Examining the Conversational Speech Intelligibility of Individuals with Hypophonia Associated with Parkinson's Disease

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Compromised speech intelligibility often is a consequence of hypokinetic dysarthria associated with Parkinson's disease (PD) (Adams, Dykstra, Jenkins, & Jog, 2008). A relatively unexplored area of research is the evaluation of conversational intelligibility in speakers with hypophonia as a primary speech symptom. Evidence suggests that hypophonia may be most evident during conversational speech tasks (Adams, Dykstra, Abrams, Winnell, Jenkins, & Jog, 2006a). This study evaluated the impact of background noise on the conversational speech intelligibility of control participants and those with hypophonia associated with PD. Thirty individuals with hypophonia and PD and 15 healthy control participants participated in conversation with various levels of background noise. Results revealed nonsignificant differences between groups when conversational intelligibility was assessed in a no background noise condition. Significant results were found when conversational intelligibility was assessed in the presence of three intensity levels of background noise. The results of this study demonstrate that participants with hypophonia have significant deficits in conversational speech intelligibility even in relatively low levels of background noise. Furthermore, deficits in speech intelligibility are exacerbated with increasing levels of background noise. Assessing speech intelligibility using conversational speech tasks that are obtained in different levels of background noise appears to provide an ecologically valid estimate of intelligibility and may be a useful indicator of the disability associated with hypophonia in PD.

INTRODUCTION

Speech intelligibility supports effective and efficient spoken language. Compromised speech intelligibility often is a consequence of hypokinetic dysarthria associated with Parkinson's disease (PD) (Adams et al., 2008). A relatively unexplored area of research is the evaluation of conversational intelligibility in speakers with hypophonia as a primary speech symptom. For

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individuals with hypophonia associated with PD, maintaining adequate speech intelligibility in the presence of background noise may be an especially difficult and challenging task (Adams et al., 2008). On average, individuals with hypophonia and PD have speech intensity levels 2 to 5 dB SPL lower than healthy, age-matched control participants (Adams et al., 2006a; Adams, Moon, Dykstra, Abrams, Jenkins, & Jog, 2006b; Fox & Ramig, 1997). Furthermore, evidence suggests that hypophonia may be most evident during conversational speech tasks (Adams et al., 2006a; Fox & Ramig, 1997; Ho, Bradshaw, Iansek, & Alfredson, 1999). Interestingly, there is a paucity of research that has examined the effect of background noise on conversational speech intelligibility in individuals with hypophonia and PD.

The assessment of speech intelligibility based on conversational samples has the appeal of providing an ecologically valid estimate of intelligibility. The majority of published speech intelligibility tests, however, focus on estimating the severity of speech intelligibility at the phoneme, single word, or sentence level. Unfortunately, there appear to be no formal measures that assess dysarthric speech intelligibility at a conversational level. Examining the intelligibility of conversational speech may be an especially valid estimate of the actual speech intelligibility experienced by individuals with hypokinetic dysarthria. In the PD population, speech intelligibility can be relatively unimpaired during tasks that involve estimating speech intelligibility based on single-word or sentence intelligibility tasks but can be degraded in conversation (Tjaden, 2006). Capturing the degradation in speech intelligibility during conversational speech has the potential to provide important information on the actual speech intelligibility deficits experienced in this population.

This study was part of a larger investigation that examined patterns of speech intensity regulation in background noise in participants with hypophonia and PD. The purpose of the present study was to evaluate conversational speech intelligibility in quiet conditions as well as to examine the impact of background noise on conversational speech intelligibility in participants with hypophonia associated with PD and in control participants.

METHODS

Participants

This study included 30 participants with hypophonia as a result of mild to severe idiopathic PD (age range, 43–77 years; mean age = 63.26 years) with an average PD onset of 8.6 years (range, 2–26 years) and 15 control participants (age range, 56–77 years; mean age = 69.4 years). Participants with PD were reported by a neurologist (MJ) to demonstrate hypophonia. Participants also demonstrated habitual conversational speech intensity levels that were consistent with hypophonia (control participants: 71.82 dB, standard deviation [SD] = 2.51; PD: 66.86 dB, SD = 3.48; refer to Dykstra, Adams & Jog, in press). Participants with PD were stabilized on their antiparkinsonian medication and were tested at approximately 1 hour after taking their regularly scheduled dose. All participants passed a 40-dB HL hearing screening. Table 1 provides a description of the participants with PD.

