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Effect of concurrent walking and interlocutor distance on conversational speech intensity and rate in Parkinson's disease

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ABSTRACT

Previous studies have demonstrated a negative effect of concurrent walking and talking on gait in Parkinson's disease (PD) but there is limited information about the effect of concurrent walking on speech production. The present study examined the effect of sitting, standing, and three concurrent walking tasks (slow, normal, fast) on conversational speech intensity and speech rate in fifteen individuals with hypophonia related to idiopathic Parkinson's disease (PD) and fourteen age-equivalent controls. Interlocuter (talker-to-talker) distance effects and walking speed were also examined. Concurrent walking was found to produce a significant increase in speech intensity, relative to standing and sitting, in both the control and PD groups. Faster walking produced significantly greater speech intensity than slower walking. Concurrent walking had no effect on speech rate. Concurrent walking and talking produced significant reductions in walking speed in both the control and PD groups. In general, the results of the present study indicate that concurrent walking tasks and the speed of concurrent walking can have a significant positive effect on conversational speech intensity. These positive, "energizing" effects need to be given consideration in future attempts to develop a comprehensive model of speech intensity regulation and they may have important implications for the development of new evaluation and treatment procedures for individuals with hypophonia related to PD.

1. Introduction

Parkinson's disease (PD) is a progressive neurological disorder characterized by resting tremor, muscle rigidity, slowness of movement, reduced range of motion, gait disturbance and postural instability [1]. It is estimated that 60–80% of individuals with PD will develop a speech impairment referred to as hypokinetic dysarthria [2]. A common speech symptom in PD is low speech intensity or hypophonia. Hypophonia is often the first speech symptom to emerge in the early stages of the disease and it is associated with a reduction of about 2–5 decibels (dB) in speech intensity relative to healthy older adults [3]. Like many of the other motor symptoms in PD, hypophonia is hypothesized to be causally related to a sensory deficit or a sensorimotor integration deficit that involves the abnormal perception of loudness and/or the abnormal integration of loudness-related auditory feedback during the normal regulation of speech intensity [4]. One approach to investigating these sensorimotor deficit hypotheses is to examine the effect of changes in sensory feedback on speech intensity and to systematically manipulate the sensorimotor conditions that are known to modulate speech intensity.

Several studies have examined speech intensity modulating conditions and contexts in PD [3,5–7]. PD participants have been found to respond to increases in interlocutor distance (distance between talkers) or increases in background noise by increasing speech intensity in a manner that is similar to that of controls [3,5]. These results suggest that individuals with PD demonstrate relatively normal patterns of intensity regulation despite a consistent overall reduction in the "gain" parameter of speech intensity control. In contrast, performing a concurrent limb and speech movement task has been found to have an inconsistent effect on speech intensity in PD participants [3,7]. For example, Ho et al. [7] examined the effect of a concurrent manual visuomotor tracking task on the intensity of speech during conversation and a loud counting task. This concurrent task produced a significant decrease in speech

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intensity for the loud counting task but not the conversational speech task. On the other hand, Adams et al. [3] found that a similar concurrent manual visuomotor tracking task was associated with a significant increase in conversational speech intensity in the PD participants but not the controls. The authors suggested that certain concurrent tasks might have an "energizing effect" on speech intensity in individuals with hypophonia related to PD. It was further suggested that the nature of the concurrent task may play an important role in the modulation of speech intensity in PD [3].

Walking and talking is a potentially important concurrent task in PD. Gait disturbance is a common symptom in PD and frequently co-occurs with speech impairment [8]. Gait and speech disturbances are classified as axial PD symptoms that may share unique and common neurodegenerative processes [9]. Previous concurrent speech and gait studies have consistently reported a negative effect on walking performance in PD [10,11]. In addition, it appears that as the demands of the speaking condition increase, there is a greater negative effect on gait and an increased risk of falls [12]. The effect of concurrent walking on speech intensity, or other aspects of speech production, has not been described in previous studies of PD.

The primary objective of this study was to examine the effect of concurrent walking tasks on conversational speech intensity and rate in PD, the second objective was to examine the effect of changes in interlocutor distance on speech intensity and rate in PD, and the third objective was to examine the effect of concurrent talking on walking speed in PD.

