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Identifying Motor-Specific Biomarkers in Parkinson's Disease: A Focus on Neural Activity in the Primary Motor Cortex

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Introduction: Current research on Parkinson's disease (PD) leverages beta-band oscillations from the subthalamic nucleus (STN) as a biomarker for optimizing deep brain stimulation (DBS) therapy. However, the beta dynamics in STN are not motor-specific [1], which constrains the effectiveness of adaptive DBS. A key challenge lies in the need to identify a more specific feedback control biomarker. In this context, we propose to expand the search for potential biomarkers to the primary motor cortex [2]. Our goal is to extract neural activity correlated with PD symptoms from M1 and investigate whether this biomarker is consistent across different stages of the disease.

Material, Methods and Results: The data acquisition and training process is shown in Fig. 1. We use Male C57BL/6 mice to build a PD model with 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine (MPTP). Before that, we implanted the 2*8 microelectrode array into the primary motor cortex, collecting both the spike activity and local field potentials. The mice were trained to perform the open-field test across early, middle, and late stages of Parkinson's progression. Meanwhile, signals from the motor cortex were recorded to assess whether the identified biomarker remains consistent throughout these stages. The PD-related features are learned via a Feature Extraction network [3], and then fed into classification models, including Support Vector Machines (SVM) and Long Short-Term Memory networks (LSTM), to validate its effectiveness. By comparing results across different disease stages, we assess whether the biomarker maintains consistent performance throughout all stages of PD.

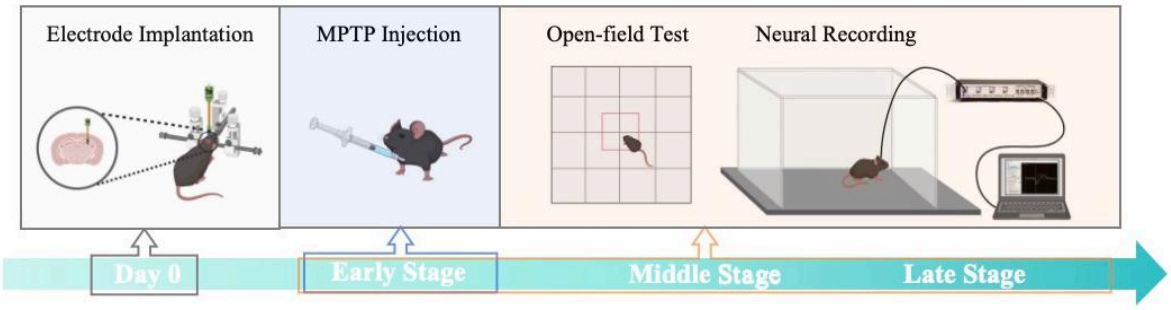

Figure 1. *The experimental setup of this work.*

Discussion and Significance: This work identifies a novel biomarker from M1 for Parkinson's disease and evaluates its performance across three stages of disease progression. The findings will provide a deeper insight into the underlying pathophysiology of PD. Future work will involve integrating this biomarker with an adaptive deep brain stimulation (DBS) device to create a closed-loop system, which could enable real-time monitoring and more personalized treatment strategies for patients.

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