

BACKGROUND

Telehealth platforms can be used to improve access to speech therapy for people with Parkinson disease (PD), who often live far from specialists or have other barriers to access [1, 2, 3]. However, it is difficult to obtain objective measurements from patients through telehealth due to the limitations of commonly used software. The Purdue Motor Speech Lab has worked with Modality.AI, Inc. to develop and test a protocol to assess the speech symptoms of people with PD through a telehealth platform. This platform uses a virtual audiovisual dialog agent (named Tina) to conduct interviews including both structured and open-ended prompts. We hypothesize that people with PD and controls will be able to complete the testing through the Modality.AI system. We also hypothesize that the speech analyses by Purdue's research staff and the Modality.AI system's automated measurements will be similar. Further, we investigated the usefulness of these measures for distinguishing speakers with PD from controls.

METHODS

Forty-three people with a neurologist's diagnosis of PD (22F, 21 M) and twenty-four control participants (19 F, 5 M) have provided consent to participate in the study. Recruitment and measurements are ongoing.

Following an initial consenting and screening session to assess a candidate's health history and baseline cognitive function, participants completed a virtual dialog session with the Modality.AI system once a week for four weeks. These sessions included an abbreviated oral motor exam and several speech tasks. Productions of the Rainbow Passage from the first session with the Modality.AI system are of interest here.

The following measurements were made from the Rainbow passage:

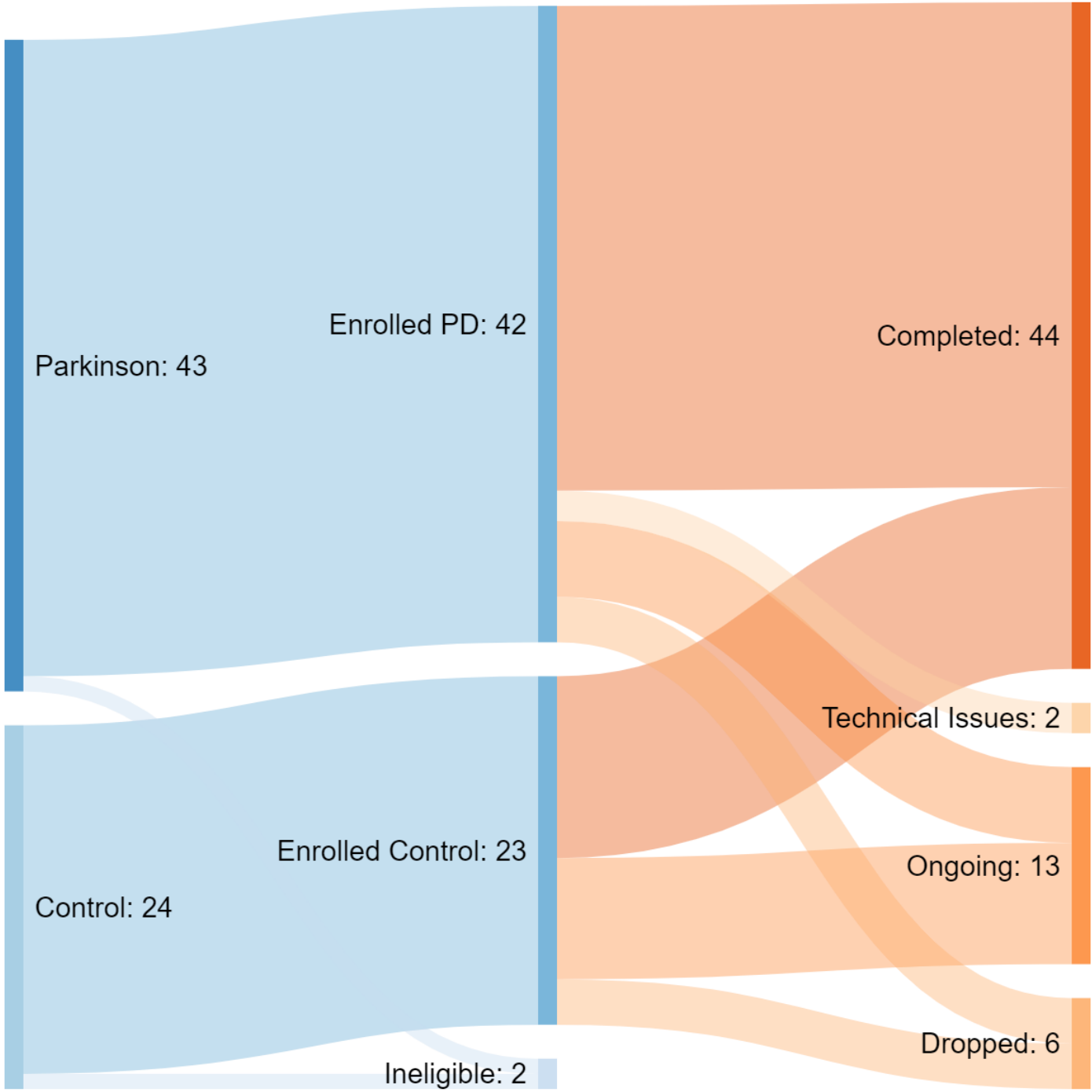
1. **Speaking rate** in syllables per second and words per minute *including* pauses as determined from an orthographic transcription of the person's speech for Purdue and from expected words for Modality.AI
2. **Articulation rate** in syllables per second and words per minute *excluding* pauses (defined as any absence of speech for at least 150 ms for Purdue, and 100 ms for Modality.AI)

