Effects of Interlocutor Distance, Multi-talker Background Noise, and a Concurrent Manual Task on Speech Intensity in Parkinson's Disease

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This study examines the effects of interlocutor distance, multi-talker background noise, and a concurrent visuomotor manual tracking task on conversational speech intensity in 14 controls and 10 participants with Parkinson's disease (PD). Participants were engaged in conversation while randomly presented with three levels of multi-talker background noise (no noise, 50, and 65 dB sound pressure level [SPL]). These were combined with two interlocutor distances of 1 and 6 metres. Participants also performed a concurrent visuomotor manual tracking task during half of the experimental conditions. This task involved squeezing a hand bulb that generated a continuous signal that was used to track a moving target (0.2 Hz sinusoid) on a computer screen. Overall, the PD group demonstrated decreased conversational speech intensity when compared to the control group. Increases in background noise and interlocutor distance were associated with significant increases in conversational speech intensity, and these effects were essentially parallel in the control and Parkinson participants. The concurrent manual tracking task was associated with a significant and consistent reduction in speech intensity for the control participants. In contrast, the participants with PD showed a significant increase or enhancing effect on conversational speech intensity for most of the concurrent tracking conditions. The results of this study suggest that specific processes involved in the regulation of speech intensity are differentially impaired in participants with PD and controls. It is also suggested that certain concurrent manual tasks may have an energizing effect on conversational speech intensity in persons with hypophonia and Parkinson's disease.

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INTRODUCTION

Low speech intensity or hypophonia is a frequently occurring symptom in Parkinson's disease (Adams & Dykstra, 2009; Duffy, 2005). The hypophonia of Parkinson's disease (PD) is generally associated with a 2–5 dB reduction in conversational speech intensity relative to control speakers (Adams, Dykstra, Jenkins, & Jog, 2008; Adams, Dykstra, Abrams, Winnell, Jenkins, & Jog, 2006a; Adams, Moon, Dykstra, Abrams, Jenkins, & Jog, 2006b; Fox & Ramig, 1997; Ho, Bradshaw, Iansek, & Alfredson, 1999a). Despite an overall reduction in speech intensity, individuals with PD have been found to demonstrate relatively normal patterns of intensity regulation in response to changes in specific experimental conditions and speaking contexts (Adams et al., 2006b; Adams et al., 2008; Ho et al., 1999a, Ho, Iansek, & Alfredson, 1999b). For example, when presented with increases in background noise, participants with PD have shown a corresponding increase in speech intensity that is parallel to the "Lombard" response seen in control participants (Adams et al., 2006b). Similarly, increases in interlocutor distance have been found to produce increases in the speech intensity of participants with PD that parallel the increases seen in controls (Ho et al., 1999b). In contrast, it appears that some experimental conditions may be associated with abnormal patterns of intensity regulation in participants with PD. For example, the production of a concurrent manual task has been found to produce a greater reduction in speech intensity in participants with PD than control participants (Ho, Iansek, & Bradshaw, 2002). However, this concurrent task effect on speech intensity was only observed when the participants with PD were performing a loud *counting* task and not during a conversational speech task. In two studies of healthy young control participants, Dromey and Bates (2005) and Dromey and Shim (2008) found that a concurrent manual task was associated with a significant increase in the speech intensity of spoken sentences. Gentilucci (2003) also found that increases in the size of concurrent hand grasping movements were associated with increased speech intensity. Thus, reports of the effect of concurrent tasks on speech intensity have been inconsistent and appear to be influenced by the speech task (i.e., number recitation versus conversation), the participant group (PD versus controls), and the type of concurrent limb task (Dromey & Bates, 2005; Dromey & Shim, 2008; Gentilucci, 2003; Ho et al., 2002). Several studies have focused on the effect of a concurrent speech task on limb performance in participants with PD. These studies have generally demonstrated a detrimental effect of concurrent speech tasks on gait and balance in participants with PD, but there is limited information on the effect of concurrent conversational speech tasks on manual performance (Bloem, Valkenburg, Slabbekoorn, & van Dijk, 2001; Marchese, Bove, & Abbruzzese, 2003; O'Shea, Morris, & Iansek, 2002). In contrast to previous findings, one recent preliminary study reported that a concurrent speech task enabled participants with PD to perform a manual grasp and reach task faster and more smoothly (Maitra, 2007).

In general, previous studies have shown a consistent pattern of results for the effects of background noise and interlocutor distance on speech *intensity*, but the combined effect of these speaking conditions has not been examined in participants with PD. In contrast, previous studies of the effects of concurrent manual tasks on speech intensity have been inconsistent and may be significantly influenced by the specific type of speech and concurrent manual tasks that are employed. The purpose of the present study is (1) to examine the combined effects of interlocutor distance, background noise, and a concurrent task on the regulation of conversational speech intensity in PD, and (2) to examine the effect of a concurrent conversational speech task on manual visuomotor tracking performance.

METHODS

Participants included 10 individuals with hypophonia and idiopathic Parkinson's disease (55–78 years of age; mean = 67.9 ± 6.44) and 14 age-matched control participants (61–80 years of age; mean = 70.29 ± 6.64). All participants with PD were reported by a neurologist (M. Jog) to demonstrate hypophonia and idiopathic Parkinson's disease. All participants with PD were classified between stages II and III on the Hoehn and Yahr System for staging of parkinsonism (Hoehn & Yahr, 1967). Participants with PD were stabilized on their anti-Parkinsonian medication and were tested, in an "on" state, at approximately 1 hour after taking their regularly scheduled dose. Table 1 provides a description of the participants with PD. PD and control participants were required to

TABLE 1. Description of Parkinson's Disease Participants.

