Neural correlates of impaired temporal processing before initiation and inhibition of speech production and hand movement: Evidence from Parkinson's disease

Karim Johari[1], Priyantha Herath[2], Roozbeh Behroozmand[1]

[1]Speech Neuroscience Lab , Department of Communication Disorders, University of South Carolina, [2] Department of Neurology, University of South Carolina

Introduction

Background:

Parkinson disease (PD) is associated with degeneration of dopaminergic neurons in basal ganglia, which subsequently affects motor function in the human brain [1]. Research has shown that PD patients demonstrate longer reaction time (slower movement) for initiation and inhibition of motor responses in the hand modality [2,3].

This slower motor response time can be attributed to deficits in neural mechanisms underlying motor timing processing in PD. The PD patients have shown impairment at temporal estimation and discrimination tasks an also have shown difficulties in generation of self-paced time intervals during finger tapping tasks [4,5]. However, the neural and behavioral mechanisms of impaired temporal processing in PD are poorly understood. In addition, it is not determined whether such deficits in motor timing of hand movement in PD generalize to other modalities such speech production.

Objectives:

The present study was a systematic investigation toward understanding the effects of temporally-predictable stimuli on speech and hand movement reaction time and underlying neural mechanisms for temporal processing of movement initiation and inhibition in PD.

Our goal was to use objective measure of reaction time in response to temporally-predictable sensory cues to address the following questions:

1 – How does temporally predictable sensory stimuli affect temporal processing during initiation and inhibition of speech and hand movement in PD and unimpaired control subjects?

2- How does PD affect neural mechanism of temporal information processing for movement initiation and inhibition?

Methods

Subjects:

8 PD patients and 8 control subjects were enrolled in the present study. Patients an control subjects were matched on age, handedness, cognitive statue (MMSE) and education. PD patients were on dopaminergic medications with different dosage to alleviate their motor symptoms.

Procedure:

Event-related potentials (ERPs) were recorded while subjects were visually-cued to prepare to produce a steady vocalization of a vowel sound or press a button in a randomized order, and to initiate the cued movement following the onset of a go signal on the screen as well as stop ongoing movement after stop signal. The time interval between visual cue and go signal as well as between go and stope signal was temporally-predictable (see figure 1).

For each subject, measures of reaction time and also ERP analysis were computed for speech and hand movement initiation and inhibition.

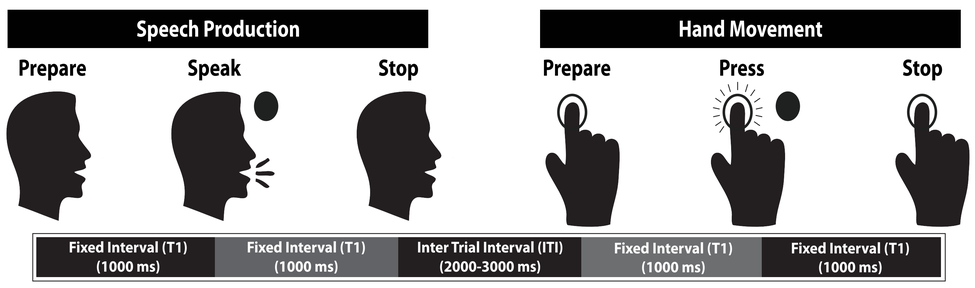

Figure 1. Experimental design.

Results

Behavioral results:

PD patients were significantly slower than control subjects during initiation and inhibition of speech (figure 2.A) and hand movement (figure 2.B).

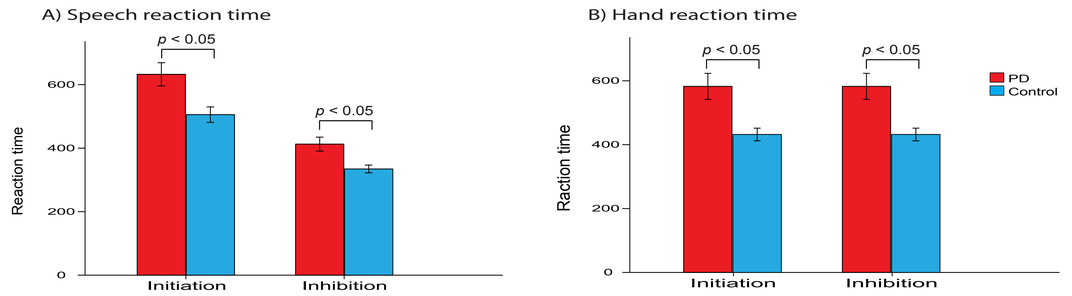

Figure 2. Behavioral response in response to temporally predictable stimuli during initiation and inhibition of speech and hand movement in both PD and control subjects.

ERP Reults:

ERP results showed suppression of ERP activates at the time window at -100 to 0 ms before movement initiation over the frontal and parietal electrodes for speech production and hand movement.

The topographical distribution maps of ERP activities are depicted for speech and hand movement initiation and inhibition in figures 3A and 4A, respectively.

PD patients showed significant suppression of ERP activities over the frontal electrodes for speech production (figure 3.B), and significant suppression over the parietal electrodes for hand movement (figure 4.B) at time the window at -100 to 0 ms before movement.

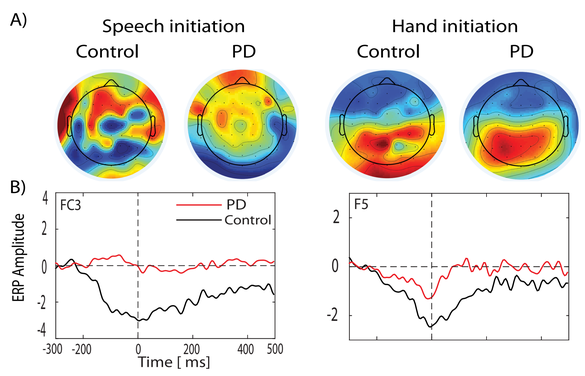

Figure 3. ERP reponse for movement initiation

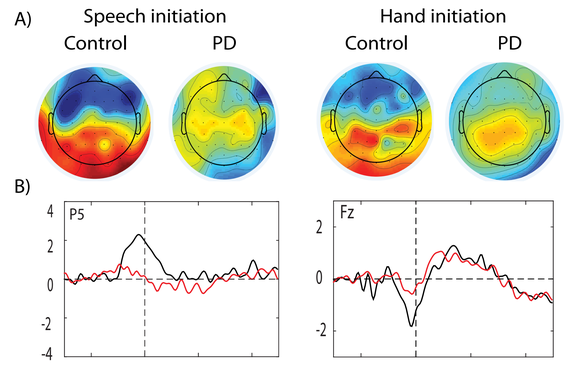

Figure 4. ERP reponse for movement inhibition

Discussion

Our findings indicate that PD patients suffer from deficits in neural mechanisms of motor timing processing that underlie movement initiation and inhibition in speech and hand modalities.

We suggest that the suppression of premotor neural activities, as indexed by reduced amplitude of ERP responses, is a neurophysiological biomarker of temporal processing impairment during speech production and hand movement in PD patients.

Slower motor reaction time and suppressed ERP activities in PD compared with control subjects is indicative of the important role of basal ganglia neural circuitry for temporal information processing during initiation and inhibition of movement production.

References

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