that were recorded and then assessed for breathiness using TF32.exe (Milenkovic, 2004). The harmonic amplitudes of H1–H2 of the same vowels in each sentence were analyzed and compared in order to test whether the group with PD exhibited a greater range in breathiness than the NO PD group. Ranges were similar across all of the participants; therefore, the study continued without need for further recruitment.

Regarding use of the APM, we followed the manufacturer's procedures for APM use precisely. We completed APM calibration at the LSU Communication Outcomes Research Laboratory or the participant's home. APM calibration for each participant was computed based on a linear regression analysis of the vibratory intensity measured by the accelerometer compared to the acoustic intensity measured by a microphone. For each participant, the following calibration procedure was followed: The accelerometer was placed according to directions, and a noise-resistant microphone (RadioShack TS031) was positioned

**Table 1.** Descriptive characteristics of the participants with Parkinson's disease (PD) and of the age- and gender-matched controls (NO PD).

Attribute	PD01	PD02	PD03	PD04	PD05	Mean					Mean (SD)	
						NO01	NO02	NO03	NO04	NO05		
Gender	F	M	M	M	F	F	M	M	M	F		
Age	77	74	68	85	73	75.40 (6.27)	77	74	68	85	73	75.20 (6.57)
MMSE	29	28	27	30	30	28.80 (1.3)	30	26	30	30	30	29.20 (1.79)
Apathy Scale rating	4	8	3	7	7	5.80 (2.17)	3	3	13	3	4	5.20 (4.38)
GDS	8	2	1	1	0	2.40 (.84)	0	1	1	0	2	0.80 (3.21)
Years postdiagnosis	7	8	5	3	3	5.10 (2.41)						
H&Y stage	2	2	2	1	1	1.60 (0.5)						
DSR	2	2	2	2	1	1.80 (0.5)						

**Note.** MMSE = Mini Mental Status Exam (Folstein et al., 1975), GDS = Geriatric Depression Scale (Sheikh & Yesavage, 1986), H&Y stage = Hoehn & Yahr PD stage (Hoehn & Yahr, 1967), DSR = Dysarthria Severity Rating (Donovan et al., 2008).

15 cm from the participant's mouth. The participant was seated before the computer and was instructed to sustain vowel /a/ beginning as softly as possible and progressing to maximum loudness. The APM calibrates an estimated dB SPL for each participant that has been found to be accurate to within  $\pm 5$  dB SPL to a sound pressure meter (Svec, Popolo, & Titze, 2003; Svec, Titze, & Popolo, 2005).

The participants received instructions to wear the APM on three *typical* days. We defined a typical day for these age- and gender-matched, retired, community-dwelling participants as a day that they would be going about their usual daily routines at home and not be participating in one-time events such as meetings, medical appointments, or social events. In order to establish the reliability of the data collected, we collected data three times on each participant. All of the participants received the same written and verbal instructions: "Wear the device for 8 hours. Keep it safely away from water. Disconnect the wire running from the sensor to the APM before preparing for bed." The following day, we downloaded the data collected by the APM to the computer, inspected sensor placement, and reinstructed the participant. We followed the same protocol on each of the three data collection days.

Because the literature has indicated that individuals with PD may have reduced insight and be poor self-reporters (Abbruzzese & Berardelli, 2003; Bodis-Wollner, 2003; Ho, Bradshaw, Iansek, & Alfredson, 1999), we also asked the study participants to

complete a self-estimated talk time log (see Appendix A) so that we could compare their actual talk time to their perceived talk time every 2 hr of device wear. At the end of the study, the participants also completed a short questionnaire to rate their comfort and satisfaction with device use (see Appendix B).

## RESULTS

We used SPSS (v. 19) to calculate the descriptive and inferential statistics. Although the number of study participants was small, the data for both of the dependent variables—mean amplitude (dB SPL) and total phonation time (minutes)—met the assumptions required to complete a two-way repeated measures  $2 \times 3$  analysis of variance (ANOVA) for each.