Participants	Age (Years)	Sex	Parkinson's Disease (PD) Duration (Years)
S1	66	M	5
S2	69	M	6
S3	73	F	7
S4	73	M	18
S5	78	M	6.5
S6	55	M	11
S7	68	M	11
S8	65	F	13
S9	70	M	6
S10	62	M	8

pass a 30 dB hearing level (HL), bilateral hearing screening at 500, 1000, and 2000 Hz. All participants had cognition and language skills that were sufficient to support conversation and perform the manual tracking task.

All participants were seated in an audiometric booth and wore a headset microphone (AKG-C420) positioned a constant 6 cm distance from the mouth. A sound level meter placed 15 cm from each participant's mouth was used to calibrate the speech intensity. The experimenter sat at 1 metre or 6 metres in front of the participant. A standard tape-recording of multi-talker noise (Audiotech—4 talker noise) was presented through the loudspeaker positioned 115 cm from the participant. The intensity of the noise (calibrated in dB sound pressure level [SPL]) was adjusted via a diagnostic audiometer (GSI 10). Participants were engaged in 3 minutes of conversation during each of the experimental conditions. During conversations, the participants were asked to discuss topics such as vacations, hobbies, interests, occupational experiences, family members, etc. This study included 13 randomized experimental conditions. Twelve conditions involved the production of conversational speech during all possible permutations of the 3 background noise conditions (0, 50, 65 dB), the 2 interlocutor distance conditions (1 and 6 metres), and the 2 tracking conditions (tracking and no tracking). The final condition involved no speech production while doing the manual tracking task. The speech signal was transferred from a digital audio tape recorder (Tascam DA-01) to a desktop computer via a sound card (Creative Audigy 2 platinum). The average speech intensity (dB) was determined for each utterance using the intensity edit/analysis routine in PRAAT (version 5.0.20) software (Boersma & Weenink, 2008). The average speech intensity values were analysed using a four-factor repeated measures analysis of variance (ANOVA) (group, noise, distance, tracking conditions). In order to examine the tracking conditions in greater detail, a secondary analysis involving a series of two-factor repeated measures ANOVAs (group, tracking conditions) was also performed.

The concurrent visual-motor tracking task involved squeezing a standard hand-held blood pressure test bulb attached to an air pressure transducer system (Glottal Enterprises MS100-A2). The output of the air pressure transducer system was sent to an oscilloscope that was controlled by a computer running specialized motor tracking software called Tracker (Vercher, 1994a). Increasing and decreasing the squeezing pressure on the hand bulb caused a response signal to move up and down, respectively, on the oscilloscope display. The participants were required to track a horizontal band that was moving up and down at a consistent 0.2 Hz rate on the oscilloscopic display. The amplitude range of this sinusoidal target signal was 25 mmHg (approximately 10% of maximum grip strength). Tracking error scores were obtained via specialized tracking analysis software, called Sigma (Vercher, 1994b), that measured the absolute difference between the target and response signals at each point in time and averaged the difference values over the tracking trial. A series of two-factor repeated measures ANOVAs (group versus tracking) were used to examine the tracking error scores of the PD and control participants during each of the experimental conditions.

