Opening Eyes Increases High Beta Activity in Human Subthalamic Nucleus Local Field Potentials

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Learning Objectives

- To emphasize the importance of defined resting states when recording LFPs in the STN so that neuronal oscillations may be compared between studies.
- To compare differences in eyes open or closed in the STN with other brain nuclei in human patients.
- To discuss how changes in eye open or closed state may effect the development of closed loop DBS systems as well as activity dependent changes in brain activation.

Introduction

Abnormal beta oscillations (13-30Hz) in the basal ganglia govern motor symptoms of Parkinson's disease (PD), and studies have shown movement, dopaminergic medication and deep brain stimulation (DBS) can reduce these oscillations in the subthalamic nucleus (STN). Local field potentials (LFPs), used to evaluate neural population activity, are promising for the development of activity dependent neurological tools and closed loop DBS systems, however the impact of routine physiological behavior changes remains unclear. We examine the effects of eye opening on LFP activity in the STN.

Methods

Intraoperative LFPs were recorded in 10 PD patients undergoing STN DBS surgery. Four 25s blocks were obtained in the STN with eyes open, closed, open with movement, and closed with movement. Post-operatively, spectrograms were made and power spectral density (PSD) analysis was performed on alpha (8-12Hz), low-beta (13–20Hz) and high-beta (21–29Hz).

Results

High-beta activity increased with eyes open. Furthermore, alpha activity increased with movement in this state. When eyes were closed, passive movement increased beta and alpha activity (Figure 2). Low-beta bands were higher in the left STN than the right when the eyes were open or closed with movement. Additionally, LFPs from the STN were compared with those in the globus pallidus interna (GPi) from dystonia and PD patients (n=5) and to LFPs in the ventralis intermedius of the thalamus (VIM) in essential tremor patients (n=7). Similar differences were not found in GPi or VIM (p>0.05). Positioning of the electrode in the STN, handedness and side of worse symptoms did not play a significant role.

Figure 1

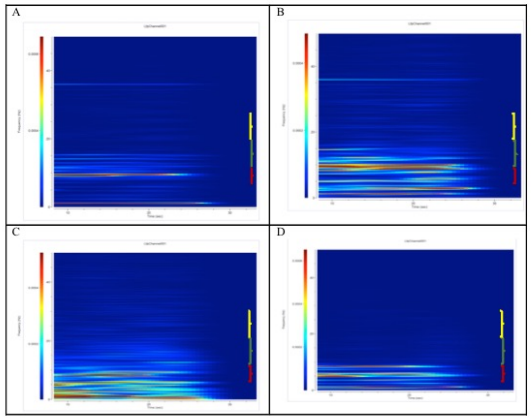
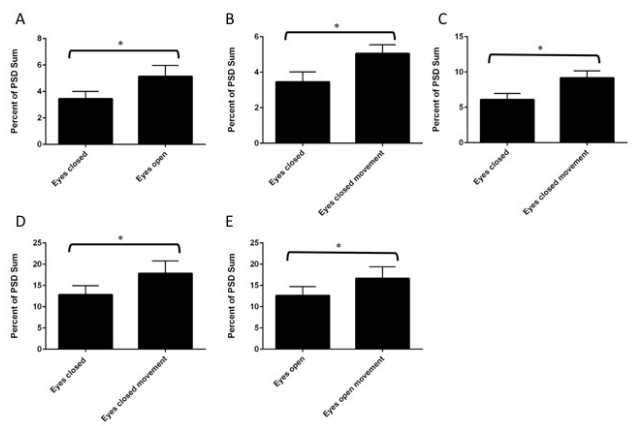


Figure 1. Spectrograms of a single patient's LFP complete recordings. The red bracket highlights the alpha range (0.8Hz – 12Hz); the green bracket the low beta range (13 – 20 Hz); and the yellow bracket the high beta range (21 – 29 Hz). A) Eyes closed B) Eye open C) Eyes closed with movement D) Eyes open with movement.

Figure 2. A) High beta activity increases when eyes are open (p=0.001). B) High beta increases with movement in the eyes closed state (p=0.032). C) Low beta activity increases with movement in eyes closed state (p=0.009). D) alpha activity increases with movement in eyes closed state. E) Alpha activity increases with movement in eyes open state (p=0.034).

Figure 2



Conclusions

Our results highlight differences in STN LFPs during two resting states: eyes open or closed. Understanding changes in brain activity is essential for our development of closed loop systems and interpretation of resting state data.

References

1. Brown P. Abnormal oscillatory synchronization in the motor system leads to impaired movement. Curr Opin Neurobiol 2007;17:656-664.

2. Marx E, et al. Eyes open and eyes closed as rest conditions: impact on brain activation patterns. Neuroimage 2004;21:1818-1824.

3. Little S, Brown P. The Functional role of beta oscillations in Parkinson's disease. Parkinsonism and Related Disorders 2014;S44-S48.

4. Hosain MK, Kouzani A, Tye S. Closed Loop Deep Brain Stimulation: an evolving technology. Australas Phys Eng Sci Med 2014 published online DOI 10.1007/s13246-014-0297-2.

5. Priori A, Foffani G, Rossi L, Marceglia S. Adaptive deep brain stimulation (aDBS) controlled by local field potential oscillations. Experimental Neurology 2013;245:77-86.