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Research Article

# The Effect of SPEAK OUT! and The LOUD Crowd on Dysarthria Due to Parkinson's Disease

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**Purpose:** SPEAK OUT! and The LOUD Crowd is a standardized speech therapy program of 12 individual treatments combined with ongoing weekly group sessions for individuals with dysarthria due to Parkinson's disease (PD). The premise of this program is that individuals with PD must rely on goal-directed basal ganglia–cortical circuits to compensate for deficits in habitual, automatic control. The purpose of this study was to assess the outcome of this therapy program.
**Method:** Forty individuals with idiopathic PD received SPEAK OUT! in 12 individual 40-min sessions 3 times per week for 4 consecutive weeks and also participated in The LOUD Crowd. Assessments were conducted 3 times at baseline and then within 1 and 6 weeks after completion of the individual SPEAK OUT! sessions. Twenty-five adults without communication disorders were assessed on the same schedule. Acoustic outcome measures were mean intensity from reading and monologue, the prosody measures of standard deviation of intensity and frequency from reading and monologue, and the voice quality measure of cepstral peak prominence from reading. Patient perception of voice was also assessed with the Voice-Related Quality of Life.
**Results:** Posttherapy, mean intensity was greater and variation of frequency was larger in reading and monologue, while variation in intensity was larger in monologue but unchanged in reading. Cepstral peak prominence and Voice-Related Quality of Life scores were significantly higher (improved) after therapy.
**Conclusion:** These data contribute to evidence of the effectiveness of this program for hypokinetic dysarthria secondary to idiopathic PD and thus inform clinical practice in the selection among treatment options.

Parkinson's disease (PD) is a neurodegenerative disorder that causes disturbances in numerous motor and nonmotor neural pathways (Forno, 1996). It is the second most common neurodegenerative disorder after Alzheimer's disease (de Lau & Breteler, 2006), affecting 1%–2% of individuals over the age of 60 years, rising to 3.5% of individuals at ages 85–89 years. Less commonly, younger individuals in their 30s and 40s may also develop the disease (de Lau & Breteler, 2006; Pringsheim et al., 2014). Common motor signs of PD include bradykinesia (defined as slowness in planning, initiating, and executing sequential and simultaneous tasks), rigidity, and resting tremor, as well as abnormalities of gait, posture, and balance (Berardelli et al., 2001).

Up to 90% of individuals diagnosed with PD are likely to develop dysarthria during the course of their disease, with the potential for substantial negative affect on intelligibility (Ho et al., 1998; Perez-Lloret et al., 2012). The research reported here is an outcomes study of a speech therapy program for individuals with PD. Thus, a brief overview of the abnormal mechanisms of PD will help to explain the therapeutic approach. The following discussion is based on the studies of Brooks et al. (1990), Brown et al. (1997), Forno (1996), Magrinelli et al. (2016), and Redgrave et al. (2010).

PD is characterized by two major pathological processes: the loss of dopaminergic neurons, especially in the substantia nigra pars compacta of the basal ganglia, and the accumulation of Lewy bodies (misshapen protein structures that are involved in neuron cell death) in the brainstem, subcortical, and cortical structures. The basal ganglia, through

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topographically organized connections to cortical and cerebellar regions, serve cognitive, sensorimotor, and limbic (motivation and emotion) functions. Broadly, two pathways within the basal ganglia can be identified. The polysynaptic indirect pathway is associated with regulation of habitual movements. Through connectivity with sensory and motor cortices, it exerts inhibitory control on the cortex and is associated with regulation of habitual movements. The monosynaptic direct pathway exerts phasic activity that releases the thalamus from its inhibitory effect on the cortex. These circuits, which connect predominantly with the frontal cortex, contribute to regulation of goal-directed movements and motor learning, thereby allowing movement to proceed. In the healthy state, activation of the indirect circuits promotes movement inhibition and activation of the direct circuit pathway to facilitate movement. This balance allows a background of automatic motor commands to facilitate expression of goal-directed movements. In PD, depletion of dopamine disproportionately affects the indirect pathway, resulting in a dominance of motor inhibition and hypokinesia, with impairment of habitual, automatic movements. Thus, motor sequences that involve a significant amount of learned, automatic movements, such as writing, walking, and speaking, require greater cognitive effort to achieve.

Diagnostic biomarkers of the hypokinetic dysarthria of PD include overall reduced loudness, decreased articulatory precision, decreased prosody (particularly, reduced variation in pitch and loudness), hoarse vocal quality, and rate abnormalities (Duffy, 2005; Skodda, Grönheit, & Schlegel, 2010). Critical factors contributing to dysarthria include bradykinesia, impaired execution of automatic motor sequences, abnormal sensory processing and internal cueing, decreased effort, and auditory perceptual deficits (Berardelli et al., 2001; De Keyser et al., 2016; Reilly & Spencer, 2013; Sapir, 2014; Spencer & Rogers, 2005).

Speech therapy has the potential to improve speech production for individuals with PD. A substantial body of high-quality research evidence has documented the success of Lee Silverman Voice Treatment (LSVT LOUD; Ramig et al., 2018), a 16-hr standardized program grounded in theories of motor learning that seeks to increase vocal loudness by increasing phonatory effort (Ramig et al., 1995). Here, we assess the outcome of another therapy—an 8-hr standardized program called SPEAK OUT! combined with an ongoing weekly group therapy called The LOUD Crowd. Four major differences between SPEAK OUT! with The LOUD Crowd and LSVT LOUD are noted. First, LSVT LOUD requires twice the number of treatment minutes (16 sessions of 1 hr each) as SPEAK OUT! (12 sessions of 40 min each). Second, The LOUD Crowd, a regular maintenance group session, is an integral component of the entire program, which patients begin to attend prior to the completion of their individual sessions and then continue on a weekly basis after SPEAK OUT!. In comparison, LSVT Global, the organization that trains speech-language pathologists (SLPs) in LSVT LOUD, has added a group component to their treatment called "LOUD for LIFE," but a separate training for the SLP is required, and the group sessions are not integrated into the individual treatment program. Third, SPEAK OUT! with The LOUD Crowd focuses on intentional speech (defined below), whereas LSVT LOUD focuses on increased loudness. Fourth, a complete workbook is provided to each patient of SPEAK OUT! with The LOUD Crowd at no charge, which is used for both in-session training and home practice.

The LOUD Crowd was developed by the third author in 2000. The development of SPEAK OUT! combined with The LOUD Crowd as a rehabilitation program was created in 2010 by the Parkinson Voice Project, a nonprofit organization that conducts speech treatment of individuals with PD-related disorders. The global focus of the therapy is scaling up attention to goal-directed behavior to compensate for the habitual control deficits that lead to impaired production of automatic sequential motor behavior (Wu & Hallett, 2005; Wu et al., 2015). Patients are prompted to "speak with intent," defined and modeled as a purposeful and deliberate cognitive focus on increasing attentiveness to speech production. Data show that increased attention to automatic, habitual motor sequences, such as writing, improves movement accuracy, speed, and range of motion (Oliveira et al., 1997). Similarly, evidence documents overall speech production is improved in individuals with PD when they are instructed to increase attentive focus on their speech—including speaking more clearly, slowly, or loudly (Goberman & Elmer, 2005; Lam & Tjaden, 2016; Tjaden et al., 2013, 2014; Wu et al., 2015), as well as the LSVT-based method that focuses on loud speech (Ramig et al., 2018).

SPEAK OUT! and The LOUD Crowd is also based on the hypothesis that an ongoing maintenance program is essential to retain initial therapeutic gains. The purpose of speech therapy for individuals with PD is to teach skills that can be used to sustain improved communication over the long term. However, due to the progressive nature of PD and the accompanying impaired motivation, sensory deficits, and internal cueing that often occur, long-term gains are difficult to maintain without continued intervention. This difficulty has been demonstrated in other rehabilitation programs for individuals with PD, for example, loss of gains after discontinuation of physical therapy sessions (Comella et al., 1994; Schenkman et al., 1998). Motor learning theory applied to skill acquisition in PD suggests that continued practice is essential for long-term neural change (Sapir et al., 2011). For this reason, the SPEAK OUT! program of individual treatment sessions is followed by participation in regular group therapy sessions of The LOUD Crowd to maintain initial therapy gains to the extent possible with progression of the disease. At least one group therapy session is encouraged in the third or fourth week of SPEAK OUT! to familiarize the patient with the group program, with subsequent weekly attendance upon completion of SPEAK OUT! (to the extent permitted by the patient's personal schedule).

To date, published research reports that SPEAK OUT! has been assessed retrospectively in 78 patients (Watts, 2016) and prospectively in three small-group studies, totaling 45 patients (Boutsen et al., 2018; Levitt et al., 2015; Levitt &

Walker-Batson, 2018). Significant improvement in speech intensity and patient self-assessment of voice has been demonstrated. Dysprosody is a common characteristic of the speech of individuals with PD, often characterized by reduced intonation, limited intensity variation, inconsistent rate, and/or abnormal pausing (Duffy, 2005; Goberman et al., 2010; Skodda, Grönheit, & Schlegel, 2010). Yet, only one small study (Boutsen et al., 2018) has assessed the effect of SPEAK OUT! on prosody, in which increased pitch variability and pitch range in a reading task posttherapy was reported. A reading task, however, may not challenge the speech production system similar to spontaneous speech. Specifically, reading may be simpler than conversation, because content planning is minimized, and reading may afford more opportunities for self-cueing (e.g., through use of punctuation). No study has examined prosody in spontaneous speech. Given that intensity and prosody in oral reading may be different from spontaneous speech (Laan & Van Bergen, 1993), the latter may provide a more realistic assessment of functional communication. Furthermore, no study has provided a stable baseline with which to compare therapeutic outcomes.

Thus, the purpose of this study was to prospectively assess the outcome of SPEAK OUT! plus The LOUD Crowd in a larger cohort of patients using a multiple baseline design and including spontaneous speech sampling of intensity and prosody. It was hypothesized that the therapy would result in significantly increased acoustic measures of intensity, prosody, and voice spectral components and perceptual evaluation of vocal function. It was also hypothesized that gains achieved in intensity and prosody would be significantly greater in reading than in monologue.