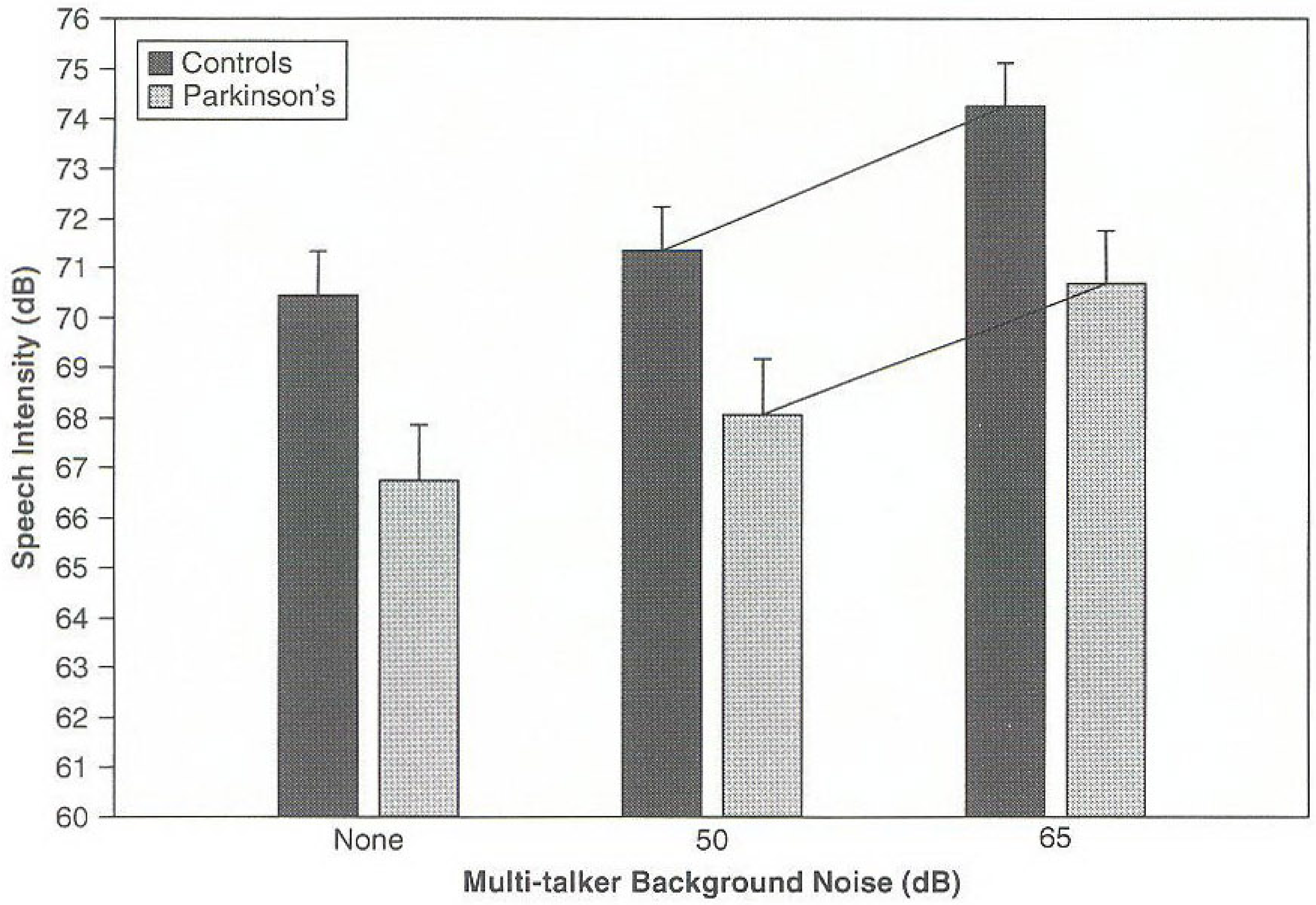

Figure 1. Effect of Multi-Talker Noise on Conversational Speech Intensity in Parkinson's Disease and Control Groups

RESULTS

The speech intensity of the participants with PD was significantly less (3–4 dB) than that of the control participants across all conditions of the study [$F(1, 21) = 6.14, p = .02$]. As the multi-talker background noise increased, there was a significant increase in speech intensity in the PD and control participants (see Figure 1) [$F(2,42) = 408.33, p < .01$]. Similarly, as the interlocutor distance increased there was a significant increase in speech intensity (Figure 2) [$F(1,21) = 98.62, p < .01$]. Across both the background noise and interlocutor distance conditions, the participants with PD showed changes in speech intensity that were reduced but parallel to those of the control participants. Both of the two-way interactions for group versus background noise [$F(2,42) = 1.15, p = .33$] and group versus interlocutor distance [$F(1,21) = 1.56, p = .23$] were not significant. This parallelism is illustrated by the parallel lines in Figures 1 and 2.

There was a significant interaction between background noise and interlocutor distance [$F(2,42) = 3.47, p < .05$]. This was reflected by the following: when background noise was increased there was a greater increase in speech intensity at the 1 meter interlocutor distance than was seen for the same increase in background noise at the 6 meter interlocutor distance. This pattern appeared to be the same in the control and PD groups (the three-way ANOVA involving the group by noise by distance interaction was not significant).