t-tests were used to determine whether the automated measurements differed significantly from the clinician-researcher measurements.

Question #1: How feasible is the system for use by people with and without Parkinson disease? Most participants are able to complete their participation through all four sessions

We have an attrition rate of 14% (5/37) among people with PD, and 20% (3/15) among controls (Figure 1).

Figure 1: Flow of Participants through the Study



Question #2: Is there a difference between the automatic measurements completed by the Modality.AI system and the measurements completed by staff in the Purdue Motor Speech Lab?

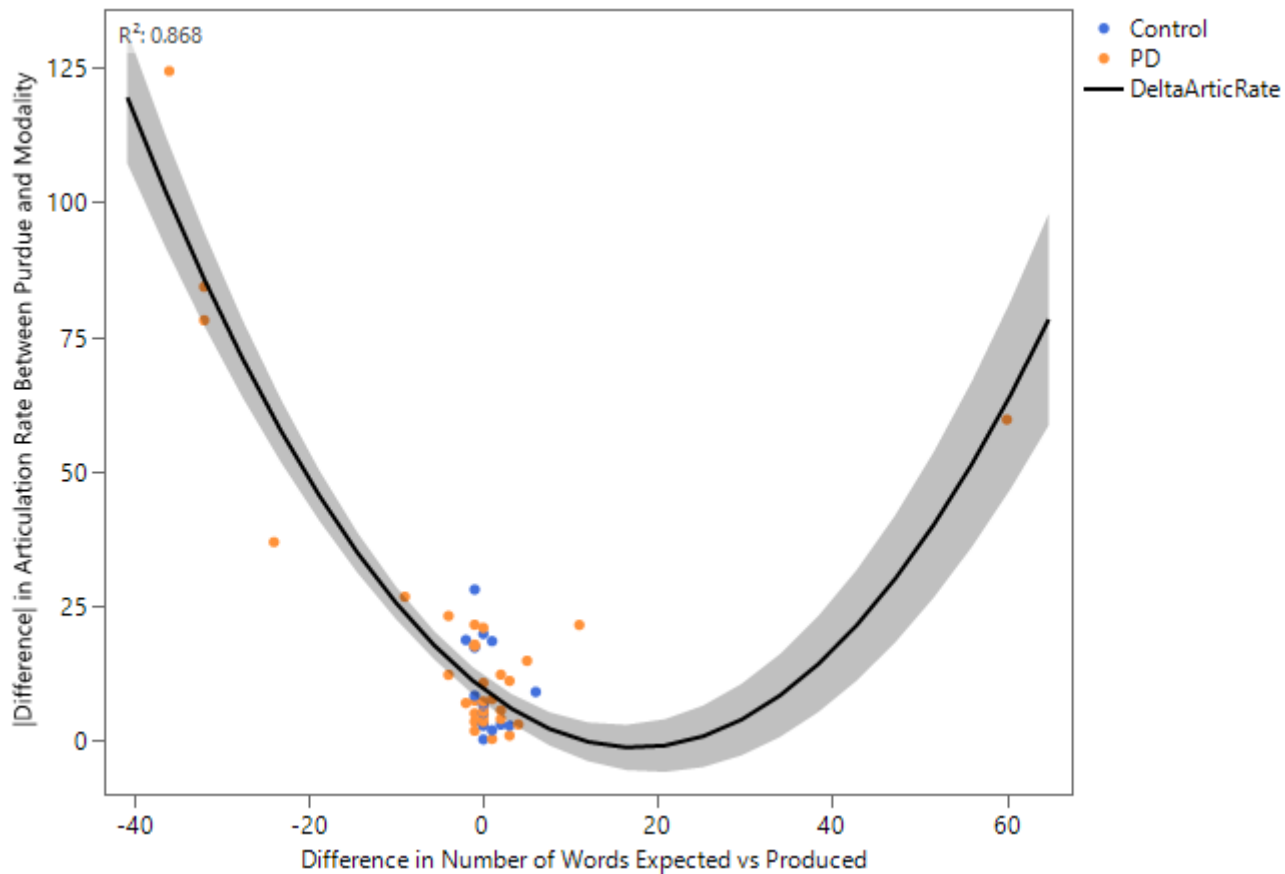
Accuracy between the systems is highest when the number of words produced is close to the text.