## Method

### *Participants*

A power analysis was calculated using G*Power 3.1.9.3 (2017; Faul et al., 2009) to determine the sample size of the PD group. The analysis estimated that a group consisting of 35 participants would be required to identify an increase in intensity of 9 dB with an $\alpha$ of .05 at a power of 80%. This intensity level was based on reports of maximum intensity gains of 9 dB (Watts, 2016) and 8 dB (Boutsen et al., 2018). Allowing a 10% dropout rate, a sample size of 40 participants in the treatment group was projected to detect a statistically significant result that would be clinically meaningful.

Patients with a diagnosis of idiopathic PD who were referred for speech therapy from their neurologist and who were seen for evaluation at the Parkinson Voice Project clinic in Richardson, Texas, were assessed for their eligibility to participate in this study. Other inclusion criteria were no history of deep brain stimulation, no history of speech therapy within the prior 2 years, no neurological diagnoses other than PD, no other medical diagnoses or procedures that could be expected to affect speech production, and proficiency in English (as determined through an informal assessment during the initial evaluation). Cognitive abilities sufficient to participate fully in therapy and stimulability for improved communication skills were also required, as determined by the SLP. Cognitive abilities were assessed through conversation, verbal instructions, and report by patient and family. Patients were excluded if they could not follow instructions or became confused or disorganized or if they or a family member reported difficulties with activities of daily living due to cognitive deficits. Stimulability was assessed through verbal instructions and cueing to use intent in single words and phrases. Patients were excluded if no change in speech was detected by the SLP when using intent.

A total of 166 patients were screened for participation, of whom 119 were excluded due to the following reasons: other neurological diagnoses such as atypical PD, Alzheimer's disease, or history of stroke ($n$ = 38); speech therapy within the prior 2 years ($n$ = 25); history of deep brain stimulation ($n$ = 7); limited knowledge of English ($n$ = 4); cognitive deficits ($n$ = 3); and scheduling conflicts (such as planned vacations, etc.; $n$ = 9). Patients having other medical diagnoses or procedures that could affect speech production were also excluded: spasmodic dysphonia ($n$ = 1), history of laryngeal tumor ($n$ = 1), vocal fold injections ($n$ = 1), velopharyngeal disorder ($n$ = 1), vocal fold atrophy ($n$ = 1), and unilateral vocal fold paralysis ($n$ = 1). No patients were excluded due to problems demonstrating stimulability. In addition, 27 patients declined participation, largely due to the required multiple baseline assessments. The remaining 47 patients were enrolled in the study.

Participants were rated according to the Hoehn and Yahr Scale by the evaluating SLP (second author), a therapist with extensive experience in treatment of dysarthria due to PD. The second author (J. C.) took the Unified Parkinson's Disease Rating Scale (Goetz et al., 2007) training offered by the Movement Disorder Society and received additional training from a neurologist (the fourth author) in how to conduct the Hoehn and Yahr evaluation.

Adults without communication disorders (control group) were also enrolled to provide comparison data and to assess the potential influence of familiarity with the assessment procedures on the data due to the repeated-measures design. A target enrollment of 25 participants was established in a gender ratio similar to that of the PD group (approximately 60% male and 40% female) and in the age span as close as possible to the PD group. Inclusion criteria consisted of no history of communication disorders or medical problems that could be expected to affect speech/voice production and no smoking within the prior 10 years. Thirty-nine adults were screened for participation, from whom 12 individuals were excluded. Three individuals were excluded due to presence of dysphonia based on a screening conducted by the first author (A. B.) using the Consensus Auditory–Perceptual Evaluation of Voice (Kempster et al., 2009). Other exclusions were medical problems that could affect speech production ($n$ = 2), scheduling conflicts ($n$ = 2), and age outside the needed range ($n$ = 5). Twenty-five participants were enrolled. Demographic information for all participants is provided in Tables 1 and 2.

**Table 1.** Age (in years) of participants with Parkinson's disease (PD; $n$ = 40) and healthy controls ($n$ = 25).

| | PD group | | Control group | |
|---|---|---|---|---|
| **Variable** | **Men ($n$ = 25)** | **Women ($n$ = 15)** | **Men ($n$ = 15)** | **Women ($n$ = 10)** |
| *M* | 69.6 | 66.7 | 69.7 | 66 |
| Range | 47–84 | 46–82 | 48–81 | 47–80 |
| *Mdn* | 70 | 68 | 73 | 64.5 |
| Mode | 70 | 62 | 75 | 60 |

Like all patients seen at the Parkinson Voice Project, the study patients were not charged for assessments or therapy. Instead, a pay-it-forward system was used, in which patients were given the opportunity, toward the end of their SPEAK OUT! sessions, to make a donation to help support treatment of future patients. Control group participants received a nominal fee for their participation.

This study was approved by the Western Institutional Review Board for participation of patients at the Parkinson Voice Project and by the City University of New York Institutional Review Board for analysis of de-identified patient data by the second author and her research team and participation of the healthy group. All participants took part in the informed consent process.

## *SPEAK OUT! and The LOUD Crowd*

The study timeline with measurement points and tasks is diagrammed in Figure 1. SPEAK OUT! was administered in 12 individual 40-min sessions 3 times per week for 4 consecutive weeks. Participants were instructed to attend at least one session of The LOUD Crowd during the third or fourth week of the SPEAK OUT! sessions, followed by a minimum of once-per-week attendance after the 12th individual therapy session on an ongoing basis as a standard of care to maintain gains achieved during individual therapy sessions. The program adheres to the principles of motor learning theory, particularly intensity of treatment, salience, and progressive complexity (Maas et al., 2008; Sapir et al., 2011). Details of the program are described in Table 3.

Two SLPs experienced in the therapy program administered the sessions. Treatment fidelity for all SLPs at the Parkinson Voice Project, the only therapy that is conducted at this organization, was ensured through intensive training upon hiring and frequent follow-up training. A total of 480 sessions were conducted with the 40 participants. To minimize bias, the SLP who conducted the assessments administered therapy to the participants only in cases of scheduling conflicts. Due to scheduling conflicts, a total of 21 therapy sessions were conducted for 15 participants.

## *Assessment Procedure and Instrumentation*

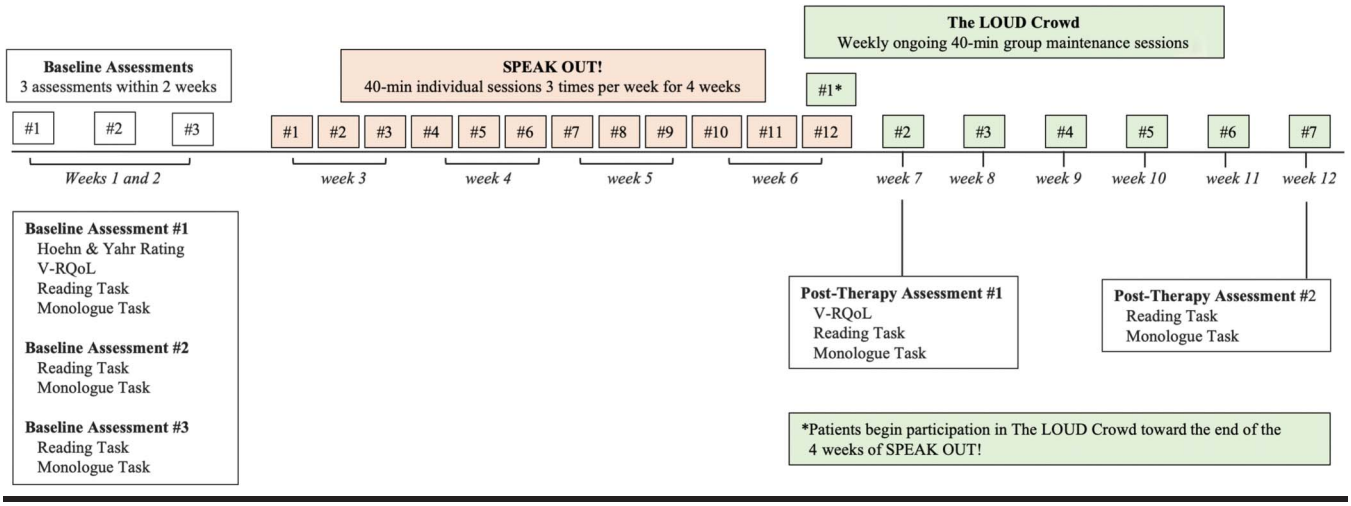
Treatment and data gathering were conducted by a team separate from the data analysis team. All assessments and therapy were conducted at the Parkinson Voice Project. All data were de-identified with codes and electronically delivered to the first author and her research team at the first author's research lab at Lehman College of the City University of New York for measurement and analysis.

Three baseline assessments were conducted within a 2-week time frame (except for five patients for whom the baseline assessments were conducted within a 3-week period), followed by the 4 weeks of individual therapy. Two more assessments were then conducted, within 1 and 6 weeks post-SPEAK OUT!. For each of the five assessments, a monologue of approximately 1 min was elicited with the instructions to "Tell me about a recent vacation, or the place where you grew up, or what you did for a living," followed by reading aloud an edited version of *The Caterpillar* (Patel et al., 2013), a passage designed to inform assessment of individuals with motor speech disorders. The passage facilitates prosodic modulation by including statements and questions, words with emphatic stress, and expression of emotion. Participants in the healthy group were recorded 5 times on a similar schedule, but without therapy. All participants were recorded individually in a quiet therapy room using a digital audio recorder (Zoom H4N) with a 44.1-kHz sampling rate with an AKG (C520) cardioid condenser headset microphone positioned approximately 30 cm from the mouth. No cueing was provided for the assessments.