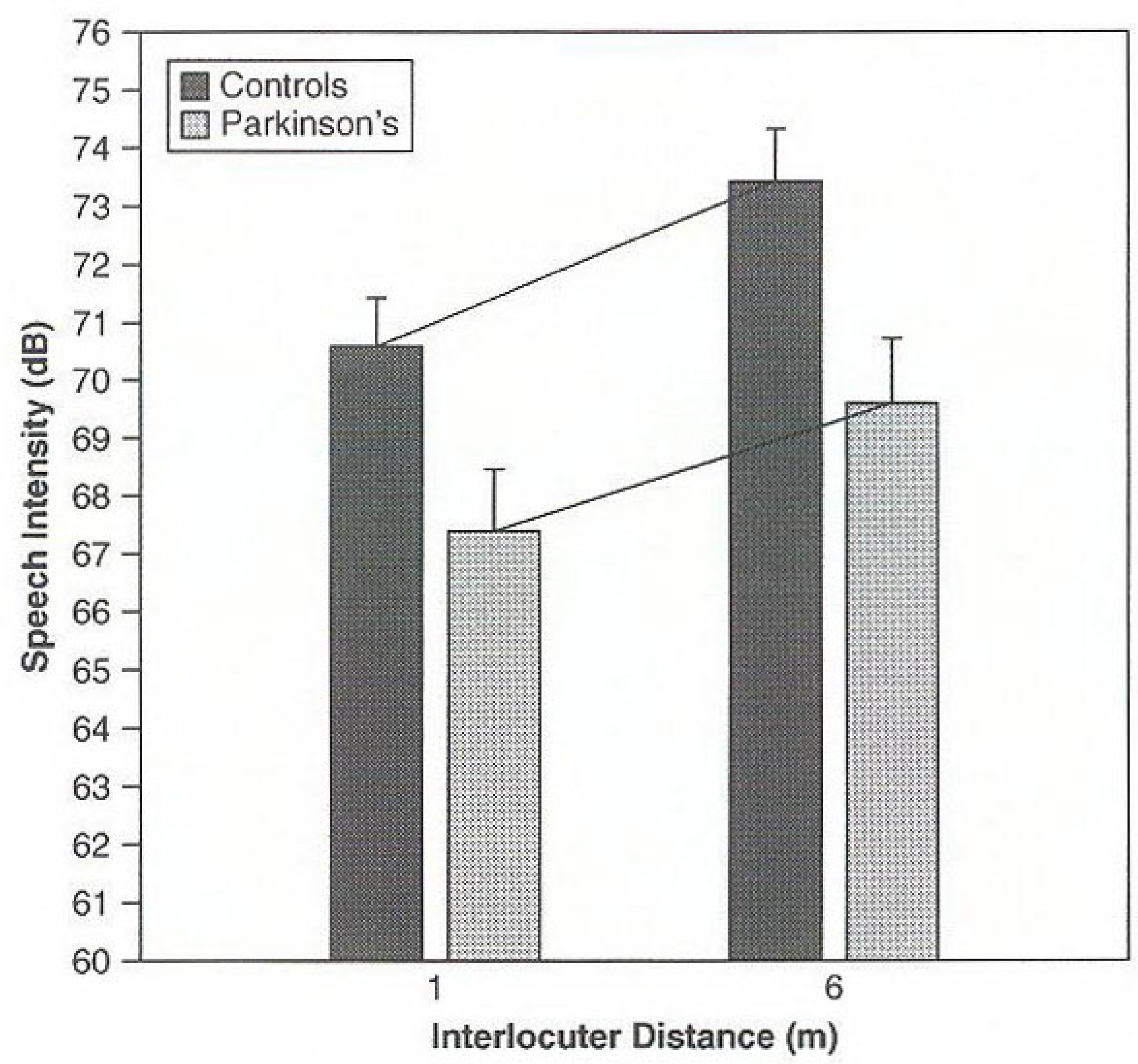

Figure 2. Effect of Interlocutor Distance on Conversational Speech Intensity in Parkinson's Disease and Control Groups

With regard to the concurrent tracking conditions, a different and apparently more complex pattern of results was observed. Significant three-way interactions were observed for the group versus noise versus tracking interaction [$F(2,42) = 3.12$, $p = .05$] and for the group versus distance versus tracking interaction [$F(1,21) = 4.20, p = .05$]. These interactions appeared to be primarily related to the differential effects of the tracking conditions on the control and participants with PD. In all of the experimental conditions, the control participants demonstrated a decrease in conversational speech intensity when they were engaged in the concurrent manual tracking task. In contrast, the participants with PD demonstrated an increase in conversational speech intensity when they were engaged in most of the concurrent manual tracking conditions (see Figure 3). This differential group effect was slightly more apparent during the 1 meter interlocutor context. Figure 4 shows how the concurrent manual task had the opposite effect on the speech intensity of controls versus participants with PD during each of the noise conditions. The related two-way interaction (group versus tracking) was significant [$F(1,21) = 6.48$, $p = .018$]. For several of the participants with PD, there was a very consistent enhancing effect of the concurrent manual tracking task in every background noise and interlocutor distance condition.