Table 1: Means and Standard Errors of Rate Measures between Purdue and Modality (*n* = 35 PD, 16 controls)

	Purdue Mean (SE)	Modality Mean (SE)	<i>t</i> -Ratio	<i>p</i> -value
Speech Rate (WPM)	168.70 (4.00)	171.69 (4.13)	1.122	0.2672
Articulation Rate (WPM)	204.65 (4.23)	214.22 (5.31)	2.865	0.0061*
Articulation Time (s)	29.05 (0.855)	28.31 (0.865)	-4.798	<0.0001*
Pause Time (s)	6.41 (0.478)	7.25 (0.521)	3.914	0.0003*
Total Duration (s)	35.46 (1.16)	35.55 (1.19)	0.579	0.5651
Number of Pauses	11.57 (0.703)	16.22 (0.897)	8.936	<0.0001*

RESULTS

Figure 2: Differences in Articulation Rate vs Differences in Number of Words



A multiple stepwise regression conducted on the data showed that the number of words produced by participants contributed the most to variance between the measurement systems in articulation rate ($R^2 = 0.5893$, $p < 0.0001$), followed by differences in articulation time ($R^2 = 0.0967$, $p = 0.0003$) and pause time ($R^2 = 0.0467$, $p = 0.0057$). Differences in the number of pauses were not found to be a significant predictive contributor ($R^2 = 0.0132$, $p = 0.1247$).

Question #3: Do speech and articulation rate demonstrate a difference between people with PD and controls? Not in this study, potentially due to the mild dysarthria of the participants.

Table 2: Means and Standard Errors of Speech Rate and Articulation Rate in WPM and Syll/Sec by Group (Purdue measures only) (*n* = 35 PD, 15 controls)

	PD Mean (SE)	Control Mean (SE)	<i>t</i> -Ratio	<i>p</i> -value
Speech Rate (WPM)	165.03 (5.22)	176.29 (5.72)	-1.454	0.1546
Artic Rate (WPM)	205.91 (5.62)	201.13 (6.11)	0.576	0.5682
Speech Rate (Syll/Sec)	3.58 (0.111)	3.81 (0.121)	-1.387	0.1738
Artic Rate (Syll/Sec)	4.47 (0.121)	4.35 (0.129)	0.705	0.4855
Age	68.08 (1.42)	64.07 (2.44)	1.422	0.1679

