Contrasting Low and High Beta Functional Connectivity Dynamics Between Globus Pallidus Internus and Sensorimotor Cortices During Ipsilateral and Contralateral Movement Behavior

Nicholas Au Yong MD PhD; Mahsa Malekmohammadi PhD; Andrew E Hudson MD, PhD; Nader Pouratian MD PhD

Department of Neurosurgery, Department of Anesthesia

David Geffen School of Medicine at UCLA, Los Angeles California

CNS 2017 ANNUAL MEETING BOSTON, MASSACHUSETTS OCTOBER 7–11, 2017

Introduction

Oscillation models of Parkinson's Disease (PD) have suggested that pathological beta oscillations are driven from the sensorimotor cortices to the basal ganglia, inducing an akinetic state. There exists some evidence that low beta (13-20 Hz) and high beta (20-35 Hz) oscillations are functionally distinct. In this study, low and high beta functional connectivity between the globus pallidus internus (GPi) and sensorimotor cortices were examined in PD subjects during both ipsilateral and contralateral movement to further clarify the roles of these oscillations in movement and disease state.

Methods

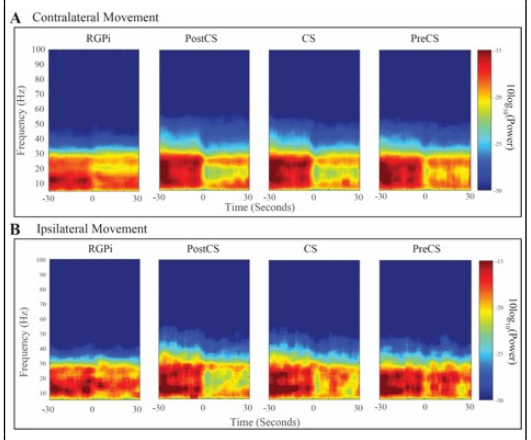
Cuncurrent local field potentials were recorded from a deep brain stimulation electrode within the right GPi and an electrocorticographic (ECoG) strip over the right sensorimotor cortices in 17 PD subjects. Contralateral (Left) hand activity was captured concurrently via a sensor-embedded glove. In a subset of 4 subjects, the experiment was repeated for ipsilateral hand movement.

Three-dimensional reconstruction of cortical surface anatomy was performed using pre-and post-operative CT scans registered to pre-operative high resolution T1-weighted brain structural MRI. Bipolar re-referencing of ECoG signals was accomplished by subtracting the adjacent anterior contact waveform at each cortical site. Bipolar signals over the post-central gyrus (Post-CS), central sulcus (CS), and pre-central

Low and high beta oscillatory power were compared between contralateral and ipsilateral movement trials. Low and high beta cortical-GPi imaginary coherence (icoh), a metric of functional connectivity, was also calculated and compared.

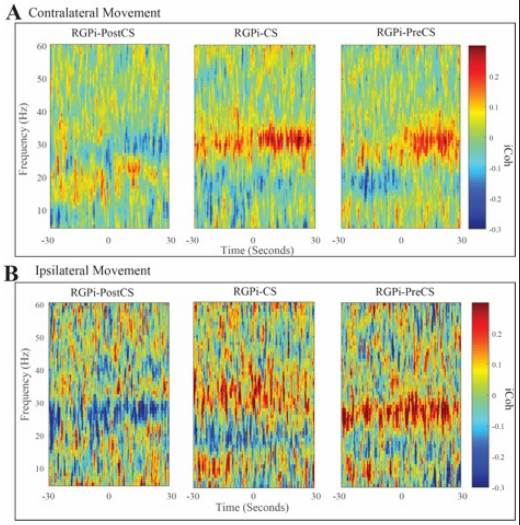
Results

Average Spectrogram during Contralateral and Ipsilateral Movement Trials



(A, top panels) Average spectrogram of right GPi LFPs and right sensorimotor ECoG recordings at the post-CS, CS, and pre-CS contacts, during rest (-30 sec to 0 sec) and contralateral movement (0 sec to 30 sec), aligned to the initiation of contralateral movement at 0 seconds. Attenuation of alpha (8-12 Hz), low beta (13-20 Hz) and high beta (21-35 Hz) occurs at all sites with contralateral movement. (B, bottom-panels) Similar alpha, beta and high beta attenuation is seen with ipsilateral movement.

Average Imaginary Coherogram during Contralateral and Ipsilateral Movement Trials



(A, Top panels) Average imaginary corticopallidal coherogram (RGPi-postCS, RGPi-CS, and RGPi-preCS) during rest (-30 to 0 sec) and contralateral movement (0 to 30 sec), aligned to the initiation of contralateral movement at 0 seconds. Positive values indicate a phase lead between the cortical oscillations and pallidal oscillations whereas negative values indicates pallidal oscillations leading cortical oscillations. (B, Bottom panels) Average imaginary corticopallidal coherogram for ipsilateral movement trials.

Results

Highly similar patterns of low and high beta desynchronization (i.e. oscillatory power) were observed within the GPi and sensorimotor cortices with both ipsilateral and contralateral movement. Contralateral and ipsilateral movement trials, however exhibited different low and high beta cortical-GPi connectivity profiles. During contralateral movement, there pronounced increase in high beta icoh from motor and premotor cortices to the GPi. Elevated low beta icoh from GPi to motor and premotor cortices during rest also decreased with movement. During ipsilateral movement trials, both high beta coh and icoh persisted throughout rest and movement with little variation. No clear modulation of low beta coh and icoh was observed.

Conclusions

1. Low and high beta oscilatory power are largely symmetrical between contralateral and ipsilateral movement conditions.

2. Low and high beta oscillations exhibit distinct cortical-GPi connectivity profiles during movement behavior indicative of separate functional roles.

3. Cortical-GPi functional connectivty metrics is a more specific biomarker of movement behavior.

Learning Objectives

Low and high beta oscillations exhibit distinct cortical-GPi connectivity