Choosing the optimal electrode trajectory, stimulation location, and stimulation amplitude in subthalamic nucleus deep brain stimulation (STN DBS) for Parkinson's disease (PD) remains a time-consuming empirical effort.

The existing methods rely on a simplified model of a straight line electrode trajectory, rather than the more realistic curved trajectory.

Husch et al. presented a highly accurate and fully automated method for electrode reconstruction that considers curved trajectories. The robustness of our proposed method is demonstrated using a multi-center clinical dataset consisting of N = 44 electrodes. In all cases the electrode trajectories were successfully identified and reconstructed. In addition, the accuracy is demonstrated quantitatively using a high-accuracy phantom with known ground truth. In the phantom experiment, the method could detect individual electrode contacts with high accuracy and the trajectory reconstruction reached an error level below 100 µm (0.046 ± 0.025 mm). An implementation of the method is made publicly available such that it can directly be used by researchers or clinicians. This constitutes an important step towards future integration of lead reconstruction into standard clinical care [1)].

Choosing the optimal electrode trajectory, stimulation location, and stimulation amplitude in subthalamic nucleus deep brain stimulation (STN DBS) for Parkinson's disease (PD) remains a time-consuming empirical effort. In this retrospective study, we derive a data-driven electrophysiological biomarker that predicts clinical DBS location and parameters, and we consolidate this information into a quantitative score that may facilitate an objective approach to STN DBS surgery and programming.

Approach: Random-forest feature selection was applied to a dataset of 1046 microelectrode recordings sites across 20 DBS implant trajectories to identify features of oscillatory activity that predict clinically programmed volumes of tissue activation (VTA). A cross-validated classifier was used to retrospectively predict VTA regions from these features. Spatial convolution of probabilistic classifier outputs along MER trajectories produced a biomarker score that reflects the probability of localization within a clinically optimized VTA.

Main results: Biomarker scores peaked within the VTA region and were significantly correlated with percent improvement in postoperative motor symptoms (MDS-UPRDS Part III, R = 0.61, p = 0.004). Notably, the length of STN, a common criterion for trajectory selection, did not show similar correlation (R = -0.31, p = 0.18). These findings suggest that biomarker-based trajectory selection and programming may improve motor outcomes by 9 ± 3 percentage points (p = 0.047) in this dataset.

Significance: A clinically defined electrophysiological biomarker not only predicts VTA size and location but also correlates well with motor outcomes. Use of this biomarker for trajectory selection and initial stimulation may potentially simplify STN DBS surgery and programming [2)].

1)
Husch A, V Petersen M, Gemmar P, Goncalves J, Hertel F. PaCER - A fully automated method for electrode trajectory and contact reconstruction in deep brain stimulation. Neuroimage Clin. 2017 Oct 6;17:80-89. doi: 10.1016/j.nicl.2017.10.004. PMID: 29062684; PMCID: PMC5645007.
2)
Rao AT, Lu CW, Askari A, Malaga KA, Chou KL, Patil PG. Clinically-derived oscillatory biomarker predicts optimal subthalamic stimulation for Parkinson's disease. J Neural Eng. 2022 Mar 10. doi: 10.1088/1741-2552/ac5c8c. Epub ahead of print. PMID: 35272281.