**Table 2.** Disease information for participants with Parkinson's disease (PD).

| | Time elapsed (in months) between diagnosis of PD and 1st baseline measures | | Score on the Hoehn and Yahr Scale (Hoehn &Yahr, 1998) | |
|---|---|---|---|---|
| **Variable** | **Men** | **Women** | **Men** | **Women** |
| *M* | 48 | 58.8 | 2 | 2 |
| Range | 1–237 | 3–189 | 1–3 | 1–3 |
| *Mdn* | 38 | 40 | 2 | 2 |
| *SD* | 53.5 | 55.0 | 0.5 | 0.7 |

**Figure 1.** Study timeline, measurement points, and assessment tasks for the Parkinson's disease group. V-RQoL = Voice-Related Quality of Life.




Acoustic outcome measures consisted of mean intensity, the prosody measures of standard deviation of intensity and frequency, and the voice quality measure of cepstral peak prominence (CPP), which correlates strongly with listener perception of overall dysphonia, breathiness, and vocal weakness in individuals with PD (Jannetts & Lowit, 2014). Patient self-perception was assessed using the 10-item survey Voice-Related Quality of Life (V-RQoL; Hogikyan & Sethuraman, 1999), which elicits information about how well the voice was functioning for the individual in daily life over the prior few weeks. The survey was administered at the first baseline and first posttherapy assessments.

On–off medication cycle was not specifically controlled, although patients were encouraged to be in an "on period" for all therapy sessions and assessments, which were conducted at approximately the same time of day whenever possible. At each assessment, the patient was asked when they last took their medications and if they felt they were within an optimal medication time. Rarely did a patient report being within an "off period." Notably, the majority of research demonstrates lack of significant effect of dopaminergic therapy on speech production (Daniels et al., 1996; Gamboa et al., 1997; Plowman-Prine et al., 2009; Skodda, Grönheit, & Schlegel, 2010).

## *Acoustic Measures*

Intensity was calculated for each speaking task for each participant using a 1-kHz calibration tone of known intensity, recorded in parallel and corresponding to the mouth-to-microphone distance, for each audio file. This calibration tone was used to convert the root-mean-square voltage to dB SPL using Goldwave Version 6 (Goldwave, Inc., 2015). Fundamental frequency ($F_0$) was calculated using Praat (Boersma & Weenink, 1992/2013). Errors in automatic pitch tracking were manually corrected. Intensity and frequency were calculated from the entire 160-word reading passage and 45 s of monologue, exclusive of silent pauses. A pause was defined as a period of silence of at least 200 ms in duration (Lam & Tjaden, 2016) or one that contained only a filler word, such as "uhm" or "well," surrounded by silence totally of at least 200 ms. Pauses were identified by manual examination of the acoustic waveform and narrow-band spectrogram and segmented using textgrids in Praat. Silences associated with stop closures were not included in pause identification (Goberman & Elmer, 2005).

Prosody was defined as the standard deviation of intensity (dB $SPL_{SD}$) and frequency ($F_{0SD}$ in Hz; the latter of which is generally referred to as "intonation") derived from the monologue. CPP was calculated using Praat from the sentence "We were away a year ago," which had been inserted into the beginning of the modified *Caterpillar Passage*. Due to the sensitivity of CPP to phonetic context, use of that all-voiced sentence has been recommended (Awan et al., 2010).

Reliability of the acoustic data was determined by remeasuring all of the data from a random selection of 10% of the subjects with PD. Intraclass correlational (ICC) analyses, using a two-way mixed-effects model and an absolute agreement definition for the ICC coefficient ($\alpha = .05$), indicated high interrater (ICC = .94, $p < .001$) and intrarater (ICC = .97, $p < .001$) reliability for intensity and high interrater (ICC = .92, $p < .001$) and intrarater (ICC = .96, $p < .001$) reliability for $F_0$.

## *Statistical Analyses*

Three models were used to analyze the data. In the first model, the PD and control groups were compared on each dependent variable (intensity, $F_0$, variation in intensity, variation in $F_0$, CPP, and V-RQoL), with the three baseline

**Table 3.** SPEAK OUT! and The LOUD Crowd program of speech therapy for Parkinson's disease.

| Parameter | SPEAK OUT! and The LOUD Crowd |
|---|---|
| Dosage | SPEAK OUT!<br>Individual treatment sessions of 40 min, 3 days per week for 4 weeks for a total of 12 sessions (8 hr total) plus home exercise program (explained further below).<br>The LOUD Crowd<br>Weekly group sessions of 40 min ongoing indefinitely. |
| Focus | Patients are instructed to speak with intent for all utterances within the session.<br>Increase cognitive focus on goal-directed, intentional behavior and minimize automatic motor behavior. |
| Verbal cues | Speak with intent.<br>Be deliberate.<br>Speak out.<br>Say it like you mean it.<br>Say it purposefully.<br>Speak with your intentional voice, not your automatic voice. |
| Therapy protocol | **Parkinson's Information Session:**<br>Prior to initiating individual treatment (SPEAK OUT!), patient and family attend a group session to learn about the basic neurophysiology of Parkinson's disease, intentional and automatic motor behaviors, home practice expectations, and need for ongoing group maintenance, The LOUD Crowd.<br>**Six SPEAK OUT! Components:**<br>1. Warm-up: Produce connected vocalizations using nasal phoneme-initial words.<br>2. Vowel: Sustain /ɑ/ with good quality voice for maximum of 10 s.<br>3. Glides: Sustain /ɑ/ and glide up the scale starting and ending with modal pitch.<br>4. Numerical sequences: Count aloud pausing after every three to five numbers.<br>5. Reading: Start with phrases and progress to paragraphs.<br>6. Cognitive–linguistic exercises: Structured activities designed to elicit novel responses. The task was designed to improve word retrieval and cognitive processing speed, while focusing on intentional speech.<br>Conversational speech was interwoven throughout the session to facilitate transfer to communication in daily life.<br>**The LOUD Crowd:**<br>Patient attends one to two LOUD Crowd sessions during Week 3 or 4 of SPEAK OUT! (depending upon scheduling) to become acquainted with the group sessions, followed by weekly sessions upon completion of SPEAK OUT!.<br>The same six components and conversational speech in a group format. Patient continues daily home practice and attends a weekly group for ongoing accountability, practice, support, and encouragement. |
| Therapy materials | SPEAK OUT! workbook is provided to each patient in the United States by Parkinson Voice Project; SPEAK OUT! therapy kit (e.g., workbook, photo/word cards) is provided to each SLP who completes training. |
| Home exercise program | 15-min home practice session using SPEAK OUT! workbook.<br>Frequency:<br>During individual therapy (SPEAK OUT!): once a day on treatment days; twice a day on nontreatment days.<br>After completion of SPEAK OUT!: ongoing once daily. |
| Shaping techniques | SLP uses modeling as well as verbal and visual cues to elicit intentional speech.<br>SLP prompts patient self-monitoring and self-generated internal cueing for increased intentional speech. Once the targeted intentional speech was produced, the SLP frequently asked the patient to describe how the speech felt. Then, the patient was asked to consciously and purposefully elicit that sensation every time they spoke. In this way, the distinction between automatic and nonautomatic was emphasized, and patient self-monitoring and self-generated internal cueing was trained. |
| Clinical data collection | **Objective:**<br>- Intensity per sound level meter for 10 responses within each therapy component<br>- Duration (up to 10 s) for sustained /ɑ/<br>**Subjective:**<br>- Level of cueing<br>- SLP perception of vocal quality and use of intentional speech. |
| Adjuvant program (not assessed in this protocol) | **SPEAK OUT! Refreshers:**<br>Patient returns for a reevaluation every 6 months; additional treatment sessions are scheduled, as needed, with the goal of returning dB SLP levels for reading and conversation to original discharge status. |
| Discharge criteria | SPEAK OUT!: Goal attainment (per clinical data collection above): typically within 10–12 sessions. (For this study, all participants received 12 sessions.)<br>The LOUD Crowd: No discharge: Participation is recommended on a regular basis to maintain therapeutic gains to the extent possible. |

*Note.* SLP = speech-language pathologist.

measurements combined. Multilevel models were fit to the data with linear splines between baseline and the first follow-up and between the first and second follow-ups. This method is equivalent to a discontinuous growth curve model. Age and gender were included as covariates. Then, as a sensitivity analysis, a similar model was used with all five time points (three at baseline and two at follow-up), with linear splines between each pair of consecutive time points. To

evaluate the progress of the PD participants, a third, similar model was fit solely on the PD group and included the additional covariates of two disease-related factors (the Hoehn and Yahr score and the number of months from diagnosis of PD to the first baseline) and also the number of The LOUD Crowd group maintenance sessions attended. A $p$ value of .05 was used to indicate statistical significance. The data obtained from all individuals who completed at least one assessment were included in the study.

## Results

Forty-seven patients with PD were enrolled into the study. Seven participants withdrew: two at baseline, four after completing only a portion of the therapy, and one just prior to the second posttherapy assessment. Withdrawal reasons consisted of health problems ($n = 3$), poor attendance ($n = 1$), or unrelated occurrences ($n = 3$). Thus, 40 patients completed the 12 sessions of SPEAK OUT!. Participants were encouraged to attend at least one session of The LOUD Crowd during the third or fourth week of SPEAK OUT! session as a standard of care, followed by a minimum of once-per-week attendance after the 12th individual therapy session. Only four of the patients did not attend any group session, while 26 patients attended between one and five sessions, and 10 patients attended more than five sessions. Twenty-five healthy controls were enrolled and completed the study.

