VRIJE UNIVERSITEIT BRUSSEL

The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Fahimeh Akbarian**

The public defense will take place on **Wednesday 21st January 2026 at 5 pm** in room **I.0.01** (Building I, VUB Main Campus)

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INVESTIGATING EXCITATION/INHIBITION BALANCE IN MS THROUGH APERIODIC NEUROPHYSIOLOGICAL ACTIVITY

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Abstract of the PhD research

Multiple sclerosis (MS) is a chronic central nervous system disease characterised by neuroinflammation, demyelination, and neurodegeneration, leading to physical and cognitive impairments. Cognitive deficits frequently affect working memory, information processing speed, and attention. Although their mechanisms are not fully understood, evidence suggests that synaptic loss, particularly of inhibitory synapses, disrupts cortical excitation–inhibition (E/I) balance and contributes to cognitive dysfunction.

In this PhD project, we used magnetoencephalography (MEG) to investigate changes in the aperiodic 1/f spectral slope, a proposed marker of cortical E/I balance. A steeper slope indicates increased inhibition or reduced excitation. MEG data from healthy controls (HCs) and people with MS (pwMS) were analysed during resting-state, visuo-verbal n-back, and auditory oddball tasks. Data were source reconstructed, parcellated into 42 brain regions, and decomposed into periodic and aperiodic components using the specparam algorithm. Neuropsychological assessments measured information processing speed, verbal fluency, and visuospatial memory.

During resting-state, pwMS taking benzodiazepines showed steeper slopes in occipital, temporal, and prefrontal regions compared with pwMS who did not take benzodiazepines, independent of beta power, supporting the slope as an oscillation-independent measure. Among pwMS who did not take benzodiazepines, those with cognitive impairment displayed steeper slopes than cognitively preserved pwMS and HCs, suggesting compensatory overinhibition mechanism.

In the n-back task, a consistent post-stimulus steepening (increased inhibition) was observed across participants. However, pwMS showed flatter slopes following distractors, consistent with impaired inhibitory control. Greater task-induced steepening predicted better visuospatial memory in pwMS, whereas the opposite relationship was observed in HCs.

In the auditory oddball task, slope steepening persisted even after correcting for event-related fields. Salient stimuli induced stronger steepening, and trials needed response showed enhanced sensorimotor steepening. Slope modulation was correlated across oddball and n-back tasks, suggesting a trait-like index of cognitive control.

Overall, the 1/f slope captured both tonic and phasic inhibitory dynamics, differentiated medication effects, correlated with cognitive performance, and generalised across paradigms. These findings support its potential as a non-invasive biomarker for cognitive dysfunction in MS, warranting further longitudinal and multimodal validation.