### Amplitude

We tested a two-way repeated measures  $2 \times 3$  ANOVA where group (PD and NO PD) was the independent variable and average amplitude dB SPL at three different time periods (T1, T2, and T3) was the dependent variable ( $\alpha = .05$ ). The two groups met the assumption of equal variance and covariance during each time period: time 1,  $F(1, 7) = 0.17, p = 0.69$ ; time 2,  $F(1, 7) = 0.03, p = 0.87$ ; time 3,  $F(1, 7) = 0.00, p = 0.97$ . The NO PD group demonstrated a significantly higher mean amplitude than the group with PD:  $F(1, 7) = 0.17, p = 0.01$ . The strength of

the relationship between a PD diagnosis and the effect on mean amplitude, as assessed by  $\eta^2$ , was strong. The PD diagnosis accounted for 72% of the variance (see Figure 1).

### Phonation Time

With respect to our second dependent variable, we tested a two-way repeated measures  $2 \times 3$  ANOVA where group (PD and NO PD) was the independent variable and average phonation time in minutes at three different time periods (T1, T2, and T3) was the dependent variable ( $\alpha = .05$ ). First, the data met the assumption of sphericity:  $W = 0.95$ ,  $\chi^2(2) = 0.30$ ,  $p = 0.86$ . The data also met the equal variance for each time period: time 1,  $F(1, 7) = 2.67$ ,  $p = 0.15$ ; time 2,  $F(1, 7) = 1.97$ ,  $p = 0.20$ ; time 3,  $F(1, 7) = 4.84$ ,  $p = 0.06$ . The two groups did not differ significantly in mean total phonation time:  $F(2, 14) = 0.75$ ,  $p = 0.49$ . Furthermore, phonation time across the three time points within the two groups was not significantly different:  $F(2, 14) = 3.50$ ,  $p = 0.06$  (see Figure 2).

### Additional Analyses

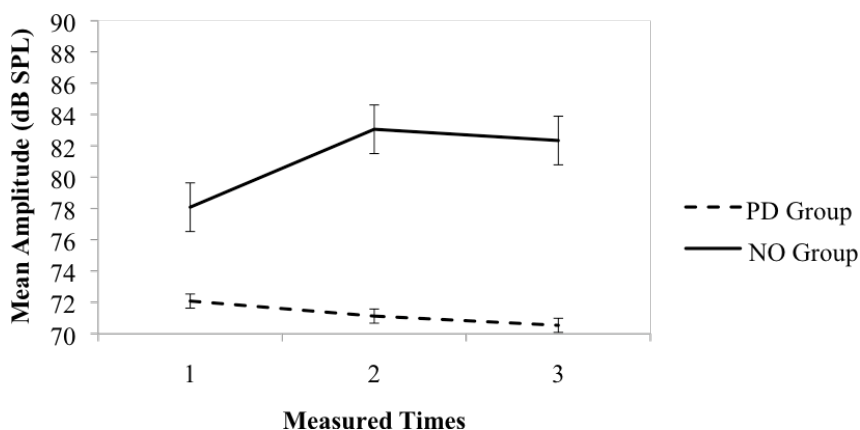
We conducted a paired-samples  $t$  test to determine if the actual phonation time differed from the self-estimated phonation time for each group. The NO PD's mean estimated phonation time ( $M = 51.09$ ,  $SD = 34.48$ ) was not significantly different from their actual phonation time ( $M = 99.72$ ,  $SD = 87.09$ ),  $t(12) = -1.97$ ,  $p = 0.07$ . However, the PD group significantly overestimated their phonation time ( $M = 86.86$ ,  $SD = 31.74$ ) compared to their actual phonation time ( $M = 32.15$ ,  $SD = 15.27$ ),  $t(13) = -5.63$ ,  $p < .01$ .