Tables 4 through 8 present the results of the discontinuous growth curve models for the PD group for intensity, variation in intensity, variation in $F_0$, CPP, and V-RQoL, respectively, and the covariates. For the PD group, statistically significant changes occurred from baseline to both posttherapy time points for all variables in both speaking tasks, where tested, except for variation in intensity. For variation in intensity, only the changes from baseline to the first and second posttherapy assessments in the monologue task were statistically significant. Changes in the reading task were not statistically significant. Tables 9 through 13 present the results of the discontinuous growth curve models comparing the control and PD groups for each variable without the disease-related covariates, since they were applicable only to the PD group. For the control group, mean values for all outcome variables remained nearly unchanged from baseline to the follow-ups, and none of the differences were statistically significant. Differences in mean values between the control and PD groups at baseline were statistically significant for all outcome variables. A two-tailed $t$ test showed that the means of the ages within each gender in the two groups were not different, $t(358) = -0.94$, $p = .35$. In Table 14, the means and standard deviations for each outcome variable are presented by speaking tasks, group, and gender. Details of the results for each variable are discussed below, in which differences between baseline and follow-up are statistically significant unless stated otherwise.

### *Intensity*

Figure 2 presents the distribution of intensity levels by group and time for reading (see Figure 2A) and monologue (see Figure 2B). In the PD group, in reading, mean intensity increased significantly for men from baseline ($M = 70.12$, $SD = 4.36$) to posttherapy ($M = 78.97$, $SD = 4.26$) and for women from baseline ($M = 69.07$, $SD = 3.93$) to posttheraphy ($M = 77.86$, $SD = 3.74$). Mean intensity also increased significantly in monologue for men from baseline ($M = 67.70$, $SD = 4.98$) to posttherapy ($M = 75.40$, $SD = 4.66$) and for women from baseline ($M = 67.12$, $SD = 4.44$) to posttheraphy ($M = 74.62$, $SD = 3.89$).

The mean values of intensity for the PD group were lower than those of the control group at baseline, but posttherapy values for the two groups were equivalent. Age, gender, disease demographics (Hoehn and Yahr score and months from diagnosis to baseline evaluation), and attendance in The LOUD Crowd sessions did not have statistically significant effects on mean intensity.

### *Variation in Intensity*

Figure 3 presents the distribution of $dB_{SD}$ by group and time for reading (see Figure 3A) and monologue (see Figure 3B). In the PD group, in reading, mean $dB_{SD}$ did not significantly change for men from baseline ($M = 8.42$,

**Table 4.** The fixed effects of time and covariates on intensity (dB at 30 cm) in the Parkinson's disease group.

| | Reading | | | | | Monologue | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Effect** | **Estimate** | ***SE*** | ***df*** | ***t*** | **Pr > \|t\|** | **Estimate** | ***SE*** | ***df*** | ***t*** | **Pr > \|t\|** |
| Intercept | 73.96 | 4.51 | 33 | 16.41 | < .0001 | 68.65 | 5.58 | 33 | 11.77 | < .0001 |
| P1 | 9.19 | 0.55 | 154 | 16.58 | < .0001 | 7.31 | 0.62 | 154 | 11.74 | < .0001 |
| P2 | 8.81 | 0.55 | 154 | 15.90 | < .0001 | 7.27 | 0.62 | 154 | 11.67 | < .0001 |
| Age | –0.004 | 0.06 | 154 | –0.07 | .95 | 0.004 | 0.08 | 154 | 0.05 | .96 |
| Gender | –1.52 | 1.02 | 154 | –1.50 | .14 | –0.61 | 1.32 | 154 | –0.46 | .64 |
| H&Y score | –1.38 | 0.81 | 154 | –1.71 | .09 | –0.40 | 1.05 | 154 | –0.38 | .71 |
| Mos from dx | 0.01 | 0.009 | 154 | 1.28 | .20 | 0.007 | 0.01 | 154 | 0.54 | .59 |
| LC sessions | –0.29 | 0.16 | 154 | –1.75 | .08 | –0.07 | 0.21 | 154 | –0.38 | .73 |

*Note.* P1, P2 = assessments at approximately 1 and 6 weeks after completion of SPEAK OUT! sessions, respectively; H&Y = Hoehn and Yahr Scale; Mos from dx = months elapsed between diagnosis of Parkinson's disease and first baseline assessment; LC sessions = number of The LOUD Crowd sessions attended.

**Table 5.** The fixed effects of time and covariates on variation of intensity ($dB_{SD}$) in the Parkinson's disease group.

| | Reading | | | | | Monologue | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Effect** | **Estimate** | ***SE*** | ***df*** | ***t*** | **Pr > \|t\|** | **Estimate** | ***SE*** | ***df*** | ***t*** | **Pr > \|t\|** |
| Intercept | 7.67 | 2.10 | 33 | 3.65 | .0009 | 4.23 | 2.53 | 33 | 1.67 | .10 |
| P1 | 0.21 | 0.58 | 154 | 0.37 | .71 | 1.46 | 0.61 | 154 | 2.38 | .02 |
| P2 | 0.64 | 0.58 | 154 | 1.10 | .27 | 2.22 | 0.61 | 154 | 3.62 | .0004 |
| Age | 0.03 | 0.03 | 154 | 1.01 | .32 | 0.02 | 0.03 | 154 | 0.54 | .59 |
| Gender | 0.14 | 0.05 | 154 | 0.31 | .76 | –0.39 | 0.57 | 154 | –0.69 | .49 |
| H&Y score | –0.31 | 0.38 | 154 | –0.83 | .41 | 1.54 | 0.45 | 154 | 3.40 | .009 |
| Mos from dx | 0.003 | 0.004 | 154 | 0.64 | .52 | –0.02 | 0.005 | 154 | –3.03 | .003 |
| LC sessions | –0.02 | 0.08 | 154 | –0.33 | .74 | –0.26 | 0.09 | 154 | –0.28 | .08 |

*Note.* P1, P2 = assessments at approximately 1 and 6 weeks after completion of SPEAK OUT! sessions, respectively; H&Y = Hoehn and Yahr Scale; Mos from dx = months elapsed between diagnosis of Parkinson's disease and first baseline assessment; LC sessions = number of The LOUD Crowd sessions attended.

*SD* = 3.32) to posttherapy (*M* = 9.66, *SD* = 2.40) or for women from baseline (*M* = 9.19, *SD* = 3.74) to posttherapy (*M* = 9.02, *SD* = 2.29). In monologue, mean $dB_{SD}$ increased significantly for men from baseline (*M* = 7.99, *SD* = 2.67) to posttherapy (*M* = 10.07, *SD* = 4.58) and for women from baseline (*M* = 7.78, *SD* = 3.22) to posttherapy (*M* = 9.11, *SD* = 3.83).

The mean values of $dB_{SD}$ for the PD group were below those of the control group at baseline and posttherapy in both speaking tasks, although group differences narrowed posttherapy to within 1–1.25 dB for reading and 0.59–1.35 dB in monologue. Age, gender, and attendance in The LOUD Crowd did not have statistically significant effects on $dB_{SD}$. The Hoehn and Yahr score and the months elapsed between diagnosis of PD and the first baseline assessment were statistically significant in monologue but not in reading. Specifically, a higher Hoehn and Yahr score (more severe PD) was associated with greater mean $dB_{SD}$, and lesser time elapsed since diagnosis was also associated with greater mean $dB_{SD}$.

## *Variation in $F_0$*

Figure 4 presents the distribution of $F_{0SD}$ by group and time for reading (see Figure 4A) and monologue (see Figure 4B). In the PD group, in reading, mean $F_{0SD}$ increased significantly for men from baseline (*M* = 18.13, *SD* = 4.71) to posttherapy (*M* = 27.40, *SD* = 5.33) and for women from baseline (*M* = 28.29, *SD* = 8.13) to posttherapy (*M* = 33.2, *SD* = 7.65). Mean $F_{0SD}$ also increased significantly in monologue for men from baseline (*M* = 15.41, *SD* = 7.21) to posttherapy (*M* = 21.72, *SD* = 5.43) and for women from baseline (*M* = 22.25, *SD* = 6.53) to posttherapy (*M* = 29.36, *SD* = 5.66).

Mean variation in $F_{0SD}$ for the PD group was below the mean of the control group at baseline for both speaking tasks and remained lower posttherapy, with the exception of reading scores for the men, which were less than 1 dB different. The effect of gender on $F_{0SD}$ was statistically significant: Men had a smaller mean $F_{0SD}$ than did women at all time points. Age, disease demographics, and attendance in The LOUD Crowd sessions did not have statistically significant effects on mean $F_{0SD}$.

## *CPP*

Figure 5 presents the distribution of CPP by group and time. In the PD group, mean CPP increased significantly for men from baseline (*M* = 11.99, *SD* = 2.69) to posttherapy

**Table 6.** The fixed effects of time and covariates on variation of fundamental frequency in the Parkinson's disease group.

| | Reading | | | | | Monologue | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Effect** | **Estimate** | ***SE*** | ***df*** | ***t*** | **Pr > \|t\|** | **Estimate** | ***SE*** | ***df*** | ***t*** | **Pr > \|t\|** |
| Intercept | 11.45 | 5.98 | 33 | 1.92 | .06 | 12.65 | 6.94 | 33 | 1.82 | .08 |
| P1 | 9.28 | 0.75 | 154 | 12.40 | < .0001 | 9.16 | 0.71 | 154 | 12.88 | < .0001 |
| P2 | 9.50 | 0.75 | 154 | 12.70 | < .0001 | 8.45 | 0.71 | 154 | 11.88 | < .0001 |
| Age | 0.03 | 0.08 | 154 | 0.44 | .66 | 0.09 | 0.09 | 154 | –0.08 | .93 |
| Gender | 10.87 | 1.35 | 154 | 8.06 | < .0001 | 1.56 | 1.57 | 154 | 6.72 | < .0001 |
| H&Y score | 1.71 | 1.08 | 154 | 1.58 | .12 | 1.11 | 1.25 | 154 | 0.89 | .38 |
| Mos from dx | –0.002 | 0.01 | 154 | –0.20 | .83 | –0.009 | 0.01 | 154 | –0.64 | .52 |
| LC sessions | 0.10 | 0.22 | 154 | 0.48 | .63 | 0.09 | 0.25 | 154 | 0.36 | .72 |

*Note.* P1, P2 = assessments at approximately 1 and 6 weeks after completion of SPEAK OUT! sessions, respectively; H&Y = Hoehn and Yahr Scale; Mos from dx = months elapsed between diagnosis of Parkinson's disease and first baseline assessment; LC sessions = number of The LOUD Crowd sessions attended.

