Doctoral Project proposal - InLife 2026

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Neural dynamics underlying the processing of emotional memory during REM sleep

Abstract

The REM and non-REM stages of sleep are both critical for the consolidation of emotional memories, a process involving a large network of brain structures including the hippocampus, prefrontal cortex, and amygdala. Non-REM sleep is characterized by discrete oscillatory events that coordinate neuronal reactivation, i.e. the reinstatement of prior waking neural activity, within and across brain regions. Reactivation is firmly established as the main mechanism supporting non-REM sleep-dependent memory consolidation. REM sleep, on the other hand, is dominated by continuous theta oscillations that were never shown to be associated with reactivation. The mechanisms underlying the role of REM sleep in emotional memory processing therefore remain unknown. This PhD project aims to investigate the internal structure of REM sleep and identify the neural mechanisms underlying REM sleep-dependent emotional processing. Notably, we will test whether identifying latent sub-stages and specific timepoints within REM sleep enables detection of neuronal reactivation previously missed due to methodological limitations. To do so, we will develop analytical approaches from applied mathematics, capable of operating on continuous, non-stationary, and multimodal neural signals without predefined temporal reference points. These methods will be applied to high-dimensional electrophysiological recordings from rodents undergoing spatial and emotional learning. First, we will characterize REM structure in the hippocampus, prefrontal cortex and amygdala using unsupervised state inference and band-free decomposition. We will test whether this structure within each brain region is modified by emotional experience and supports neuronal reactivation (Aim 1). Then, we will use information-theoretic methods to characterize the extent and directionality of cross-regional coordination and reactivation during the identified substates. We will also quantify their reorganization by prior emotional experience (Aim 2). The study will leverage new computational and mathematical methods to uncover biologically interpretable results on the internal organization of REM sleep and its functional role.