Figure 3: Mean Rate of Speech/ Articulation (WPM) by Group

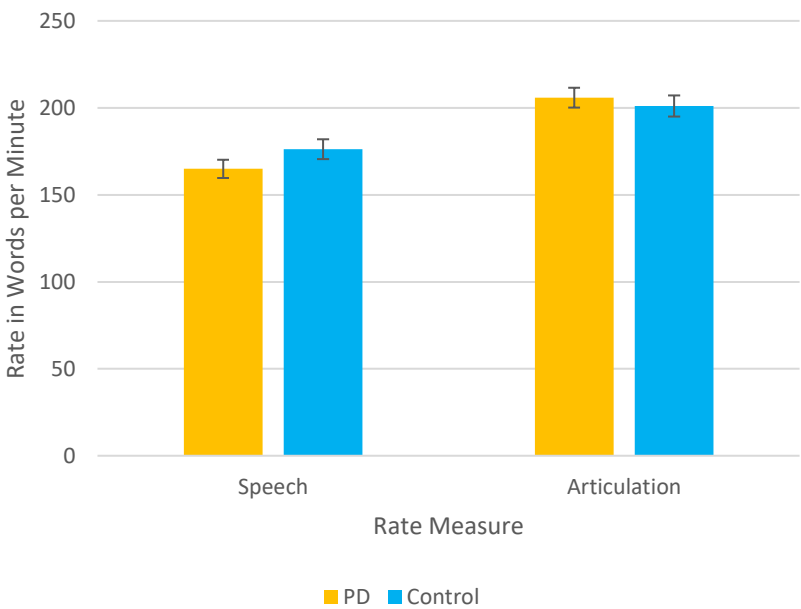
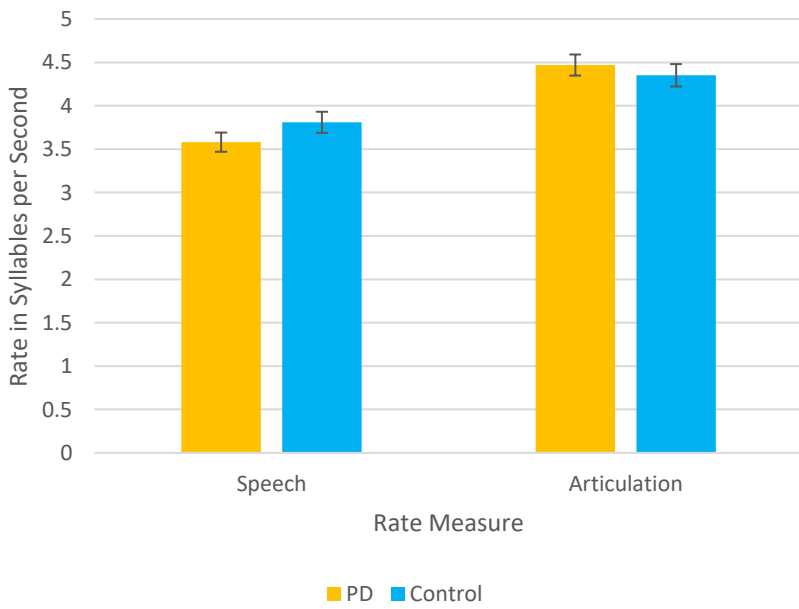


Figure 4: Mean Rate of Speech/ Articulation (Syl/Sec) by Group



Question #4: Does the measurement unit (WPM vs. syll/sec) make a difference? Words per Minute and Syllables per Second performed similarly as units of speech rate.

By visual comparison of Figures 3 and 4, the patterns across the speech and articulation rates for both groups are similar for both measurement units. Further, rate measures in the two units (WPM and syll/sec) were strongly correlated in Purdue's measures for both speech rate ($R^2 = 0.992$) and articulation rate ($R^2 = 0.988$).

DISCUSSION

1. Modality is feasible for use by people with and without Parkinson disease.
2. Articulation rate differs between Purdue and Modality, but this difference depends predominantly on differences in the number of words produced by participants. Accuracy between the systems is highest when the number of words produced is close to the text.
3. Although rate abnormalities are commonly reported in people with PD [5, 6], we found, as do many authors, no significant difference in speaking or articulation between people with PD and controls [7, 8]. Rate abnormalities become more prevalent with disease progression [9]. The participants with PD were mostly on the milder side in the current study, potentially too early for large rate changes.
4. Words per Minute and Syllables per Second performed similarly as units of speech rate. For automatic measures of speech in a known passage, words are an easier measure to obtain than syllables or other lexical units.

LIMITATIONS AND FUTURE DIRECTIONS

This is a small data set and only includes data from one session per participant. Further, the majority of participants with PD are on the milder end of the severity scale. It will be useful to examine more severe patients to understand whether performance of the system is impacted by disease severity. Analysis of other acoustic measures is ongoing.

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