**Table 7.** The fixed effects of time and covariates on cepstral peak prominence measured from the sentence "We were away a year ago" in the Parkinson's disease group.

| Effect | Estimate | *SE* | *df* | *t* | Pr > \|*t*\| |
|---|---|---|---|---|---|
| Intercept | 12.98 | 2.48 | 33 | 5.24 | < .0001 |
| P1 | 5.53 | 0.54 | 154 | 10.17 | < .0001 |
| P2 | 5.36 | 0.54 | 154 | 9.86 | < .0001 |
| Age | –0.05 | 0.03 | 154 | –1.46 | .15 |
| Gender | 1.12 | 0.56 | 154 | 2.00 | .05 |
| H&Y score | 0.86 | 0.45 | 154 | 1.94 | .05 |
| Mos from dx | –0.007 | 0.005 | 154 | –1.46 | .15 |
| LC sessions | 0.06 | 0.09 | 154 | 0.69 | .49 |

*Note.* Cepstral peak prominence was calculated only from the sentence "We were away a year ago." P1, P2 = assessments at approximately 1 and 6 weeks after completion of SPEAK OUT! sessions, respectively; H&Y = Hoehn and Yahr Scale; Mos from dx = months elapsed between diagnosis of Parkinson's disease and first baseline assessment; LC sessions = number of The LOUD Crowd sessions attended.

($M$ = 16.38, $SD$ = 3.54) and for women from baseline ($M$ = 12.24, $SD$ = 2.78) to posttherapy ($M$ = 19.15, $SD$ = 3.41).

Mean CPP values for the PD group were below those of the control group at baseline and equivalent posttherapy. Gender was a statistically significant factor: The improvement achieved by the women was approximately 2.5 dB greater than that achieved by the men. Age was not a statistically significant influence on CPP. The Hoehn and Yahr score had a statistically significant effect on CPP. Specifically, a higher Hoehn and Yahr score (more severe PD) was associated with a higher CPP. The months elapsed between diagnosis of PD and the first baseline assessment as well as attendance in The LOUD Crowd sessions did not have statistically significant effects upon mean CPP.

### *V-RQoL*

Figure 6 presents the distribution of V-RQoL by group and time. In the PD group, V-RQoL increased significantly for men from baseline ($M$ = 75.29, $SD$ = 14.93) to posttherapy ($M$ = 80.20, $SD$ = 13.19) and for women from baseline ($M$ = 83.23, $SD$ = 12.52) to posttherapy ($M$ = 85.31, $SD$ = 9.44).

**Table 8.** The fixed effects of time and covariates on the Voice-Related Quality of Life score in the Parkinson's disease group.

| Effect | Estimate | *SE* | *df* | *t* | Pr > \|*t*\| |
|---|---|---|---|---|---|
| Intercept | 79.07 | 17.06 | 34 | 4.64 | < .0001 |
| P1 | 11.99 | 2.74 | 37 | 4.38 | < .0001 |
| Age | 0.19 | 0.22 | 37 | 0.83 | .41 |
| Gender | 11.38 | 3.84 | 37 | 2.96 | .005 |
| H&Y score | –12.21 | 3.07 | 37 | –3.98 | .0003 |
| Mos from dx | 0.02 | 0.03 | 37 | 0.68 | .50 |
| LC sessions | 0.17 | 0.61 | 37 | 0.28 | .78 |

*Note.* The Voice-Related Quality of Life was administered only at B1 (first baseline) and P1 (approximately 1 week after completion of SPEAK OUT! sessions). H&Y = Hoehn and Yahr Scale; Mos from dx = months elapsed between diagnosis of Parkinson's disease and first baseline assessment; LC sessions = number of The LOUD Crowd sessions attended.

Mean posttherapy V-RQoL scores of the PD group were below those of the control group at baseline and remained lower posttherapy. Thus, while overall, the PD group considered their voices to function significantly better in everyday life after the therapy, they still considered their voices to have greater limitations than did the healthy individuals. Gender was a statistically significant factor in V-RQoL: Scores increased by approximately 5 points for men and 2 points for women from baseline to posttherapy. The Hoehn and Yahr scores had a statistically significant effect upon mean V-RQoL scores. Specifically, a higher Hoehn and Yahr score (more severe disease) was associated with a lower V-RQoL score (worse perception of voice). The months elapsed between diagnosis of PD and the first baseline assessment as well as attendance in The LOUD Crowd sessions did not have statistically significant effects upon mean V-RQoL scores.

## Summary

In summary, when comparing posttherapy to baseline values within the PD group, mean intensity and variation of frequency were larger in reading and monologue, while variation in intensity was larger in monologue but unchanged in reading. CPP and V-RQoL scores were significantly higher (improved) after therapy. Overall, gains achieved in reading were greater than those achieved in monologue (except for variation of intensity). All baseline values of the outcome variables from the PD group were significantly below those from the control group. After therapy, within each gender, mean intensity levels and CPP of the PD group were similar to levels for the control group. All other variables, however, remained below those of the control group after therapy. The control group data demonstrated no statistically significant changes across time for any of the outcome variables. Thus, the improvements in scores for the PD group were likely due to the therapy and not due to the repeated-measures design or random factors.

## Discussion

The major finding of this study is that an 8-hr, 12-session standardized program of SPEAK OUT!, with a focus on use of intentional speech, resulted in a statistically significant improvement in the acoustic measures of intensity, prosody, and voice quality as well as patient self-perception of voice. All baseline levels were significantly below levels of the control group. While significant posttherapy gains were achieved for almost all variables, values remained below those of the control group, except for intensity and voice quality.

The intensity gains achieved with use of intentional speech are consistent with earlier studies of SPEAK OUT! (Boutsen et al., 2018; Levitt et al., 2015; Levitt & Walker-Batson, 2018; Watts, 2016) and also consistent with the intensity levels reported post-LSVT (Ramig et al., 1995,

**Table 9.** The fixed effects of time, group, and their interaction on intensity (dB at 30 cm) for both the Parkinson's disease (PD) and control groups.

| | Reading | | | | | Monologue | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Effect** | **Estimate** | ***SE*** | ***df*** | ***t*** | **Pr > \|t\|** | **Estimate** | ***SE*** | ***df*** | ***t*** | **Pr > \|t\|** |
| Intercept | 75.34 | 3.13 | 67 | 24.09 | < .0001 | 75.71 | 3.38 | 67 | 22.39 | < .0001 |
| P1 | 0.60 | 0.65 | 267 | 0.92 | .36 | 0.29 | 0.72 | 267 | 0.41 | .69 |
| P2 | –0.24 | 0.65 | 267 | –0.37 | .71 | 0.33 | 0.72 | 267 | 0.46 | .65 |
| PD group | –7.38 | 0.82 | 267 | –9.03 | < .0001 | –6.84 | 0.89 | 267 | –7.72 | < .0001 |
| PD Group × P1 | 8.63 | 0.82 | 267 | 10.50 | < .0001 | 7.23 | 0.92 | 267 | 7.90 | < .0001 |
| PD Group × P2 | 9.21 | 0.83 | 267 | 11.15 | < .0001 | 7.05 | 0.92 | 267 | 7.71 | < .0001 |
| Age | 0.03 | 0.04 | 267 | 0.70 | .48 | –0.01 | 0.05 | 267 | –0.28 | .78 |
| Women | –0.87 | 0.78 | 267 | –1.11 | .27 | –1.28 | 0.84 | 267 | –1.52 | .13 |

*Note.* P1, P2 = assessments at approximately 1 and 6 weeks after completion of SPEAK OUT! sessions, respectively.

2018). Increased intensity is achieved largely by increasing lung pressure (Isshiki, 1964), coregulated with faster and more firmly adducted vocal fold closure (Titze, 1994). It is likely that the increased effort used to achieve intentional speech resulted in a scaling up of the speech production system overall, thus increasing lung pressure and therefore increasing intensity. The spread of heightened motor activity beyond the target speech behavior has been observed in other studies of dysarthria (Tjaden et al., 2014).

The posttherapy gains in intensity are clinically significant. Although loudness is a complex psychoacoustic phenomenon, within the speech range of frequencies, a 10-dB increase in speech intensity is generally perceived by the listener to be roughly twice as loud (Moore, 2004). Thus, the magnitude of increase in reading (approximately 9 dB) and monologue (approximately 7.5 dB) would certainly be quite noticeable to a typical listener.

Prosody was measured as the variation in intensity (dB $SPL_{SD}$) and frequency ($F_{0SD}$). Prosody is a critical feature that facilitates listener understanding, and narrower ranges of intonation and intensity have been associated with decreased intelligibility (Cutler et al., 1997). The baseline values of dB $SPL_{SD}$ in both the control and PD groups are consistent with the literature in reading (Lam & Tjaden, 2016). (No comparable data on this variable for monologue have been found in the literature.) Posttherapy, the mean dB $SPL_{SD}$ did not change significantly in reading for either gender, and the means remained below the means of the control group. While the posttherapy values were significantly improved in monologue for both genders, the means remained below the control group. Furthermore, as shown in Figure 3, the posttherapy increase was highly variable across participants. It is possible that participants may have been hesitant to vary their intensity levels while focusing upon intentional speech and the associated overall increase in intensity.

The baseline values of $F_{0SD}$ for reading are consistent with the literature in that the PD group had significantly lower values (less variability) than did the healthy group. However, the mean values for reading were generally higher overall than those reported in the literature (Skodda, Grönheit, & Schlegel, 2010; Skodda, Visser, & Schlegel, 2010), likely associated with the reading passage used in this study, which promoted prosodic variation.

