Spatio-temporal Neuronal Dynamics in Subthalamic Nucleus and Cortex in Patients with Parkinson's Disease

Vadim Nikulin
Charité - University Medicine
Berlin, Germany

***Abstract*— Parkinson's disease (PD) is characterized by widespread neural interactions in cortico-basal-ganglia networks primarily in beta oscillations (approx. 10-30 Hz). Previous research on this topic has been primarily based on the analysis of the amplitude changes of these oscillations. Our approach, however, takes into account complex spatio-temporal neuronal dynamics in subthalamic nucleus (STN) and cortex in patients with PD. We quantify sequential neuronal activity with Long-Range Temporal Correlations (LRTCs) in the amplitude dynamics of neuronal oscillations. LRTCs indicate that the brain operates at a metastable state, which was theoretically shown to be beneficial for the optimal brain processing. We demonstrated that although LRTCs were present in STN they were considerably weaker in OFF compared to ON-levodopa state thus indicating that LRTCs can serve as a potential biomarker of pathological neuronal processes in PD. Furthermore, using measures insensitive to volume conduction, we showed intricate patterns of connectivity both within and between STN nuclei in patients with PD, these patterns being modulated by levodopa and correlated with the clinical scores. Finally, we even showed that alpha-frequency LRTCs in the cortex correlated with beta-frequency intra-STN connectivity, thus providing an evidence for multiscale interactions between the two most dominant rhythms in basal ganglia and cortex. We suggest that the investigation of multiscale interactions might contribute to our understanding of cortical-subcortical neural coupling in PD.**

Keywords*— *Parkinson's disease, oscillations, complexity, connectivity, LFP