Brain Mind Institute (BMI)
Neuro-x Institute (INX)
Defitech Chair in Clinical Neuroengineering

PhD position on underlying mechanisms of non-invasive deep brain stimulation

The Laboratory of Clinical Neuroengineering, directed by Friedhelm Hummel (https://www.epfl.ch/labs/hummel-lab), has an open position for a PhD student on the topic of underling neural mechanisms of non-invasive brain stimulation of deep brain structures such as the striatum or the hippocampus by means of transcranial temporal interference electric stimulation (tTIS) to enhance cognitive functions in healthy subjects and neurological patients. To address this question multimodal systems neuroscience methods by means of structural and functional magnetic resonance imaging (s/fMRI), magnetic resonance spectroscopy (MRS) and M/EEG combined with behavioral evaluations will be used.

Project description:

Deep brain structures like the basal ganglia (and its subregions) or the hippocampus are core structures in the pathophysiology of several major neurological and psychiatric disorders such as Parkinson' disease, Dementia, Stroke, Addiction, Epilepsy or Apathy. Non-invasive neuromodulation by means of brain stimulation (TMS, tDCS) has been developed in the last years as a treatment strategy for such disorders (for review e.g., Coscia *et al.* 2019 Brain; Kan *et al.* 2023 Lancet Psychiatry). However, these techniques have the significant limitation that they cannot reach deep brain structures such as the striatum or hippocampus without stimulating the whole overlying cortical areas that renders them not feasible for deep brain stimulation leaving only invasive deep brain stimulation methods with all potential risks as currently the only opportunity.

However, recently we were able to pioneer a novel deep brain stimulation technology described in rodents (Grossman et al. 2017 Cell) towards human application to neuromodulate non-invasively and topographical specific the striatum. Here we demonstrated for the first time in humans modulation of activity of the striatum with respective changes in behaviour by transcranial temporal interference stimulation (tTIS) (Wessel, Beanato *et al.* 2023 Nature Neuroscience, Vassiliadis *et al.* accepted Nature Human Behavior). tTIS has currently be also validated for the neuromodulation of the hippocampus in humans (Violante *et al.* 2023 Nature Neuroscience; Popa, Beanato *et al.* biorXiv 2023).

These findings open exciting novel opportunities for basic human neuroscience such as addressing causal relationships of deep brain structures for human behaviour, but even more importantly, opens novel innovative treatment strategies for neurological and psychiatric disorders where is a lack of effective treatment, such as dementia, addiction, stroke or apathy. To further adapt tTIS towards clinical translation and optimize its parameters and application for personalized treatments it is critically important to understand the underlying mechanism and determine markers that allow to predict the response to tTIS. The present PhD position is dedicated to achieve these goals.

Project description

Specifically, the project plans to investigate the underlying mechanisms of theta-burst deep brain stimulation (see Wessel, Beanato *et al.* 2023 Nature Neuroscience) applied to the striatum or the hippocampus by means of structural MRI, functional MRI and GABA MR-Spectroscopy and by combination with EEG/MEG and to determine markers that allow to

predict the response to tTIS. This multimodal imaging factors will be associated with the impact of tTIS on cognitive behavior. Furthermore, these data will be used for modelling and simulation of the effects of tTIS. The PhD will achieve important understanding of this disruptive novel interventional strategy that allows to non-invasively neuromodulate deep brain structures.

The ideal candidate should have a Master's degree (or equivalent degree) in computer science, engineering, neuroscience, medicine or psychology, be strongly motivated with a keen interest in systems neuroscience especially neuroimaging and brain stimulation and neurotechnology, ML and AI. (1) Strong programming skills in machine learning and modelling, (2) a strong neuroimaging background, especially in MRI, (3) a strong neuromodulation background, especially non-invasive brain stimulation or (4) previous research experience in the experimental neuroscience are a plus.

Working environment:

The successful applicant will join the EPFL Defitech Chair of Clinical Neuroengineering which is led by Prof. Friedhelm Hummel and focuses on translational human neuroscience and neuroengineering with a focus learning and memory in healthy aging and in patients suffering from stroke, traumatic brain injury or dementia. The Lab is based in Geneva's beautiful Campus Biotech, right next to Lake Geneva and with a second strategic Lab hub in an hospital environment in Sion in the heart of the beautiful area of Valais. The Ph.D. candidate will be enrolled in the EPFL Ph.D program Neuroscience (EDNE).

Start of position:

Spring 2024

Application procedure:

Interested candidates must submit their application to the EDNE doctoral school

(https://www.epfl.ch/education/phd/edne-neuroscience/edne-how-to-apply/)