The increase in $F_{0SD}$ after therapy was clinically significant: The improvement posttherapy for the PD group in reading and monologue was equivalent to approximately seven and six semitones, respectively, for the men and approximately three and five semitones, respectively, for the women. These gains would likely be quite apparent to

**Table 10.** The fixed effects of time, group, and their interaction on variation of intensity ($dB_{SD}$) for both the Parkinson's disease (PD) and control groups.

| | Reading | | | | | Monologue | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Effect** | **Estimate** | ***SE*** | ***df*** | ***t*** | **Pr > \|t\|** | **Estimate** | ***SE*** | ***df*** | ***t*** | **Pr > \|t\|** |
| Intercept | 11.42 | 1.78 | 68 | 6.53 | < .0001 | 12.06 | 1.75 | 68 | 6.91 | < .0001 |
| P1 | –0.63 | 0.85 | 268 | –0.74 | .46 | –0.02 | 0.83 | 268 | –0.02 | .98 |
| P2 | –0.45 | 0.85 | 268 | –0.53 | .59 | –0.09 | 0.83 | 268 | –0.11 | .91 |
| PD group | –2.34 | 0.54 | 268 | –4.30 | .0001 | –2.72 | 0.54 | 268 | –5.05 | < .0001 |
| PD Group × P1 | 1.18 | 1.06 | 268 | 1.11 | .27 | 1.38 | 1.04 | 268 | 1.33 | .19 |
| PD Group × P2 | 1.24 | 1.07 | 268 | 1.15 | .25 | 2.30 | 1.05 | 268 | 2.19 | .03 |
| Age | –0.005 | 0.024 | 268 | –0.20 | .84 | –0.02 | 0.02 | 268 | –0.79 | .43 |
| Women | –006 | 0.43 | 268 | –0.14 | .89 | –0.32 | 0.43 | 268 | –0.74 | .46 |

*Note.* P1, P2 = assessments at approximately 1 and 6 weeks after completion of SPEAK OUT! sessions, respectively.

**Table 11.** The fixed effects of time, group, and their interaction on variation of fundamental frequency for both the Parkinson's disease (PD) and control groups.

| | Reading | | | | | Monologue | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Effect** | **Estimate** | ***SE*** | ***df*** | ***t*** | **Pr > \|t\|** | **Estimate** | ***SE*** | ***df*** | ***t*** | **Pr > \|t\|** |
| Intercept | 26.82 | 5.21 | 67 | 5.15 | < .0001 | 27.72 | 5.52 | 67 | 5.29 | < .0001 |
| P1 | –0.27 | 0.80 | 267 | –0.34 | .74 | –0.75 | 1.25 | 265 | –0.58 | .56 |
| P2 | –0.37 | 0.80 | 267 | –0.47 | .64 | –1.38 | 1.66 | 265 | –1.68 | .09 |
| PD group | –11.04 | 1.33 | 267 | –8.28 | < .0001 | –9.04 | 1.87 | 265 | –5.22 | < .0001 |
| PD Group × P1 | 9.43 | 1.01 | 267 | 9.38 | < .0001 | 9.82 | 1.60 | 265 | 6.18 | < .0001 |
| PD Group × P2 | 9.84 | 1.01 | 267 | 9.74 | < .0001 | 10.47 | 2.11 | 265 | 5.31 | < .0001 |
| Age | 0.03 | 0.07 | 267 | 0.42 | .67 | –0.05 | 0.08 | 265 | –0.83 | .41 |
| Women | 10.77 | 1.30 | 267 | 8.30 | < .0001 | 9.68 | 1.40 | 265 | 6.96 | < .0001 |

*Note.* P1, P2 = assessments at approximately 1 and 6 weeks after completion of SPEAK OUT! sessions, respectively.

listeners. The semitone increases were greater than those reported after LSVT for both reading and monologue (Ramig et al., 1995). The increase in dB $SPL_{SD}$ after therapy in reading is consistent with the gains achieved in reading with use of clear speech or hyperarticulation (Lam & Tjaden, 2016). No data are available for comparison in monologue.

Three hypotheses are offered for the improvement in prosody posttherapy. First, intentional speech may have improved the efficiency of the phonatory system. Specifically, the laryngeal adjustments necessary for prosodic modulation of frequency and intensity may be viewed as articulatory gestures of the phonatory system. In PD, the undershoot that characterizes oral articulatory gestures appears to similarly affect laryngeal articulation (Baker et al., 1998; Solomon & Hixon, 1993). Thus, intentional speech may have partially overcome the articulatory undershoot of the phonatory system, resulting in increased efficiency and greater prosody. A second, related reason for the improvement in prosody posttherapy may be that the increased focus on intentional, deliberate speech may have given the patients greater control of their speech and, therefore, greater ability to vary features such as prosody. Third, intonation has been shown to be linked to mental state (Edison & Adams, 1992) and overall communicative abilities in individuals with dysarthria (Dykstra et al., 2007). Thus, it may be that the patients had, in general, a more positive attitude after therapy due to their improved communication, as reflected in the improved self-assessment scores of the V-RQoL. These hypotheses are speculative, of course, and would require testing with additional physiological and attitudinal data.

We had hypothesized that gains in prosody would be significantly greater in reading than in monologue. The findings were mixed: Larger gains in $F_{0SD}$ were observed in monologue compared to reading for the women. The reading passage was constructed to elicit prosodic variation, and the baseline prosody values were higher than the monologue. Thus, it is reasonable that the increase in prosody posttherapy in reading, while still significantly greater than pretherapy, was not as large as the increase achieved in monologue. Prosody in monologue is heavily dependent upon content. Participants were given a choice of three topics. However, even if participants had been restricted to a single monologue topic, emotional content on even a narrow topic can vary widely among speakers. Variation among speakers, as reflected in the standard deviation around the mean, was not greater for monologue compared to reading for any variable that was assessed in both speech tasks. Any evaluative speech task, such as reading or monologue, offers both advantages and disadvantages in regard to data interpretation. Of

**Table 12.** The fixed effects of time, group, and their interaction on cepstral peak prominence measured from the sentence "We were away a year ago" for both the Parkinson's disease (PD) and control groups.

| **Effect** | **Estimate** | ***SE*** | ***df*** | ***t*** | **Pr > \|t\|** |
|---|---|---|---|---|---|
| Intercept | 18.74 | 1.92 | 66 | 9.74 | < .0001 |
| P1 | –0.08 | 0.57 | 267 | –0.14 | .89 |
| P2 | 0.13 | 0.57 | 267 | 0.23 | .82 |
| PD group | –5.26 | 0.53 | 267 | –9.97 | < .0001 |
| PD Group × P1 | 5.68 | 0.73 | 267 | 7.82 | < .0001 |
| PD Group × P2 | 5.18 | 0.73 | 267 | 7.10 | < .0001 |
| Age | –0.03 | –0.03 | 267 | –0.96 | .34 |
| Women | 0.96 | 0.48 | 267 | 2.01 | .05 |

*Note.* P1, P2 = assessments at approximately 1 and 6 weeks after completion of SPEAK OUT! sessions, respectively.

**Table 13.** The fixed effects of time, group, and their interaction on the Voice-Related Quality of Life score for both the Parkinson's disease (PD) and control groups.

| **Effect** | **Estimate** | ***SE*** | ***df*** | ***t*** | **Pr > \|t\|** |
|---|---|---|---|---|---|
| Intercept | 80.43 | 10.52 | 67 | 7.64 | < .0001 |
| P1 | 0.20 | 2.72 | 64 | 0.07 | .94 |
| PD group | –26.63 | 3.09 | 64 | –8.61 | < .0001 |
| PD Group × P1 | 11.34 | 3.43 | 64 | 3.31 | .0015 |
| Age | 6.89 | 2.62 | 64 | 2.63 | .01 |
| Women | 0.21 | 0.15 | 64 | 1.42 | .16 |

*Note.* The Voice-Related Quality of Life was administered only at B1 (first baseline) and P1 (approximately 1 week after completion of SPEAK OUT! sessions).

**Table 14.** Means (standard deviations) of the average of the three baseline time points and the two follow-up time points for each outcome variable for the Parkinson's disease (PD) and control groups.

| | PD group | | | | Control group | | | |
|---|---|---|---|---|---|---|---|---|
| | Baseline | | Post-tx | | Baseline | | +6 weeks | |
| Variable | Men | Women | Men | Women | Men | Women | Men | Women |
| dB reading | 70.12 (4.36) | 69.07 (3.93) | 78.97 (4.26) | 77.86 (3.74) | 77.36 (3.80) | 76.67 (3.39) | 77.70 (3.92) | 76.60 (4.29) |
| dB monologue | 67.70 (4.98) | 67.12 (4.44) | 75.40 (4.66) | 74.62 (3.89) | 75.04 (4.09) | 73.20 (3.72) | 75.70 (4.33) | 73.00 (3.38) |
| $dB_{SD}$ reading | 8.42 (3.32) | 9.19 (3.74) | 9.66 (2.40) | 9.02 (2.29) | 11.16 (4.38) | 10.93 (4.30) | 10.91 (4.84) | 9.96 (4.49) |
| $dB_{SD}$ monologue | 7.99 (2.67) | 7.78 (3.22) | 10.07 (4.58) | 9.11 (3.83) | 10.47 (3.59) | 10.88 (4.49) | 10.66 (3.67) | 10.46 (4.22) |
| $F_{0SD}$ reading | 18.13 (4.71) | 28.29 (8.13) | 27.40 (5.33) | 33.20 (7.65) | 28.67 (5.33) | 40.03 (6.40) | 28.16 (6.37) | 39.99 (6.27) |
| $F_{0SD}$ monologue | 15.41 (21.72) | 22.25 (6.53) | 21.72 (5.43) | 29.36 (5.66) | 25.51 (5.05) | 34.59 (8.17) | 24.92 (5.76) | 34.89 (8.16) |
| CPP | 11.99 (2.69) | 12.24 (2.78) | 16.38 (3.54) | 19.15 (3.41) | 17.34 (2.45) | 17.41 (2.54) | 16.91 (2.67) | 18.12 (2.97) |
| V-RQoL | 75.29 (14.93) | 83.23 (12.52) | 80.20 (13.19) | 85.31 (9.44) | 97.33 (3.06) | 97.58 (3.62) | 97.33 (3.20) | 97.75 (3.62) |

*Note.* dB was measured at 30 cm. CPP was calculated only from the sentence "We were away a year ago." V-RQoL was administered only once at baseline and once at follow-up. Post-tx = posttreatment $F_{0SD}$ = standard deviation of fundamental frequency; CPP = cepstral peak prominence; V-RQoL = Voice-Related Quality of Life.

clinical importance, it has been noted that a monologue task may be more sensitive to prosodic disturbances than reading (Leuschel & Docherty, 1997). Furthermore, the greater increase in posttherapy prosody in monologue may reflect actual daily conversation better than the oral reading task.