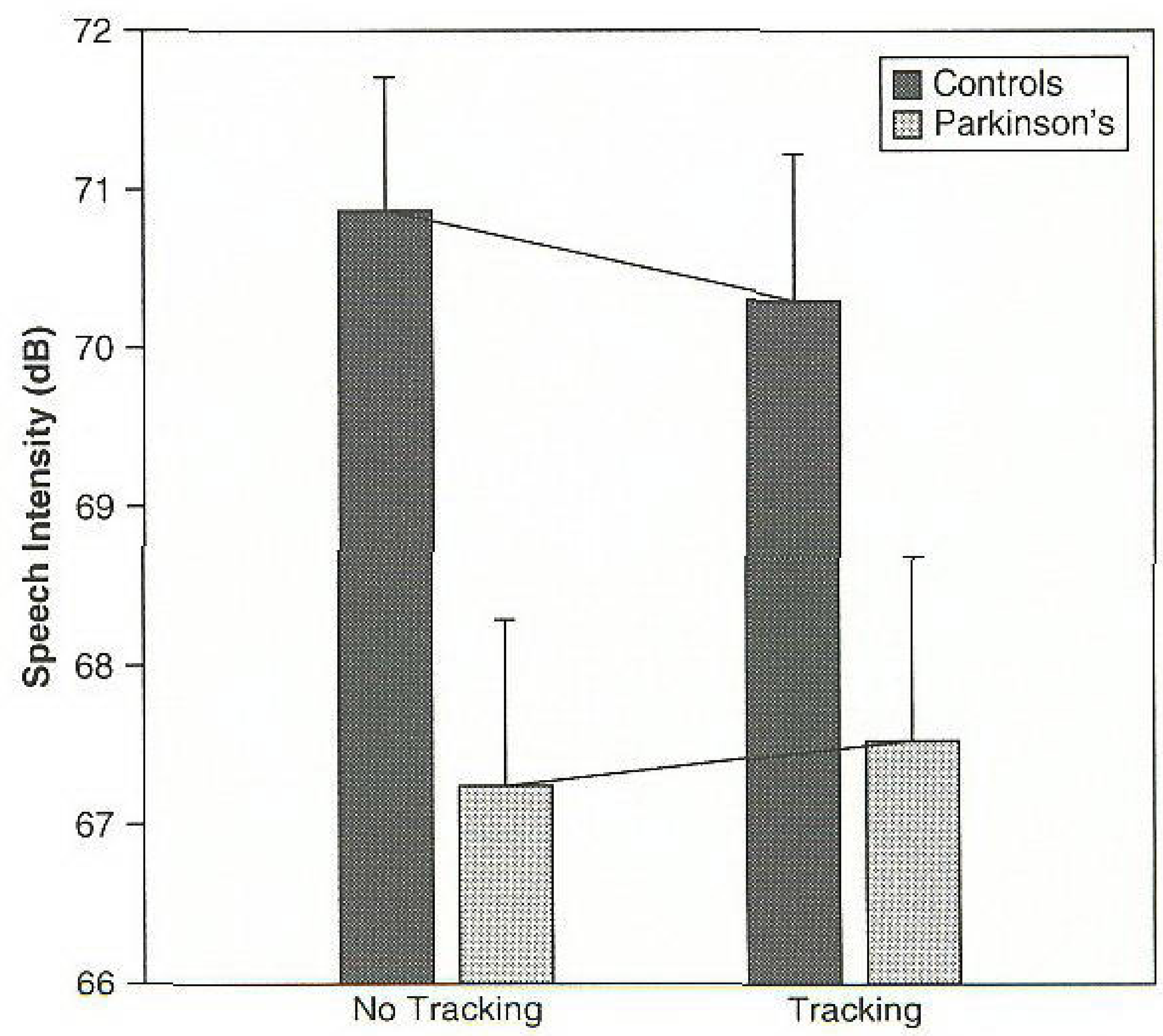

Figure 3. Effect of the Concurrent Manual Tracking Task on Conversational Speech Intensity at an Interlocutor Distance of 1 Meter for Control and Parkinson's Disease Groups

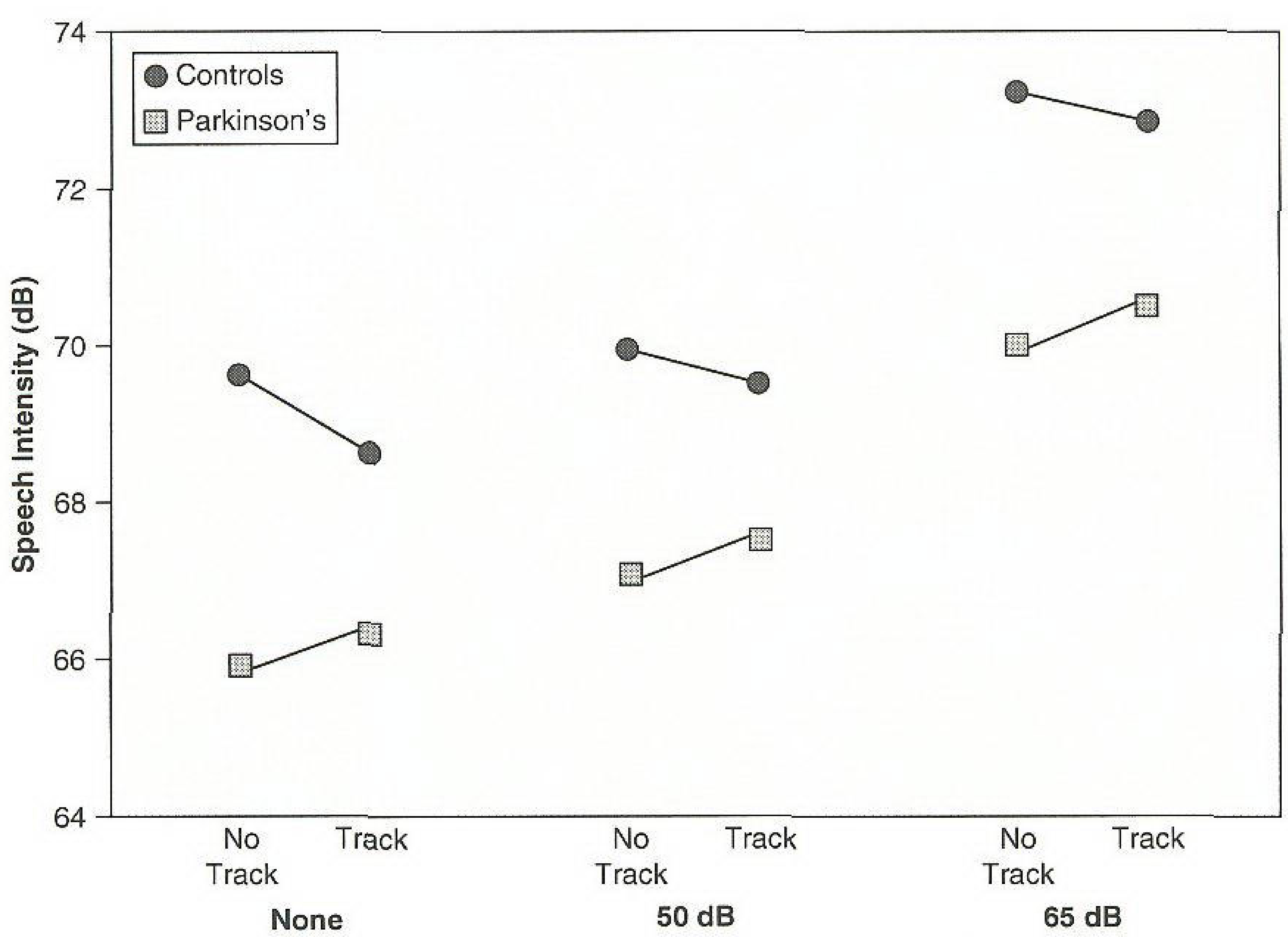

Figure 4. Effect of the Concurrent Manual Tracking Task on Conversational Speech Intensity at Each of the Background Noise Levels for the Control and Parkinson's Disease Groups

