Neural correlates of impaired speech and hand motor timing processing in Parkinson’s disease

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Introduction

Background: Parkinson’s disease (PD) is a neurological disorder associated with the degeneration of dopaminergic neurons in the basal ganglia primarily affecting the motor system. Studies have shown that patients with PD exhibit slowness responses during a wide range of motor reaction time tasks (1-2), which is accounted for by their abnormal temporal processing during the planning phase of movement compared to neurologically intact control subjects (3-4). In addition, PD patients show deficits in tasks involving temporal judgment and generate shorter timing intervals in self-paced tapping tasks (5).

The previous findings support the notion that temporal processing mechanisms of movement are compromised in PD due to dysfunctional frontostriatal circuits. Electrophysiological studies have found desynchronization of neural activities within the Beta band (15-30 Hz) as a neural signature of impaired temporal processing in PD during the planning phase of limb movement (6). However, our understanding about how PD may affect motor timing during speech remains relatively unclear.

Objectives:

In the present study, we conducted a systematic investigation to examine the neural and behavioral correlates of motor timing deficits during the planning phase of speech and hand movement in mild to moderate non-demented PD patients compared with neurologically intact healthy matched control subjects.

Methods

Experimental task: The experiment consisted of two random-order tasks of speech production and hand movement. Subjects prepared to perform one of the motor tasks following the onset of a relevant visual cue on the screen (Fig. 1). During each task, subjects were instructed to prepare for the cued movement and start vocalizing the speech vowel /a/ or pressing a button after a circle (GO signal) appeared on the screen. We designed two counterbalanced blocks within which the subjects performed the tasks in response to temporally predictable and unpredictable stimuli.

ERP responses: The topographical distribution maps of ERP activities are illustrated for PD vs. Controls during predictable and unpredictable conditions for speech production (Fig. 2A) and hand movement (Fig. 2C). The global field power analysis revealed that premotor neural activities over the frontal and parietal areas were significantly attenuated in PDs vs. controls for speech production (Fig. 2B) and hand movement (Fig. 2D) regardless of stimulus timing.

Results

Behavioral responses: Results revealed that PD Patients were slower than control subjects for both speech and hand movement regardless of stimulus timing.

ERP responses: The topographical distribution maps of ERP activities are illustrated for PD vs. Controls during predictable and unpredictable conditions for speech production (Fig. 2A) and hand movement (Fig. 2C). The global field power analysis revealed that premotor neural activities over the frontal and parietal areas were significantly attenuated in PDs vs. controls for speech production (Fig. 2B) and hand movement (Fig. 2D) regardless of stimulus timing.

Discussion

PD patients were significantly slower than control subjects for initiating speech production and hand movement regardless of stimulus timing.

Our findings showed that pre-movement ERPs activities were diminished in PD patients compared with healthy control subjects. In addition, correlation results showed that the increase in the pre-movement ERPs was associated with faster motor reaction time in PD, but not control subjects.

Source estimation findings linked the motor timing deficits in PD to the decrease in neural activities within the right inferior frontal gyrus (IFG) for speech and the right precentral gyr for hand movement. Based on these findings, we propose that pathological attenuation of pre-movement ERPs within the right inferior frontal and precentral gyr areas is a neural biomarkers of impaired motor timing processing in PD during speech and hand movement.

References