Differences in Cortical Oscillations During Self-initiated Movement Between Parkinson's Disease and Essential Tremor

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Introduction

Patients with **Parkinson disease (PD)** express difficulty in **self-initiating (SI) movements** (Jahanshahi et al., 1995). These are primarily associated with the **rigidity and bradykinesia**, and have been linked to the **beta (13-35 Hz) hypersynchrony within the basal ganglia thalamocortical (BGTC) network** (Hallett, 2011;Brown, 2007). While previous studies provided important insight, dynamics of cortical activity during the SI movement and how they are related to the disease symptoms remain relatively underexplored. Here, we explore the **dynamics of movement-related BG-cortical oscillatory activity** in subjects with **PD, compared to essential tremor (ET)** without any dysfunction in movement initiating.

Methods

Patients: 13 PD and 10 ET patients (DBS lead implantation)
Local field potentials (LFPs) recording: 8-channel ECoG strip on contralateral motor cortex (for 13 PD and 10 ET) and 4-channel DBS lead in globus pallidus (bilateral: 10 PD, left: 1 PD, right: 1 PD)
Movement task: SI and externally cued (EC) finger tapping (up to 20 blocks for SI movement, 3-5 blocks for EC movement)
LFP analyses: Event-related spectral perturbation (ERSP) using Hilbert-filtering method (Voytek et al., 2013) and coherence (from -2 to 1 sec relative to movement onset)

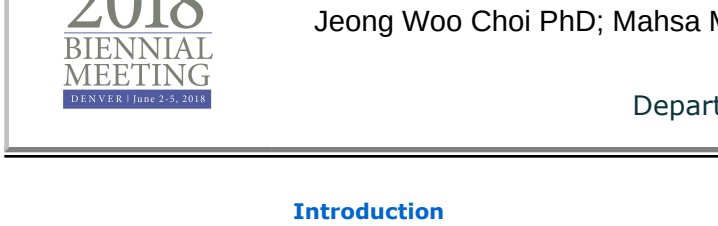

Fig. 1. (A) Tips of stereotactic frame ('+') and DBS leads (red/blue solid lines) as landmark for the fusion of fluoroscopic image and cortical surface. Cortical contacts are marked manually on the fused images (red dots). (B) Marked ECoG contacts on the cortical surface relative to central sulcus and bipolar contact pairs on M1/PM and S1. (C) DBS lead penetrating though GP and bipolar contact pairs in the GP.

Demographic and clinical data

	Parkinson's disease	Essential tremor
Subjects	13	10
Gender (male/female)	10/3	4/6
Age	61 (52-73)	73.5 (37-79)
Pre-operative total UPDRS III	31 (8-72)	-
Pre-operative lat. UPDRS III	10 (2-20)	-
Pre-operative lat. rigidity/bradykinesia scores	9 (2-18)	-
Pre-operative lat. tremor scores	0 (0-7)	-

Table 1. Summary of demographic and clinical data, OFF medication, for subjects of study (values: N or median with range in parenthesis; lat.: lateralized; UPDRS: unified Parkinson's disease rating scale)

Difference in cortical oscillations between PD and ET

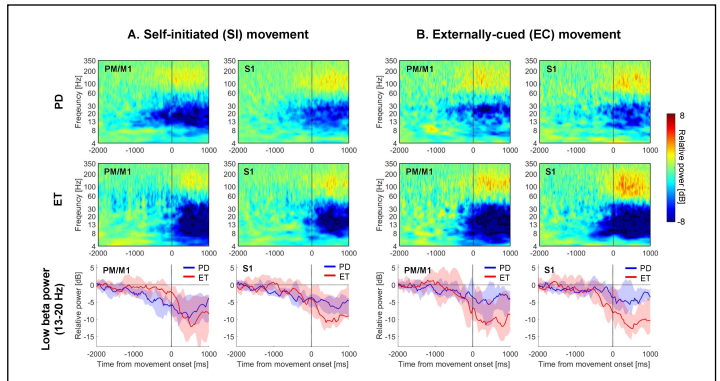

Fig. 2. Comparison of movement-related cortical oscillatory changes between Parkinson's disease and essential tremor patients for (A) self-initiated movement and (B) externally-cued movement

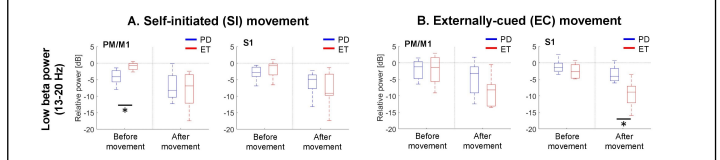

Fig. 3. Statistical comparisons in low-beta power (13-20 Hz) between Parkinson's disease and essential tremor before movement onset (1 sec) and after movement onset (1sec) for (A) self-initiated movement and (B) externally-cued movement (Wilcoxon's rank sum test, *: p(corrected)<0.05, where FDR<0.05)