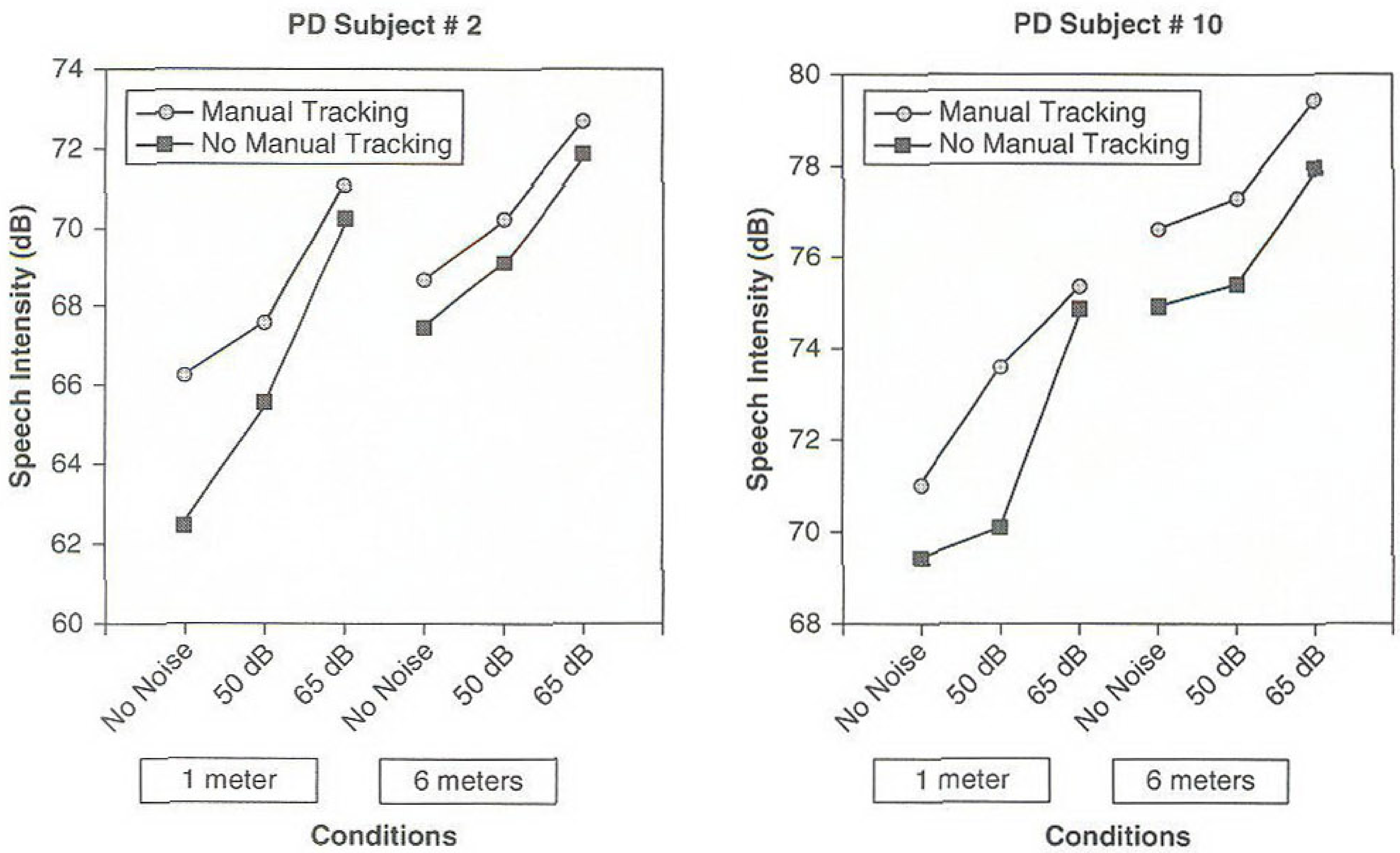

Figure 5. Effect of the Concurrent Manual Tracking Task on Conversational Speech Intensity of Two Parkinson's Disease Participants

Figure 5 shows this consistent enhancing effect in two participants with PD with mild (PD #10) and severe (PD #2) hypophonia.

With regard to the manual tracking performance, the control participants generally had significantly better manual tracking scores than the participants with PD [$F(1,21) = 6.85, p = .02$]. Changes in background noise and interlocutor distance did not have a significant effect on tracking performance (see Figure 6).

