

Brain activation of Parkinson's patients during a delayed cued finger movement task – a preliminary study

J.-H. Lee^{1,2}, D. M. Henkel¹, J. M. Storrs¹, J. C. Eliassen^{2,3}, W.-J. Chu^{2,3}, N. Burton⁴, and A. J. Espay⁴

¹Biomedical Engineering, University of Cincinnati, Cincinnati, OH, United States, ²Center for Imaging Research, University of Cincinnati, Cincinnati, OH, United States, ³Psychiatry, University of Cincinnati, Cincinnati, OH, United States, ⁴Neurology, University of Cincinnati, Cincinnati, OH, United States

Introduction: It has been shown through EEG measurements that in the early stages of Parkinson's disease (PD) impaired motor preparation relates to a decrease in the latency of mu rhythm event-related desynchronization (ERD) when compared with control subjects, suggesting hypo activation of the primary sensorimotor (PSM) cortex [1]. In this study, we investigate the motor preparation impairment in PD patients using fMRI measurement with a delayed cued finger movement paradigm. The results not only confirm hypoactivation of PSM but also demonstrate that hypoactivation also appears in others area such as premotor, putamen, and thalamus in PD patients.

Methods: Three unmedicated early-stage Parkinson's patients and two age- and gender-matched healthy controls were consented and participated in this study. During fMRI scans, subjects laid supine on the scanner bed. Non-ferromagnetic goggles were positioned to provide clear visualization of the stimuli and a radio-frequency (RF) coil was placed over the subject's head. Padding was then placed around the subject's head to minimize movement and headphones were provided to block background noise and to allow investigators to communicate with subjects during scans. The paradigm used was the delayed cued finger movement task introduced by Richter and his co-workers [2]. The presentation time and preparation times were set to 2 and 10 seconds, respectively. Each movement trial lasted about 30 seconds and the task was repeated 17 times; therefore, the total fMRI run time was about 8.5 minutes.

MRI scans were carried out with a 4 T whole body imaging system (Varian, Palo Alto, CA). Following a scout image, the shim procedure FASTMAP was performed to generate a homogeneous magnetic field. Then, a high-resolution, T1-weighted, 3-D brain scan was obtained using an MDEFT sequence ($T_{MD}=1.1$ s, $TR=13$ ms, $TE=6$ ms, $FOV=25.6 \times 19.2 \times 19.2$ cm, matrix $256 \times 192 \times 96$ pixels, flip angle=20 degrees) in order to provide anatomical localization for activation maps. Thirty-five contiguous 4 mm coronal slices that cover the entire brain were obtained while subjects completed an fMRI session, where they perform the finger movement task, in which images are acquired using a T2*-weighted gradient-echo EPI pulse sequence ($TR/TE=2000/30$ ms, $FOV=25.6 \times 25.6$ cm, matrix 64×64 pixels, slice-thickness=4 mm, flip angle=75°). FMRI data was analyzed in the AFNI software package with deconvolution using a set of basis functions consisting of three sine waves used to model the entire 30 sec trial. Thus, both preparation and execution events were modeled as a continuous event to generate brain activation maps (threshold at $p \leq 0.001$). The average single-trial time series (converted to percentage change) of 17 trials in one scan was calculated from the activated pixels for several brain regions of interest, which include the left and right primary motor, PSM, supplementary motor area (SMA), putamen, internal pallidum, thalamus, cerebellum and etc.

Results: Figure 1 shows the comparison of brain activations between PD patients and healthy controls for several brain areas. From left to right, panels show the percentage of fMRI signal changes (i.e. hemodynamic responses) for, PSM, premotor, SMA, putamen, thalamus, and cerebellum. The red and blue lines represent the average hemodynamic responses of PD patients ($n=3$) and healthy controls ($n=2$), respectively. This study confirms the study by Ohara et al. [1] of hypoactivation in PSM during motor preparation in PD patients. This study also agrees with that of Richter et al. [2] that premotor and SMA activate during motor preparation in healthy controls. We also found that many brain regions, including non motor brain areas, also activate including putamen, caudate, palladium, thalamus, insula, and fusiform gyrus. In general, there were no significant differences in hemodynamic responses during motor executions between patients with PD and healthy controls for any brain region. However, there are significant differences in several brain regions during motor preparations including premotor, thalamus, putamen, and cerebellum.

Discussion: This study confirms the finding of a previous study that there is hypoactivation in PSM in patients with PD. This study, although providing less temporal resolution, agrees with earlier work showing that premotor and SMA are involved with motor preparation. Additionally, we also found other brain regions involved in motor preparation that were not reported previously due to minimal coverage of the scan in their study. The results suggest no significant differences between PD and healthy control in motor execution activation in any region. However, PSM, putamen, thalamus, and cerebellum show significant differences during motor preparation. We have demonstrated that the delayed cued finger movement paradigm can be used to effectively study motor preparation deficits in patients with PD, which may provide a potential imaging biomarker for PD.

References: 1) S Ohara, et al. Brain 2000; 123:1203-15. 2) W Richter, et al. Neuroreport. 1997; 8: 1257-61.

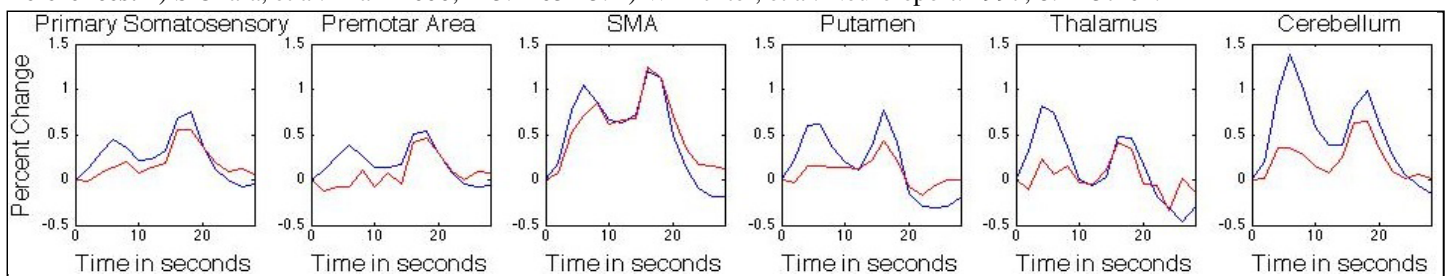


Fig 1. Comparison of brain activation between Parkinson's patients and healthy controls on a delayed cured finger movement task.