2. Methods

2.1. Participants

This study included 15 participants (2 F, 13 M) between 58 and 80 years old ($M = 72.07$) that were identified and diagnosed with mild to moderate idiopathic PD and hypophonia by a neurologist. In all PD participants, hypophonia was the primary speech symptom. Parkinson severity scores, obtained with the Unified Parkinson Disease Rating Scale (part 3), ranged from 10 to 45 out of a maximum severity of 108 ($M = 25.7$; SD = 10.2). Only PD participants with mild gait impairment were included in the study. Duration of PD ranged from 1 to 17 years ($M = 8.7$; SD = 6.2). PD participants were stabilized on their anti-Parkinson medications, and tested approximately one hour after taking their regular medication. Three PD participants were not on anti-Parkinson medication. All PD participants passed ($M = 28.8$, $SD = 1.4$) a cognitive screening (Mini Mental Status Examination). The study also included 14 age-equivalent healthy control participants (7 M, 7 F) between 59 and 82 years old with no history of speech or gait impairments. The study was approved by the local Health Sciences Research Ethics Board at Western University and all participants provided written informed consent.

2.2. Instruments

Participants wore a belt pack containing an audio recorder (M-audio Microtracker II) that was connected to a head-mounted microphone (DPA 4060) positioned 6 cm from the mouth. The headset microphone was calibrated with an audio signal (70 dBA SPL) and a sound level meter placed at 15 cm from the participant's mouth [13]. A video camera was placed perpendicular (Panasonic HC-V700) to a walking path (1 m× 21 m) and was used to record each participant's walking performance.

2.3. Procedures

Participants performed several concurrent and non-concurrent speech and walking conditions. Speech conditions involved engaging in a conversation with the experimenter for approximately 3 min about a familiar topic. The topics included favorite vacations, interests, hobbies, relatives, occupational experiences, etc. The conversations took place with the participant positioned at an interlocutor distance of 1 and 6 m. The five walking conditions included, (1) sitting, (2) standing, (3) walking at a habitual speed, (4) walking at a speed perceived to be two times slower than the habitual speed, and (5) walking at a speed perceived to be two times faster than habitual. During all walking conditions the examiner walked alongside the participant (at 1 or 6 m) and tried to follow, rather than lead, the participant's walking pace. No instructions were given with regard to the focus of attention on walking or talking.

2.4. Measures and statistical analysis

Speech recordings were analyzed using the acoustic waveform editing and analysis functions in the Praat software [14]. The two primary speech measures included: average speech rate (words per minute) and average speech intensity (dB SPL). The first ten conversational utterances (minimum five words in length and excluding dysfluencies) were analyzed from each experimental condition. Following a re-measurement of 20% of the data by two examiners, the average inter-judge ($r = 0.90$) and intra-judge ($r = 0.92$) reliability for the combined speech intensity and rate measures were found to be significant ($p = 0.001$).

Walking speed was obtained from the video recordings by manually counting the number of steps in each 21-m walking segment and measuring duration (speed = 21 m/duration). The speech intensity, speech rate and walking speed data were examined with separate three-way ANOVAs.

3. Results

3.1. Conversational speech intensity

Results related to conversational speech intensity are presented in Table 1 and Figs. 1 and 2. Across all of the experimental conditions, the participants with PD had an average speech intensity level that was significantly lower (−4.1 dB) than controls [$F(1, 21) = 11.322$, $p = 0.003$]. The increase in interlocutor distance was associated with a significant increase in speech intensity (+2.5 dB) [$F(1, 21) = 103.233$, $p = 0.000$]. There was a significant effect of the walking tasks on speech intensity [$F(4, 21) = 58.406$, $p = 0.000$].

In general, the post hoc analysis (Bonferonni corrected t-tests; 0.05/10 = 0.005) revealed that the normal and fast walking conditions had significantly higher speech intensity than the sitting and standing conditions. In particular, the PD and control groups had significantly higher speech intensity while walking at a normal speed than while standing and talking at an interlocutor distance of 1 m ($p < 0.005$) and 6 m ($p < 0.005$). In addition, both

Table 1
Average conversational speech intensity at 1 and 6 m interlocutor distances across walking conditions for the control and PD participants.

	1 m		6 m		
	Control	PD	Control	PD	Mean
Sitting	69.7 (2.6)	65.5 (3.5)	72.9 (2.2)	68.6 (3.6)	69.1 (2.9)
Standing	69.3 (2.6)	64.2 (3.8)	72.2 (2.5)	68.0 (3.5)	68.4 (3.1)
Walking slow	71.3 (2.5)	67.6 (4.5)	74.1 (2.8)	70.3 (3.4)	70.8 (3.3)
Walking normal	71.8 (2.4)	68.2 (3.2)	74.3 (2.4)	70.2 (3.1)	71.1 (2.7)
Walking fast	73.4 (2.8)	69.7 (3.4)	75.7 (3.0)	70.8 (3.3)	72.4 (3.1)
Mean	71.1 (2.5)	67.04 (3.7)	73.8 (2.6)	69.6 (3.3)	

Note: Speech intensity levels are in dB SPL. Standard deviations appear in parentheses beside means.