Last, we asked the participants to rate aspects of comfort while wearing the APM on a 5-unit Likert scale (1 = *very uncomfortable* to 5 = *very comfortable*; Appendix B). The ratings of all 10 participants were averaged for each question. Overall comfort received a mean rating of 3.82, comfort wearing the APM in public received a mean rating of 4.64, and comfort while speaking received a mean rating of 4.86. On a set of yes/no questions, nine of the 10 participants agreed that the APM captured their performance during typical speaking days. Seven participants agreed that they spoke as long as usual, one as less than usual, and two as more than usual. Finally, 7 of the participants reported that the APM did not affect the way they spoke at all. However, three participants from the group with PD indicated that wearing the APM reminded them to talk louder. The implications of these results will be discussed in the next section.

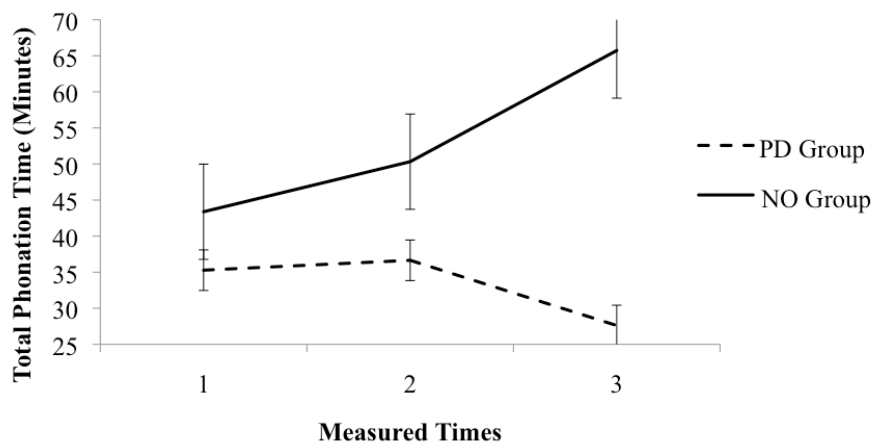
## DISCUSSION

This study aimed to determine whether significant differences existed between participants with idiopathic PD and dysarthria and an age- and gender-matched control group in mean amplitude and total phonation time collected over three data collection sessions. Our results demonstrated that the PD group produced significantly lower mean amplitudes compared to the control group, but that the groups did not differ in their mean total phonation time. The following discussion includes the research and clinical implications of the results, as well as study limitations and opportunities for future research.

**Figure 1.** Mean amplitudes across the three measured times comparing the results of the group with Parkinson's disease (PD) and the age- and gender-matched control (NO) group.



**Figure 2.** Total phonation time across the three time points comparing the results of the PD group and NO group.



Our results for amplitude were similar to those of other researchers who reported reduced vocal amplitude associated with PD (Duffy, 2012; Fox & Ramig, 1997; Ramig, Sapir, Fox, & Countryman, 2001; Stewart et al., 1995). Although preliminary, these results demonstrate that the differences in vocal amplitude demonstrated between PD and NO PD groups under controlled conditions can also be obtained in a person's everyday speaking environment. If these results were replicated in larger groups, a more ecologically valid measure of vocal amplitude—one obtained in a person's everyday speaking environment—might serve as a valid predictor of a person's success in everyday speaking situations. However, in the future, more control over the natural speaking environment will be necessary in order to ensure that the results are valid and replicable.

Previous studies related to speaking time over the course of a day have come primarily from the occupational voice use literature, where investigators are interested in alleviating voice use/overuse through prevention or treatment. Therefore, it is interesting that the results of this study, which were obtained from retired, community-dwelling individuals with and without PD, were comparable to the mean speaking times ( $M = 6.25$  min per hour,  $SD = 1.3$  s) of 20 people in various occupations, as reported by Watanabe et al. (1987). However, when compared to the results by Ryu et al. (1983), who studied teachers only, both groups demonstrated notably less phonation time (9.1 min per hour compared to  $\sim 3.9$  min per hour). Differences could be attributed to age, employment status, or individual variation among speakers. Or, differences could be attributed to differences in the communication environments of the

participants in each of the studies. It is also feasible that cross-cultural differences in phonation time exist between the American participants in this study compared to the Japanese participants in the two studies described.