Procedures

Conversational Speech Intelligibility

All participants were engaged in conversation with the examiner in four intensity levels of background noise, and their recorded conversational utterances were edited into four spontaneous conversational excerpts representing the following background noise conditions (0, 60, 65, and 70 dB SPL). Each conversational excerpt ranged in duration from 30 to 45 seconds, and each excerpt was edited to include only the speech of the participant and not the conversational partner. A total of 180 conversational excerpts ranging in length from 30 to 45 seconds each was compiled into play lists and were presented to two naive listeners. Each of the 180 conversational excerpts was audio recorded from a floor microphone placed 150 cm from the participant. Playback of the conversational excerpts was presented from the floor microphone audio recordings. Listeners rated each conversational excerpt using a 100-mm visual analogue scale with anchors of "0% intelligibility" on the left end of the scale and "100% intelligibility" on the right of the scale (see Appendix A).

TABLE 1. Description of Participants with Parkinson's Disease

Subject	Age	Sex	PD Duration (years)	Antiparkinson Medications	Maximum Intensity (dB SPL)	Habitual Intensity (dB SPL)
PD1	55	M	6	Amantadine	79.98	67.88
PD2	54	F	10	Mirapex, Sinemet	70.79	62.95
PD3	66	M	5	Sinemet, Permax	76.89	68.92
PD4	66	M	8	Sinemet	77.26	64.82
PD5	55	M	6	Sinemet, Permax	73.53	69.75
PD6	55	M	8	Sinemet, Permax	82.19	72.89
PD7	67	M	12	Sinemet, Mirapex	73.78	67.05
PD8	66	F	2	Sinemet, propranolol	78.66	72.10
PD9	64	F	6	Sinemet, Permax, Mirapex	82.82	69.66
PD10	72	M	17	Sinemet	75.80	64.53
PD11	75	M	8	Sinemet	79.21	72.43
PD12	68	M	3	Sinemet	84.87	65.77
PD13	64	F	15	Sinemet	71.39	65.38
PD14	55	M	10	Sinemet	77.19	64.81
PD15	55	M	3	Sinemet, Requip	80.50	66.62
PD16	61	M	5	Amantadine, Mirapex	81.57	67.99
PD17	63	F	6	Sinemet	80.84	72.31
PD18	53	M	6	Sinemet, Requip	83.25	66.69
PD19	60	F	10	Sinemet	77.16	70.76
PD20	68	M	10	Sinemet, Requip	69.54	61.54
PD21	77	M	5	Sinemet	76.32	63.82
PD22	61	F	11	Sinemet, Permax	72.90	68.11
PD23	74	M	7	Sinemet	76.86	60.87
PD24	70	F	11	Sinemet	67.70	61.07
PD25	63	M	6	Lamictal, lithium, propranolol	72.35	68.27
PD26	43	M	2	Sinemet, Mirapex	80.44	68.45
PD27	61	M	10	Sinemet	82.71	67.83
PD28	69	M	26	Sinemet, domperidone, propranolol	72.05	65.96
PD29	66	M	18	Sinemet, amantadine, Requip	79.03	65.95
PD30	72	F	6	Sinemet	60.04	60.51

F = female; M = male.

RESULTS

Conversational Intelligibility with No Added Background Noise

An independent samples *t*-test revealed nonsignificant differences between PD and control participants (t [43] = 1.447; $P = .155$, not significant). This result suggests that when no background noise is added, the habitual conversational speech intelligibility of the participants with PD is lower and more variable but not significantly different than that of control participants (Table 2).