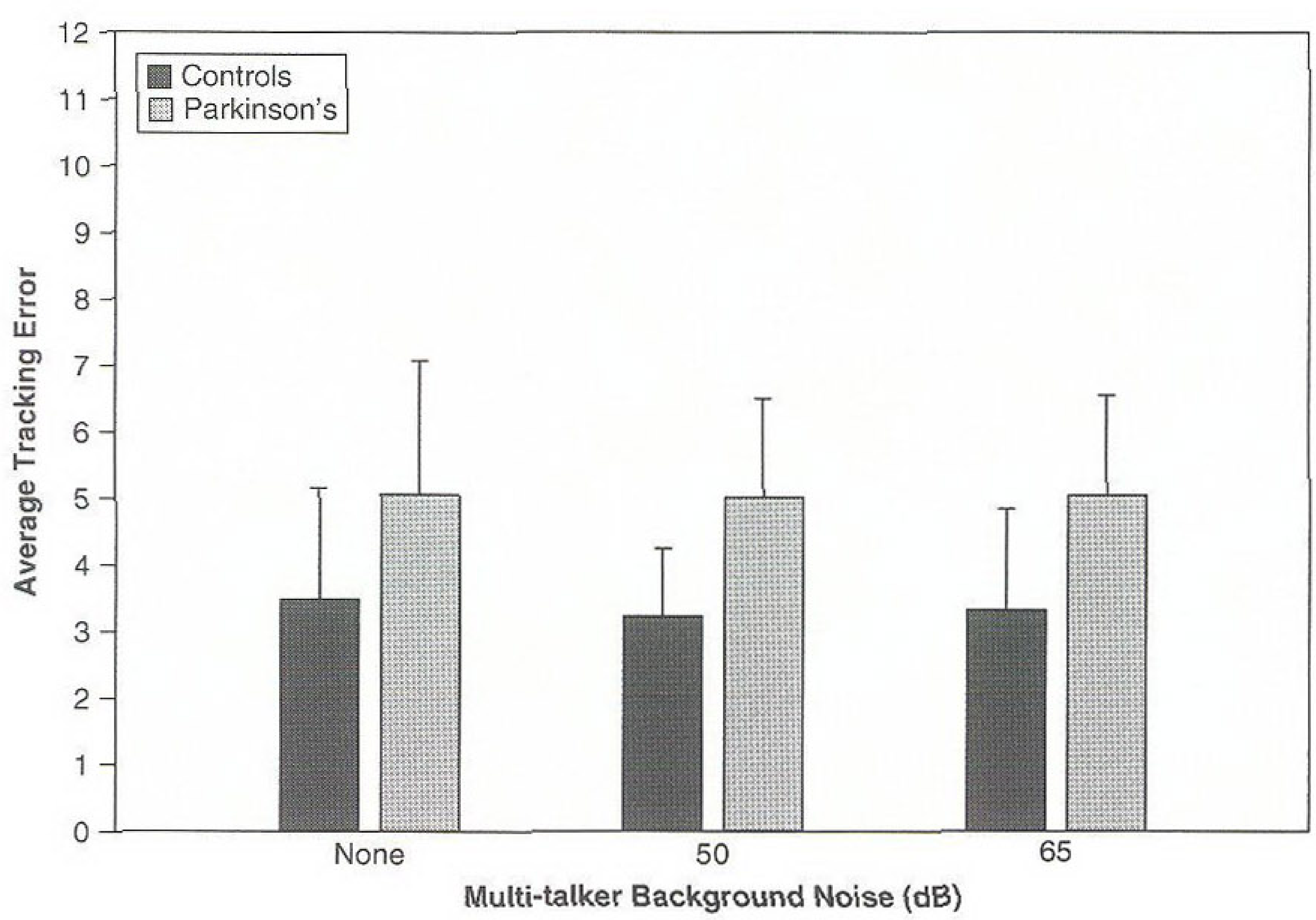

Figure 6. Effect of Background Noise on Average Manual Tracking Error Scores for Control and Parkinson's Disease Groups (tracking error units = mmHg)

DISCUSSION

Overall, it appears that changes in background noise and interlocutor distance (in isolation and combined) had similar effects on speech intensity modulation in the control and hypophonic participants with PD. These results replicate and extend previous reports on background noise and interlocutor distance in PD (Adams et al., 2006b; Adams et al., 2008; Ho et al., 1999a, 1999b). The results of this study indicate that changes in background noise and interlocutor distance are associated with fairly consistent changes in conversational speech intensity and that these effects are essentially parallel in control participants and Parkinson participants with hypophonia.

In contrast to the background noise and interlocutor distance effects, the manual concurrent task was associated with very different and nonparallel changes in conversational speech intensity in the PD and control participants. In particular, the concurrent tracking task consistently reduced the conversational speech intensity in the control participants, but it had an enhancing effect on the conversational speech intensity of the participants with PD. These results are inconsistent with a previous study by Ho et al. (2002), reporting that participants with PD showed a significant reduction in speech intensity when a concurrent manual tracking task was combined with a loud counting speech task. This inconsistency may be related to differences in the speech intensity levels that the participants with PD used in the two studies. Ho et al. (2002) had participants with PD use a "loud" speech intensity level (85 dB) that was dramatically higher than the highest average speech intensity (70 dB SPL) used by the participants with PD in the present study. Thus, it is possible that the enhancing effect of the concurrent manual task may only be present when participants with PD are using speech intensity levels that are close to typical or habitual conversational levels. At very high speech intensity levels, the enhancing effect of a concurrent manual task may disappear in participants with PD.

The results of the present study are more consistent with two previous studies involving concurrent manual tasks and speech tasks performed at comfortable or habitual levels of speech intensity (Dromey & Bates, 2005; Dromey & Shim, 2008). In one study, Dromey and Bates (2005) found that a concurrent manual task was associated with a 4 dB increase in the speech intensity of sentences spoken at typical conversational intensity levels by healthy control participants. These authors suggested that the increase in speech intensity seen during the concurrent manual task may have been the result of "an overall increase in effort" that was caused by the introduction of the concurrent task. Based on this suggestion, it is hypothesized that certain concurrent manual tasks may have an energizing effect on speech intensity. This novel energizing hypothesis is in dramatic contrast to traditional concurrent task hypotheses (i.e., reduced resource allocation or interference) that predict a decrement rather than an enhancement in motor performance following the introduction of a concurrent task. Further research is required to test this energizing hypothesis and determine the types of concurrent tasks that produce the greatest effects on speech intensity.