The baseline CPP values for the PD group are consistent with values reported in the literature (Patel et al., 2013). Individuals with PD may have incomplete vocal fold closure (Perez et al., 1996; Smith et al., 1995), which could contribute substantially to increased noise and decreased harmonic structure in the voice sound pressure wave, thus lowering CPP values (Maryn et al., 2010). The posttherapy CPP values are typical of healthy speakers of a similar age group (Maryn et al., 2010) and may be related to improved vocal fold closure associated with increased intensity (Awan et al., 2012). The greater improvement in CPP posttherapy achieved by women compared to men may be due to gender-based spectral differences in the voice signal of healthy adults. Male voices tend to have greater spectral energy close to $F_0$ and lower harmonic energy compared to female voices (Titze, 1989). It is possible that the increased intensity achieved with intentional speech may have differentially affected the spectral characteristics of men and women (Awan et al., 2010), leading to differences in CPP posttherapy.

In regard to patient demographic variables, lesser time elapsed since diagnosis of PD was associated with greater variation in intensity, but only in monologue. Perhaps the shorter time since diagnosis represented less severe PD and, thus, less negative impact on ability to control intensity variation. It must be acknowledged, however, that clinical anecdote does not support a direct relationship between time since diagnosis and severity of PD symptoms because patients vary widely in the timing of the

**Figure 2.** Intensity during (A) reading and (B) monologue for the Parkinson's disease (PD) and control groups. Note that, in a box-and-whisker plot, the boundary of the box closest to 0 indicates the 25th percentile and the boundary of the box farthest from 0 indicates the 75th percentile. Whiskers above and below the box indicate the 10th and 90th percentiles. The horizontal line with the box marks the media. Wks = weeks; post-tx = posttreatment.

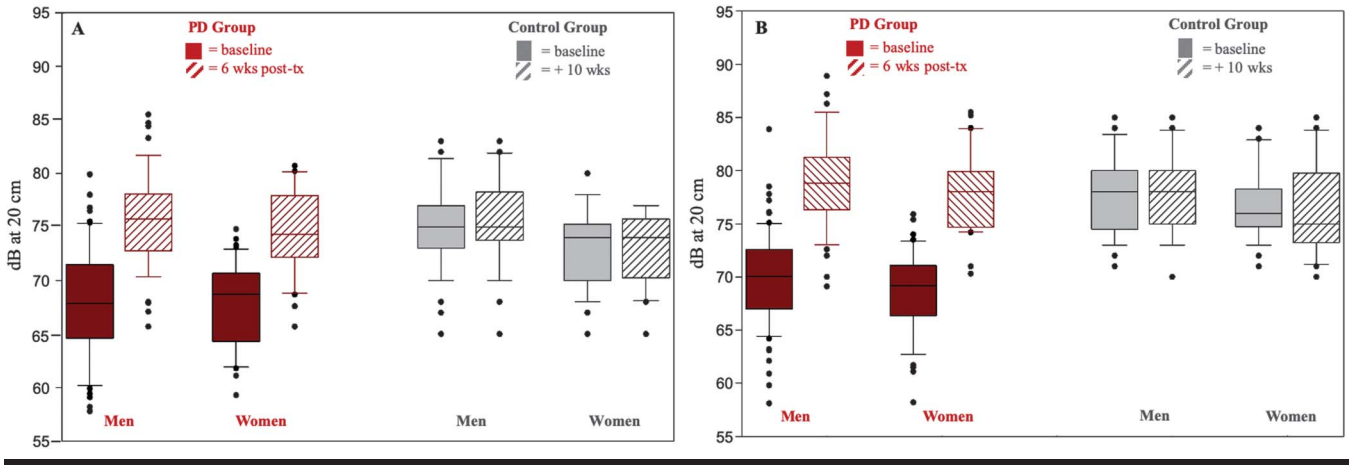
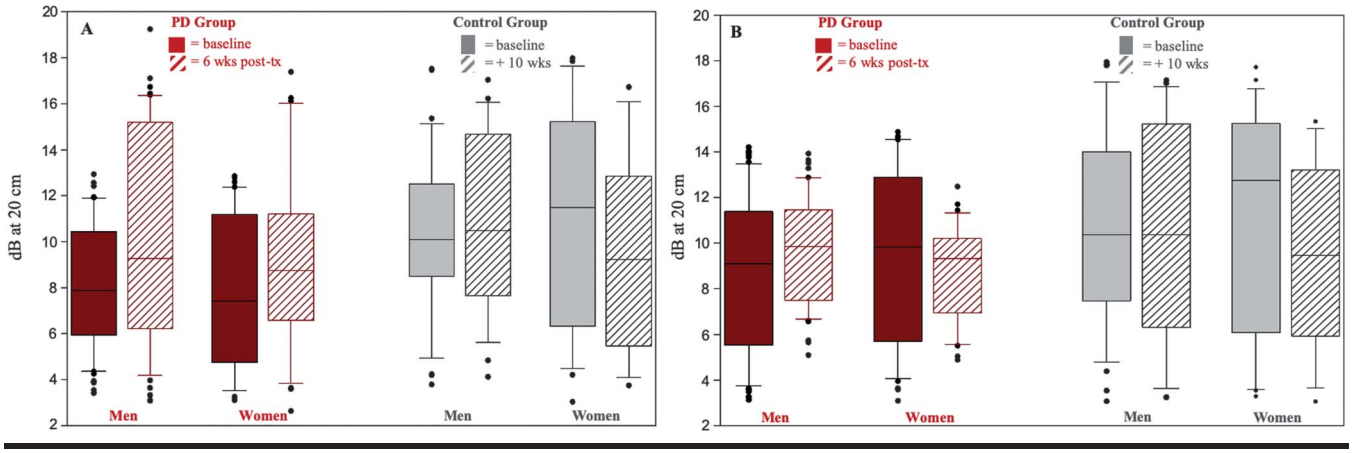


**Figure 3.** Variation in intensity ($dB_{SD}$) during (A) reading and (B) monologue for the Parkinson's disease (PD) and control groups. Wks = weeks; post-tx = posttreatment.




presentation of their symptoms and the circumstances surrounding a visit to the neurologist for diagnosis as well as the progression of their disease.

Higher Hoehn and Yahr scores (more severe PD) were significantly associated with greater variation in intensity in monologue and higher CPP (better vocal quality). These associations are counterintuitive and difficult to explain. Examination of the data did not reveal any outliers that might have accounted for these relationships. It is possible that these variables ($dB_{SD}$ in monologue and CPP) are not valid measures of PD-related speech symptoms of disease progression. However, such a statement contradicts the long-standing clinical observation (Duffy, 2005) that prosody and vocal quality become worse as the disease progresses. Another possible explanation is that the Hoehn and Yahr Scale, by itself, is not a valid indicator of disease severity. In fact, the more comprehensive Unified Parkinson's Disease Rating Scale, which contains the Hoehn and Yahr Scale, is widely considered the current standard for assessing PD disease severity (Fahn et al., 1987). The explanation for the unusual relationship may be a combination of random factors and also nonrandom factors that were not captured by the outcome variables measured in this study.

Higher Hoehn and Yahr scores were also associated with lower V-RQoL scores. This relationship is more easily understood in that greater severity of disease may possibly result in lesser satisfaction with voice production as it relates to everyday life.

Scores of the V-RQoL survey from the control group were consistent with scores from elderly healthy individuals reported in the literature (Schneider et al., 2011). Scores from the PD group were significantly improved posttherapy yet still below the mean of the healthy group. This finding is consistent with the data from Boutsen et al. (2018), although comparison with those data was made based on recalculation of their published data, which were reported using nonstandardized scoring. In contrast, Levitt and Walker-Batson (2018) found scores increased to the level of the healthy

**Figure 4.** Variation in frequency ($F_{0SD}$) during (A) reading and (B) monologue for the Parkinson's disease (PD) and control groups. Wks = weeks; post-tx = posttreatment.