Conversational Intelligibility in Background Noise

Results of a two-factor repeated measures analysis of variance with one between-group and one within-group factor revealed the main effect of "group" was significant (F[1, 43] = 11.344; $P = .002$) (Table 3 and Figure 1). There also was a significant main effect for "noise" (F_{adj}[1.490,43] = 26.306; $P = .001$). The "group" (PD, control) by "noise" interaction approached significance (F[2,43] = 2.725; $P = .071$). The significant main effects suggest that control and PD participants differ significantly in conversational speech intelligibility in various intensity levels of multi-talker background noise. More specifically, the participants with PD had significantly lower conversational intelligibility scores than control participants across all intensity levels of background noise. The weak interaction between "group" and "noise" levels suggests that the conversational speech intelligibility of PD and control groups is being affected differentially with increasing levels of background noise. Figure 1 shows that the slope lines are not parallel across noise conditions for the PD and control participants.

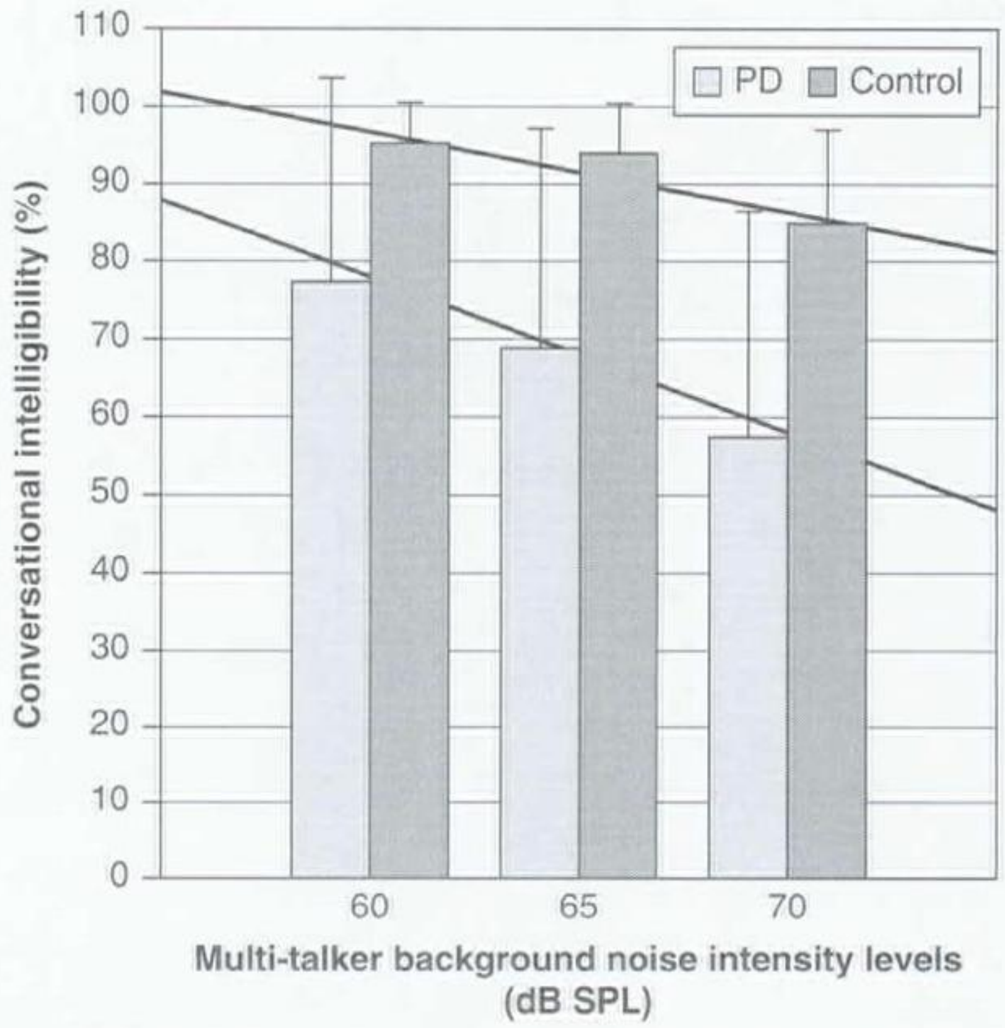

Figure 1. Mean conversational speech intelligibility of control and Parkinson's disease (PD) participants in various intensity levels of background noise.

For example, the slope of the PD group is steeper than the slope of the control group across increasing levels of background noise. This interaction appears to become more pronounced in the 65- and 70-dB background noise conditions where the PD slope diverges to a greater extent than the control slope.