In the present study, the concurrent manual task was associated with an increase in speech intensity in the participants with PD but not the control participants. One possible explanation for these differences is that the relative difficulty of the manual tracking task may have been responsible for these differential enhancing effects. The manual tracking task was probably more challenging for the participants with PD than for the control participants. Based on our previous work with participants with PD using a similar manual tracking paradigm, we selected a target frequency (0.2 Hz) that we considered fairly easy and that we were confident could be performed by all of the participants with PD (Adams, Jog, Eadie, Dykstra, Gauthier, & Vercher, 2004). This relatively slow manual tracking task may not have been challenging enough to produce an enhancing or energizing effect on the speech intensity of the control subjects. It is suggested that future studies are required to systematically examine the effect of increasing concurrent manual task difficulty on enhancing conversational speech intensity in control and participants with PD.

In general, the results of the present study and the two previous studies by Dromey and colleagues (Dromey & Bates, 2005; Dromey & Shim, 2008) appear to provide preliminary support for an energizing effect of certain concurrent manual tasks on the speech intensity of PD and control participants. If this energizing hypothesis is confirmed and further defined it may be possible to consider incorporating the enhancing effects of selected concurrent manual tasks into treatment procedures for hypophonia in PD.

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REFERENCES

Adams, S. G., & Dykstra, A. D. (2009). Hypokinetic dysarthria. In M. R. McNeil (Ed). *Clinical management of sensorimotor speech disorders*, 2nd edition. New York: Thieme Publishers.

Adams, S. G., Dykstra, A., Abrams, K., Winnell, J., Jenkins, M., & Jog, M. (2006a). Conversational speech intensity under different noise conditions in hypophonia and Parkinson' disease. *Canadian Acoustics*, *34*, 96–97.

Adams, S. G., Moon, B., Dykstra, A., Abrams, K., Jenkins, M., & Jog, M. (2006b). Effects of multi-talker noise on conversational speech in Parkinson's disease. *Journal of Medical Speech-Language Pathology*, *14*, 221–228.

Adams, S. G., Jog, M., Eadie, T., Dykstra, A., Gauthier, G., & Vercher, J. J. (2004). Jaw and finger movements during visual and auditory motor tracking in Parkinson's disease. *Journal of Medical Speech-Language Pathology*, *11*, 215–222.

Adams, S. G., Dykstra, A. D., Jenkins, M., & Jog, M. (2008). Speech-to-noise levels and conversational intelligibility in hypophonia and Parkinson's disease. *Journal of Medical Speech Language Pathology*, *16*, 165–172.

Bloem, B. R., Valkenburg, V., Slabbekoorn, M., & van Dijk, J. G. (2001). The multiple tasks test: Strategies in Parkinson's disease. *Experimental Brain Research*, *137*, 478–486.

Boersma, P., & Weenink, D. (2008). PRAAT (version 5.0.20). *Institute of Phonetic Sciences*, University of Amsterdam, Spuistraat 210, 1012VT, Amsterdam, the Netherlands (http://www.fon.hum.uva.nl/praat/).

Dromey, C., & Bates, E. (2005). Speech interactions with linguistic, cognitive, and visuomotor tasks. *Journal of Speech, Language, and Hearing Research*, *48*, 295–305.

Dromey, C., & Shim, E. (2008). Effects of divided attention on speech motor, verbal fluency and manual task performance. *Journal of Speech, Language, and Hearing Research*, *51*, 1171–1182.

Duffy, J. R. (2005). *Motor speech disorders—Substrates, differential diagnosis, and management*, 2nd edition. Philadelphia: Elsevier Mosby.

Fox, C. M., & Ramig, L. O. (1997). Vocal sound pressure level and self-perception of speech and voice in men and women with idiopathic Parkinson's disease. *American Journal of Speech-Language Pathology*, *6*(2), 85–94.

Gentilucci, M. (2003). Grasp observation influences speech production. *European Journal of Neuroscience*, *17*, 179–184.

Ho, A. K., Bradshaw, J. L., Iansek, R., & Alfredson, R. (1999a). Speech volume regulation in Parkinson's disease: Effects of implicit cues and explicit instructions. *Neuropsychologia*, *37*, 1453–1460.

Ho, A. K., Iansek, R., & Bradshaw, J. L. (1999b). Regulation of parkinsonian speech volume: The effect of interlocuter distance. *Journal of Neurology, Neurosurgery and Psychiatry*, *67*, 199–202.

Ho, A. K., Iansek, R., & Bradshaw, J. L. (2002). The effect of a concurrent task on parkinsonian speech. *Journal of Clinical and Experimental Neuropsychology*, *24*(1), 36–47.

Hoehn, M., & Yahr, M. D. (1967). Parkinsonism: Onset, progression, and mortality. *Neurology*, *17*, 437–442.

Maitra, K. K. (2007). Enhancement of reaching performance via self-speech in people with Parkinson's disease. *Clinical Rehabilitation*, *21*, 418–424.

Marchese, R., Bove, M., & Abbruzzese, G. (2003). Effect of cognitive and motor tasks on postural stability in Parkinson's disease: A posturographic study. *Movement Disorders*, *18*(6), 652–658.

O'Shea, S., Morris, M. E., & Iansek, R. (2002). Dual task interference during gait in people with Parkinson disease: Effects of motor versus cognitive secondary tasks. *Physical Therapy*, *82*(9), 888–897.

Vercher J. L. (1994a). *Tracker software*. Marseille, France: Centre National de la Recherche Scientifique.

Vercher J. L. (1994b). *Sigma software*. Marseille, France: Centre National de la Recherche Scientifique.