# Movement-related Dynamics of Beta Band Causal Interactions Between STN and Sensorimotor Cortex Revealed Through Intraoperative Recordings in Parkinson's Disease

Ahmad Alhourani MD; Anna Korzeniewska PhD; Thomas A Wozny BS; Efstathios Kondylis; Witold J Lipski BS, PhD; Donald Crammond; R. Mark Richardson MD, PhD

## Introduction

Beta oscillations play an important role in gating movement. Because pathological oscillatory changes in the beta band represent a hallmark of Parkinson's disease (PD), tracking oscillatory changes in this band has been proposed as a marker for closed loop stimulation. However, the dynamics of casual influences across the motor circuit during movement remain unknown. Using intracranial local field potential (LFP) recordings, we employed both standard functional connectivity and Event-Related Causality (ERC) techniques to explore these interactions.

## Methods

LFPs were recorded simultaneously from subthalamic nucleus (STN) and sensorimotor cortex while PD subjects (n=8) undergoing the implantation of DBS leads performed an incentivized, bimanual handgrip task. Using the beta frequency band between 13-30 Hz, functional connectivity was estimated using wavelet-based phase locking values (PLV), and ERC was calculated by constructing a multivariate autoregressive model based on the signal of interest from M1, S1 and STN channels. A false discovery rate correction of 5% was applied.

## Results

All the patients showed significant causal interactions between STN and sensorimotor cortex that coincided with movement epochs showing significant PLV on the individual level. In the 200 ms prior to movement, precentral beta activity modulated beta activity in the STN, implying that cortical beta activity drives the STN beta activity in that epoch. Reciprocal modulations between the cortex and STN were apparent at the termination of movement. Causal influences from the precentral cortex to the STN in the beta band around 0.5ms after movement onset correlated significantly with the time to peak force (rho=0.86, corrected $p<0.0028$).

## Conclusions

The directionality of causal interactions across the basal ganglia-cortical motor loop are specific to The directionality of causal interactions across the basal ganglia-cortical motor loop are specific to different phases of motor planning and execution. These novel data highlight the value of intraoperative recordings for furthering our understanding of cortical-basal ganglia models.

## Learning Objectives

By the end of this session, participants should be able to: 1) Describe the current understanding of connectivity across the cortico-basal ganglia circuit, 2) Describe the importance of novel techniques in acquiring and analyzing neural data on understanding the neurobiology of disease, 3) Discuss the utility of connectivity measure as biomarkers for closed loop stimulation.