DISCUSSION

The results of this study indicate that speakers with hypophonia as a primary speech symptom of hypokinetic dysarthria demonstrate significant

TABLE 2. Mean Habitual Conversational Speech Intelligibility of Control and Parkinson's Disease Participants in No Added Background Noise*

	Control	PD
% Intelligibility	96.77	89.63
(SD)	(5.07)	(18.65)

*Speech intelligibility levels are expressed as a percentage. Standard deviations appear in parentheses below means. PD = Parkinson's disease; SD = standard deviation.

TABLE 3. Mean Conversational Speech Intelligibility of Control and Parkinson's Disease Participants in Different Levels of Multi-talker Background Noise*

Group	Multi-talker Background Noise Level		
	60 dB SPL	65 dB SPL	70 dB SPL
Control	95.40	94.13	85.03
	(5.20)	(6.37)	(12.09)
PD	77.47	68.98	57.57
	(26.29)	(28.28)	(29.05)

*Speech intelligibility is expressed as a percentage. Standard deviations appear in parentheses below means.

deficits in conversational speech intelligibility in even the least intense background noise conditions (i.e., 60 dB SPL). This hypophonia-related speech intelligibility deficit is exacerbated to a greater extent with increasing levels of background noise. In general, control participants maintained near normal to mildly reduced speech intelligibility throughout the background noise conditions. Conversely, participants with PD had mildly reduced conversational intelligibility scores when no background noise was added but had intelligibility scores that dropped off quickly and significantly when any background noise was presented. For example, in 70 dB of multi-talker background noise, the conversational intelligibility of participants with PD was reduced to approximately 57%. This result is especially striking when it is contrasted with their average conversational intelligibility score of approximately 89% in no background noise. These results suggest that even moderate levels of background noise can have a deleterious effect on conversational intelligibility in participants with hypophonia associated with PD despite these individuals having fairly high intelligibility scores in no-noise testing conditions. Unfortunately, speech intelligibility in individuals with hypophonia as a primary speech symptom is not typically assessed formally if there is no significant articulatory deficit present because, in quiet conditions, intelligibility is relatively unimpaired. If intelligibility is assessed, then it is typically evaluated in a standard, quiet testing environment such as a clinic treatment room, and intelligibility is evaluated at the single-word or the sentence level. It is possible that the actual speech intelligibility of speakers with hypophonia is underestimated through assessment tasks administered in quiet settings that use highly controlled stimuli (i.e., single words, standardized sentences). Assessing speech intelligibility using conversational speech tasks that are obtained in different levels of background noise appears to provide an ecologically valid estimate of speech intelligibility. Assessing intelligibility in noise also is relevant in order to obtain a valid indicator of the disability associated with hypophonia in PD. Despite these promising results, further research is required to delineate systematically the most accurate and valid means of assessing speech intelligibility in this population.

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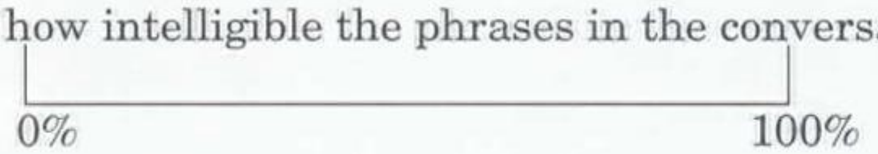
Appendix A: Conversational Intelligibility Rating Scale

Instructions for listeners:
You will be listening to 180 conversational excerpts ranging in length from 30 to 45 seconds each. Following each conversational excerpt, you will be required to rate the intelligibility of the phrases in the conversational excerpt. Conversational excepts will be randomly presented to you with either no noise in the background or different intensity levels of multi-talker background noise. Samples will only be presented once.

Intelligibility Rating
Please rate your perception of how intelligible the phrases in the conversation were.



*Each conversational excerpt was rated by the listener by placing an "X" on the 100 mm long visual analogue scale. "Speech Intelligibility" was measured as the distance in millimeters from the left end of the scale where the listener marked an "X" and was expressed as a percentage (i.e., 76 mm = 76% perceived intelligibility).

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