Project Details	
Project Code	NMH27Br Fischer
Title	Developing brain-activity based non-invasive stimulation techniques for movement disorders
Research Theme	Neuroscience & Mental Health
Project Type	Dry lab
Summary	Parkinson's disease and dystonia can severely affect movement, and existing treatments do not work well for everyone. This PhD project will develop personalised treatments that continuously monitor brain activity and deliver stimulation timed to disrupt brain activity associated with symptoms. The student will test whether this works best using brief pulses of vibration or by directly stimulating brain areas non-invasively. The longer-term benefits of a lightweight wearable device co-developed with an industry partner will also be tested. The aim is to provide a safe and low-cost treatment alternative for people who receive limited benefit from existing treatments.
Description	Parkinson's disease and dystonia are neurological disorders that cause disabling movement impairments. The effectiveness of current treatments varies substantially between individuals, and approximately 20–35% of people with dystonia are dissatisfied with their treatment. Both conditions are associated with excessive synchronisation of brain activity, although the specific pathological rhythms differ. Excessive neural synchronisation can be disrupted with precisely timed stimulation pulses, which can either be delivered 1) indirectly via somatosensory pathways by using brief pulses of vibration or 2) directly to targeted cortical regions. Direct cortical stimulation can, in principle, be delivered non-invasively using high-definition transcranial electrical stimulation (tES). However, brain-activity-guided tES remains underexplored because stimulation artefacts make real-time monitoring technically challenging. Our laboratory has successfully used brain-activity-based, "closed-loop" vibrotactile stimulation (VTS) to reduce involuntary muscle contractions in dystonia. In some participants, substantial improvements persisted for up to 45 minutes after stimulation ended. Other groups also have shown that continuous VTS can benefit people with Parkinson's disease (Macerollo et al., 2018; Azoidou et al, 2025), and we hypothesise that benefits can be enhanced by delivering stimulation in a personalised, closed-loop manner, timed to each individual's neural activity. We have also developed a system that enables brain-activity-guided cortical tES by filtering out stimulation artefacts. This creates a unique opportunity to directly compare the neural and behavioural effects of closed-loop VTS and cortical stimulation. The key research question of this PhD project is: which approach — brain-activity-guided VTS or direct cortical stimulation — is more effective in reducing pathological network synchronisation and alleviating movement symptoms in dystonia and Parkinson's disease? The first objective is to develop a closed-loop tES protocol targeting the sensorimotor cortex, initially aiming to reproduce and potentially enhance the beneficial effects of VTS in dystonia. Once robust and reproducible neural and behavioural effects have been established, the protocol will be extended to target other relevant brain areas and

	determine which are the best targets for effectively disrupting excessive network synchronisation. The student will have significant ownership over the set of areas to test. The second objective is to apply our closed-loop protocols in Parkinson's disease, targeting the rhythms excessively synchronised in Parkinson's (13-30 Hz beta oscillations), and compare them with continuous VTS. The student will lead the selection and refinement of a focused set of controlled tasks to quantify movement ability and symptoms with and without stimulation. Dystonia and Parkinson's disease are both heterogeneous conditions: symptoms and underlying network abnormalities vary considerably between individuals. For example, tremor may be present or absent, which might determine whether cortical stimulation is more appropriate than VTS. Detailed patient stratification will therefore be used to identify which stimulation modality and cortical target are most suitable for distinct clinical and neurophysiological profiles. Computational models of network-level effects will complement these analyses and guide further optimisation of stimulation parameters. The third objective is to investigate and attempt to maximise longer-term efficacy in a subgroup that responded most strongly to closed-loop VTS. This will involve delivering stimulation for several hours across multiple days, including potentially overnight. Long-term testing is enabled by our collaboration with the industry partner huru, who have developed a lightweight EEG sensor (clicEEG) and custom-written firmware tailored to our project. Our device combination enables wireless delivery of brain-activity based VTS, which can be comfortably worn during social, work and outdoor activities without being intrusive. VTS is particularly promising for extended use because of its excellent safety profile and suitability for overnight delivery. Stimulation during sleep - in particular which sleep stages to target – will be discussed in detail with the co-supervisor MJ, who is an expert in sleep neurophysiology. Stimulation during sleep might achieve prolonged symptom reduction and might reduce the need to wear a VTS device during the day. Overnight stimulation will at first be tested in a very small pilot sample (n=2) to fully characterize any cumulative effects. The student will co-design the long-term testing protocol with patients to maximise feasibility, acceptability and adherence. This project addresses a substantial unmet clinical need in dystonia and Parkinson's disease. By directly comparing two personalised closed-loop stimulation strategies, identifying predictors of response and optimising sustained delivery, it will establish the mechanistic and translational foundations for more effective, individually targeted therapies. In the longer term, precise manipulation of pathological neural synchronisation could provide a non-invasive means of reshaping dysfunctional networks and relieving symptoms, offering a much-needed treatment alternative for patients who do not benefit sufficiently from existing therapies.
Can be completed part time?	Yes
Supervisory Team	

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