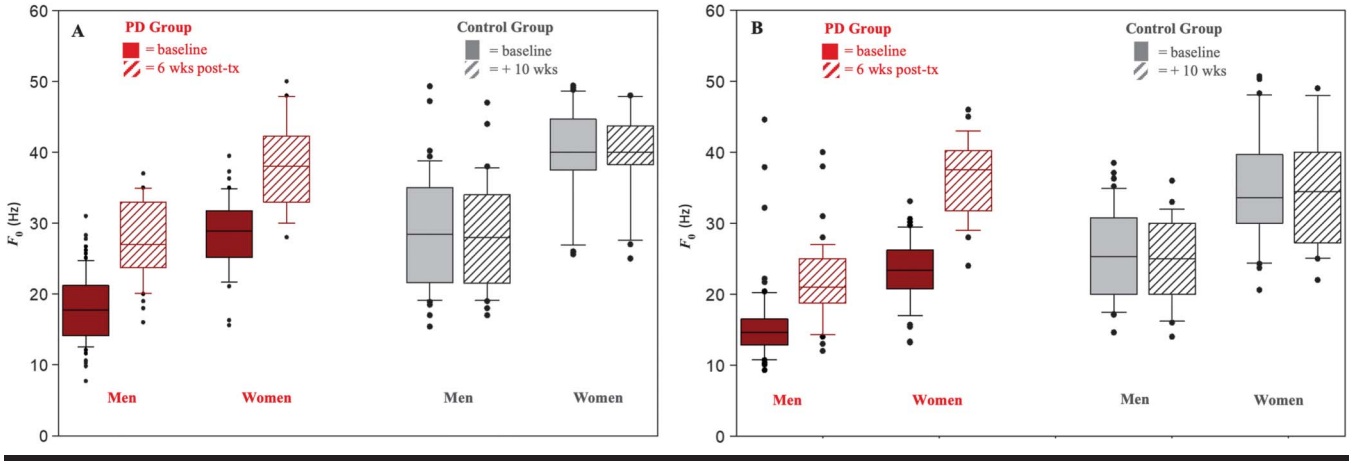
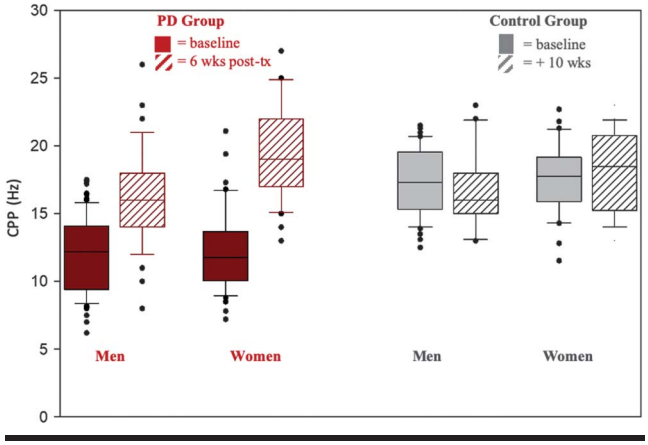


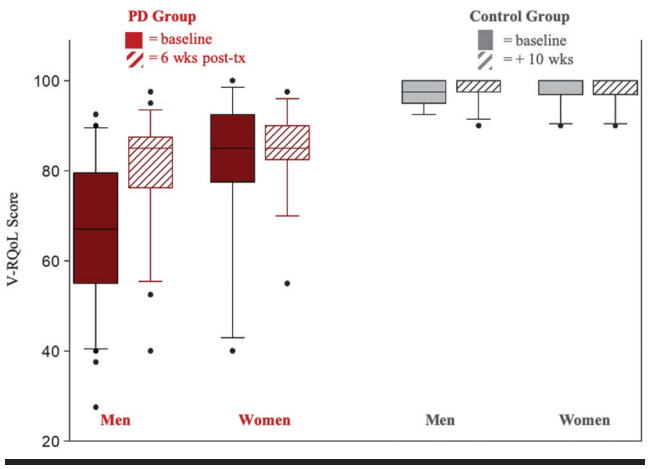
**Figure 5.** Cepstral peak prominence (CPP) from the first line of the reading passage "We were away a year ago" for the Parkinson's disease (PD) and control groups. Wks = weeks; post-tx = posttreatment.




talkers in a group of 17 individuals with PD after SPEAK OUT!. However, mean scores of their control group were lower than those of the current study. The finding in the current study that posttherapy scores improved yet remained below those of the control group is consistent with reported assessments of patients post-LSVT using other voice quality surveys (Sackley et al., 2018). Fox and Ramig (1997) made the observation that individuals with PD judged their voice and speech to be impaired. Those authors commented on the discrepancy between that judgment and the apparent lack of awareness of insufficiently loud voice pretherapy. They hypothesized that the discrepancy arose from an impaired sense of effort related to motor behaviors, not to a lack of awareness of the dysarthria. Thus, like LSVT, SPEAK OUT! addresses this underscaling problem with recalibration to increased effort.

Approximately two thirds of the participants attended at least one session of The LOUD Crowd in the final week

**Figure 6.** Voice-Related Quality of Life (V-RQoL) for the Parkinson's disease (PD) and control groups. Wks = weeks; post-tx = posttreatment.




of SPEAK OUT! and at least one more session between completion of SPEAK OUT! and before the second posttherapy assessment. Research in adherence to physical therapy programs for individuals with PD suggests that, when the patient has confidence in the therapy and the therapist provides a supportive environment, strong rapport is established between the patient and the therapist, and adherence is enhanced (Comella et al., 1994; Schenkman et al., 1998). For these reasons, initial participation in The LOUD Crowd occurs prior to completion of SPEAK OUT!. Although 90% of the patients did attend at least one group session, only 25% of the patients adhered to the recommended schedule of one group session prior to completion of SPEAK OUT! and weekly attendance thereafter. (Note that data are reported through the sixth week after completion of the individual sessions. The standard of care recommendation made to all patients, however, is ongoing weekly group attendance with no end date.) It is possible that some of the patients considered further therapy unnecessary after having achieved success in the individual therapy sessions. It is also possible that some patients may have had concerns about entering a group PD environment. Furthermore, patients were asked to delay vacations and other trips during the 4 weeks of SPEAK OUT! to maintain the research protocol scheduling. Thus, some patients may have taken those delayed trips immediately after the last SPEAK OUT! session. It may also be that patients did, in fact, attend The LOUD Crowd on a regular basis but did not adhere to the recommended weekly schedule or did not adhere to the schedule early on after SPEAK OUT!. Those data are currently being examined for a long-term follow-up study.

The lack of statistical significance between attendance in The LOUD Crowd and all of the outcome variables is likely due to the effect of participation in the individual SPEAK OUT! sessions. That is, the second assessment was only 6 weeks after the last SPEAK OUT! session. The LOUD Crowd is designed to hold participants accountable for daily practice of speech exercises and continued focus on use of intentional speech. Thus, we hypothesize that longer term follow-up may reveal that the The LOUD Crowd component is necessary for maintenance of therapeutic gains. Those data are currently being gathered.

### *Individual Response to Treatment*

For each of the six outcome variables, plots of each patient's data at each of the five time points were visually examined to assess individual differences in the patterns of response to treatment. For all variables except variation in intensity in reading, only a few patients whose baseline values were at or below the mean of the control group did not demonstrate improvement after therapy. However, those patients differed from one variable to the next. That is, no single patient demonstrated lack of improvement on all six outcome variables. Variation of intensity in reading demonstrated the largest variability among the patients from one time point to the next, with some patients achieving a

large improvement and others not. However, overall, the average change was quite small from baseline to posttherapy (consistent with the finding of no group mean statistical significance). The reasons for these different individual responses to therapy are difficult to discern in a group design, and no readily apparent reason, such as age or other covariate, offered a good explanation. Deeper understanding of the variables that help a patient to find success with this program should be explored through a single-subject experimental design.

## Limitations and Further Study

Enrollment into this study was limited to individuals with idiopathic PD with cognitive resources sufficient to fully participate in therapy. No formal, standardized assessment of cognitive abilities was conducted. Approximately one quarter of patients with PD who do not have dementia do exhibit mild cognitive changes (Weintraub & Burn, 2011). Therefore, additional data are needed to more carefully define the relationship of cognitive status and response to therapy. In that way, SLPs might better predict patient suitability for this therapeutic approach. Data are also needed on the outcome of this program for patients with Parkinson-related disorders, including early-onset PD.

The mechanisms of change that resulted in improvements with use of intentional speech are unknown. No physiological data were obtained from the participants. Lung pressure and physiological correlates of effort, for example, could help clarify how and why change did or did not occur. Another reason for the uncertain mechanisms of change is that the exact causes of hypokinetic dysarthria are unclear. Traditionally, bradykinesia has been identified as the major etiologic factor, associated with the dopamine deficits (Berardelli et al., 2001). In contrast, however, Skodda, Visser, and Schlegel (2010) hypothesized that the reduced prosody of PD may be due to nondopaminergic circuits. The lack of consistent improvement in speech in response to dopamine therapy, as reported in the literature (e.g., Plowman-Prine et al., 2009), is further evidence that the pathophysiology of dysarthria is multifactorial.

A third reason for the lack of clarity regarding this program's mechanisms of change is that the extent to which intentional speech shifts neural activity to the goal-directed basal ganglia circuits is unknown. Brain imaging studies demonstrate that assumptions made about neural activity in the neurotypical central nervous system cannot be generalized easily to those with PD. Manes et al. (2018) noted that fMRI studies suggest that, in the presence of PD pathology, basal ganglia–cortical circuits are not solely responsible for the abnormal motor control. Wu et al. (2015) described the automatic control circuits as being destabilized in PD, and the authors cautioned that even attention to goal-directed movements does not result in "normal" functioning. Baumann et al. (2018) found that, in individuals with PD, compensatory behaviors can result in complex changes in neural connectivity that can be challenging to explain. Thus, further study, including brain imaging research, could increase knowledge of the mechanisms of change in this therapeutic approach and perhaps guide modifications to increase treatment effectiveness.

Further clinical research is needed to better understand the efficacy of SPEAK OUT! with The LOUD Crowd. Treatment fidelity was not measured in this study and should be included in future studies. A randomized controlled trial comparing this program with other treatment approaches, such as LSVT, is also recommended to assist clinicians in treatment selection for their individual patients. In addition, it is reasonable to assume that the posttherapy assessments in themselves acted as a cue to use intentional speech. Thus, a study involving use of ambulatory monitoring could provide invaluable information about how patients do or do not use intentional speech in their daily lives. Finally, although the V-RQoL scale used in this study provided some information on patient perception, use of additional established self-report tools, such as provided by the Communicative Participation Item Bank (Baylor et al., 2014), would provide a more comprehensive measure of communicative participation.

## Clinical Implications

The ability to select among evidence-based therapeutic approaches is essential for optimal speech therapy. Factors related to therapist preference and individual patient response, which are not clearly evident in group data, must be considered in clinical treatment selection. Furthermore, the realities of clinical scheduling and insurance reimbursement often drive the choice of one therapeutic approach over another. The data presented here contribute to evidence of the effectiveness of an 8-hr program of SPEAK OUT! combined with The LOUD Crowd participation as a treatment option for hypokinetic dysarthria secondary to idiopathic PD and thus inform clinical practice in the selection among treatment options.

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