In advocating for an objective measure of vocal parameters, Hillman et al. (2006) suggested that patient-reported outcomes are subjective and may not be *true* indicators of performance. In this study, we compared subjective and objective measures of total phonation time to determine whether speakers were able to provide an accurate estimation of how much they talked during a given time period. Ohlsson et al. (1989) reported that teachers and speech-language pathologists overestimated the amount of time they talked in a day compared to recorded data. In this study, the NO PD group demonstrated no statistically significant differences between their estimated phonation time and the APM-recorded total phonation time, indicating that they were accurate self-reporters. However, the group with PD significantly overestimated their phonation time compared to the APM-recorded total phonation time, as did the teachers and speech-language pathologists in Ohlsson et al. The PD group's self-report estimates were typical of that reported by others studying this population (Abbruzzese & Berardelli, 2003; Bodis-Wollner, 2003; Ho et al., 1999). The question that requires further investigation is why individuals with PD overestimate their performance.

Finally, with regard to the feasibility of using the APM to collect vocal parameter data, it would appear from the participants' responses that the APM was comfortable and did not interfere with or change the way they talked, although several participants

suggested that a smaller device would be even better. In addition, three participants with PD stated that wearing the APM reminded them to speak louder. Taking these comments into consideration, it is possible that the APM elicited a performance effect, although Hillman et al. (2006) proposed that the APM is an objective way to collect data on vocal parameters in the natural environment.

### Study Limitations

This study had a small sample size; therefore, the findings should not be generalized. Considerable variation in each vocal parameter existed within and between the two groups. Particularly with regard to total phonation time, we expect that our definition of a typical day was too broad to account for the individual differences revealed by the data. In the future, it will be important to add a level of control over the communicative environment, such as a log of communication partners. We did not impose more stringent control over the communication environment in an effort to capture speaking in the natural environment. More control along with a larger sample size should decrease the variability and result in more robust findings.

### Future Research

At least three opportunities for future research in this area come to mind. First, the communication environment must be better defined/controlled in order to decrease large swings in total phonation time as seen in the NO PD T3 group. Under that more controlled communication environment, the study could be conducted again with a larger sample size and equal numbers of males and females in both groups. In addition, with a larger sample size, the ability to stratify males and females will also allow us to study whether changes in  $f_0$  differ when measured in the clinic versus the natural environment. Finally, research into what may have accounted for the difference found in the PD group between their estimated talk time and their total talk time could lead to a better understanding of whether the difference was attributed to reductions in attention, memory, or executive functioning versus changes in perception.

This is the first known study to examine the difference in two vocal parameters between a group of individuals with idiopathic PD and dysarthria and an age- and gender-matched control group using an objective measure in a naturalistic setting. The data are preliminary but indicate that the APM may be useful in collecting objective phonation measures.

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## APPENDIX A. TALK TIME LOG

Please write down an estimation of how many minutes you spoke in each two-hour time slot.

Hours 1–2 (9:00–11:00) \_\_\_\_\_  
Hours 3–4 (11:00–1:00) \_\_\_\_\_  
Hours 5–6 (1:00–3:00) \_\_\_\_\_  
Hours 7–8 (3:00–5:00) \_\_\_\_\_

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## APPENDIX B. DEVICE USE SATISFACTION

(1 = not very comfortable; 5 = very comfortable)

1. Was the ambulatory phonation monitor a comfortable device to wear?  
1            2            3            4            5
2. How comfortable were you wearing the Ambulatory Phonation Monitor in public?  
1            2            3            4            5
3. Did you feel comfortable speaking while wearing the Ambulatory Phonation Monitor?  
1            2            3            4            5
4. Do you feel that it measured a “normal” day of speech for you?  
Yes            No
5. Do you feel that you spoke more, less, or the same amount as you usually speak in a typical day while wearing the Ambulatory Phonation Monitor?  
More            Less            Same
6. Do you feel that the Ambulatory Phonation Monitor affected your speech in any way?  
No            Yes. How? \_\_\_\_\_
7. Did you experience any difficulties with the Ambulatory Phonation Monitor?  
No            Yes. How? \_\_\_\_\_