BG-cortical oscillations during SI and EC movements in PD

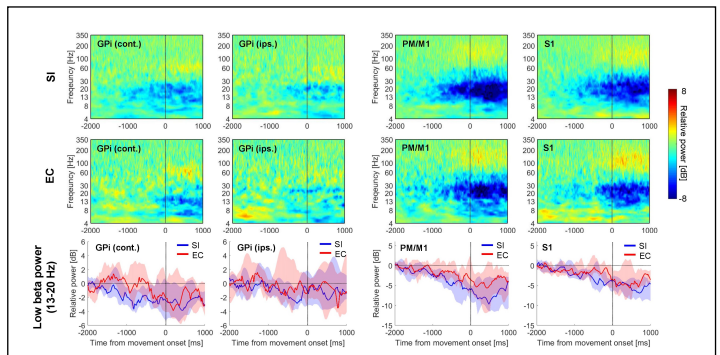

Fig. 4. Comparison of movement-related oscillatory changes in contralateral and ipsilateral globus pallidus internus (GPi) and contralateral cortices between self-initiated movement and externally-cued movement for Parkinson's disease

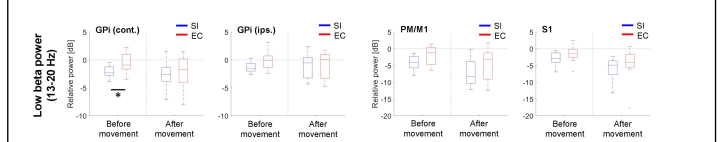

Fig. 5. Statistical comparisons in low-beta power (13-20 Hz) between self-initiated movement and externally cued movement before movement onset (1 sec) and after movement onset (1sec) for Parkinson's disease (Wilcoxon's signed-rank test, *: p(corrected)<0.05, where FDR<0.05)

BG-cortical coherence during SI and EC movements in PD

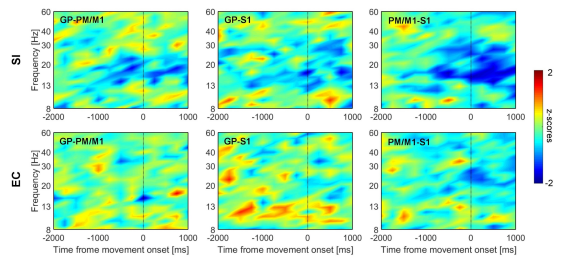

Fig. 6. Comparison of movement-related coherence dynamics between globus pallidus internus (GPi) and cortices between self-initiated movement and externally-cued movement for Parkinson's disease. All time-frequency (TF) maps were normalized to the TF maps from surrogate data (shuffling temporal structure of raw LFPs).

Fig. 7. Statistical comparisons in low-beta coherence (13-20 Hz) between self-initiated movement and externally cued movement before (1 sec) and after (1 sec) movement onset for Parkinson's disease (Wilcoxon's signed-rank test, *: p(corrected)<0.05 and **: p(corrected)<0.01, where FDR<0.05)

Correlation with motor symtomps in PD

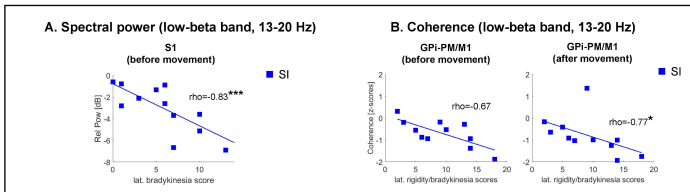

Fig. 8. Correlation analyses with clinical data during self-initiated (SI) movement. (A) Low-beta power (13-20 Hz) (B) Low-beta coherence (13-20 Hz) (Spearman correlation, *: p(corrected)<0.05, ***: p(corrected)<0.005, where FDR<0.05)

Conclusion

PD patients with the **more severe motor symptoms** showed the **greater suppression in low-beta cortical power and BG-cortical coherence** during **SI** movement. It can be interpreted that, to **initiate movements**, the **enough reduction of exaggerated beta oscillations** would be necessary (Heinrichs-Graham & Wilson, 2016). Also, PD patients showed **earlier beta suppression** in **BG-cortical networks** during **SI** movement, which might reflect the **prolonged or slow movement initiation** associated with the **motor symptoms**. Our findings can provide the **electrophysiological evidence** that the **difficulty in SI movement in PD** may be associated with **altered BGTC networks**.

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