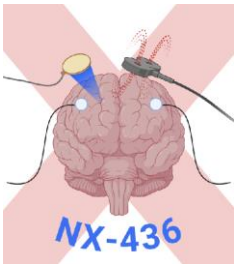

Semester Exercise 2024/2025 - Vignette – Groups - SS

Temporal Interference Stimulation and EEG/MEG recordings

Non-invasive Brain Stimulation techniques (NIBS), such as transcranial magnetic stimulation (TMS) and transcranial direct/ alternate current stimulation (tDCS/tACS), are currently used in rehabilitation therapy of neurological diseases as a complementary approach (Kesikburun S, 2022). However, NIBS techniques are subject to a focality/depth trade off, resulting in targeting insufficiently deep brain structures in comparison with invasive brain stimulation techniques (Davidson et al., 2024). Transcranial temporal interference (TI) stimulation is a novel non-invasive technique, that utilizes the temporal interference-superposition of 2 oscillating electric fields at high frequencies, that differ by a frequency in the range of neuronal response. This creates an envelope, whose amplitude is modulated in the difference frequency and drives the activity of neurons in-vivo in animal models (Grossman et al., 2017).

This technique permits for the first time the possibility for deep brain stimulation and neuromodulation non-invasively of deeper structures in the brain. In a study by Wessel, Beanato et al. it is shown that theta-burst patterned striatal TI increased the activity in striatum and associated motor network, as well as it was associated with enhanced motor performance in healthy older subjects (Wessel, Beanato et al., 2023). Moreover, TI stimulation with difference frequency 80 Hz can modulate neural activity within the striatum and it can inhibit the reinforcement on motor learning, as it was shown by Vassiliadis et al., 2024. Furthermore, another study in humans shown that TI stimulation can modulate hippocampal activity and subsequently enhance the accuracy of episodic memory in healthy subjects (Violante et al., 2022).

However, the underlying mechanism of how TI stimulation can modulate brain activity is not fully elucidated yet. There is evidence that neurons are mixing endogenous and exogenous oscillations, producing new mixing frequencies, a mechanism based on the voltage-gated ion channels (Luff et al., 2024). This could explain how TI works and modulates the brain activity. For this reason, EEG/MEG techniques can be used to record brain electrical/magnetic field activity simultaneously with TI and provide us insight into how the TI stimulation works.

In this semester project, you will develop a way to record EEG/MEG concurrently with TI stimulation during a motor learning task. You will be familiar with the technical parameters of the stimulation and EEG/MEG recordings. Moreover, you will design your own experimental paradigm for motor learning and define EEG/MEG biomarkers that could be affected during the TI stimulation.

The challenges of the project will be:

- To understand the implementation of hardware filters for concurrent recording of EEG/MEG and TI stimulation
- To understand the advantages and disadvantages of EEG/MEG techniques in relation to the experimental design
- To develop a motor learning paradigm that will demonstrate the modulation of brain activity during motor learning
- To understand the different patterns of TI stimulation that can be applied concurrently with the motor learning task and evaluate the expected changes in the brain activity

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