

The Effect of Deep Brain Stimulation on the Pallido-Cortical Coherency Pattern of Parkinson's Disease

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Introduction: The mechanism of deep brain stimulation (DBS) through Globus pallidus (GPi), used for the neurotherapy of Parkinson's disease (PD), is still not well understood [1-2]. In this study we investigated the pallido-cortical neuronal coupling during DBS while PD patients were at rest. The preliminary analysis shows reduction in the beta band activity during DBS-ON relative to DBS-OFF state. Better understanding of brain neural function during stimulation, can not only point the way towards better medications for PD but can also act as a biomarker to facilitate the development of a closed loop neuromodulation BCI system.

Material, Methods and Results: Three PD patients underwent DBS surgery targeting the GPi with simultaneous insertion of an eight contact ECoG strip covering the frontal and parietal cortices. Simultaneous local field potential (LFP) recordings were also obtained from four leads implanted in the right GPi. The data have been recorded and amplified (g.tec Medical g.USBamp) with the sampling rate of 2400 Hz and high pass filter of 0.1 Hz [3]. Concomitant kinematic data were also recorded using a glove (5DT DataGlove, Mumbai, India) that was worn on the hand contralateral to the DBS lead and oversampled at 2400 Hz using BCI2000 software. Rest periods were detected using automated electromyography (EMG) envelope detection and analysis was conducted over this period with the therapeutic stimulation parameters set at 1V and 185 Hz. Using a zero phase FIR filter [2-200 Hz] data were bandpass filtered and the line noise was removed with a notch filter. For a better spatial resolution and in order to reduce the stimulation artifact, bipolar configuration of two leads located on the motor and pre-motor cortex was used for further analysis. To investigate the pallido-cortical connectivity pattern for each patient at each condition, eight non-overlapping blocks of two seconds were used to calculate the coherency between sensorimotor and pallidal signals at each frequency using one second sliding window with 50% overlap. The average coherence was computed over four frequency bands of alpha (8-12 Hz), beta (13-35 Hz), low gamma (36-80 Hz) and high gamma (81-150 Hz). Non-parametric Wilcoxon signed rank statistical test was applied to show how significant the DBS-ON state can affect the pallido-cortical coherency pattern during rest at different frequency bands. The results showed that there is a significant ($p < 0.05$) pallido-cortical coherence reduction during DBS in the beta band while there were no considerable coherence changes in the gamma bands (Fig. 1).

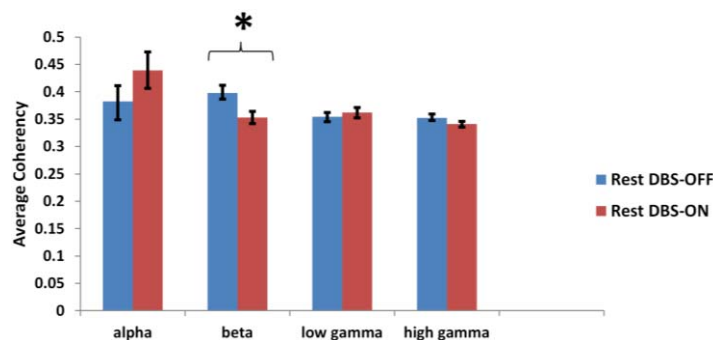


Figure 1. Mean and standard errors for two different states of DBS-ON and DBS-OFF over four different frequency bands. Significant differences ($p < 0.05$) have been shown with a star (*).

Discussion: Our preliminary analysis suggests a significant pallido-cortical coherency reduction in the beta frequency band during DBS-ON. This finding can be attributed to the inhibitory nature of DBS on cortico-subcortical synchronous activity associated in beta oscillations. Further investigation is required with more PD patients using the same protocol to increase the power of analysis.

Significance: The outcomes of this study will contribute to better understanding of DBS mechanism on pallido-cortical synchrony changes and may suggest strategies for the development of more sophisticated therapeutic procedures in PD.

References

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