MASTER 2 Computational Neurosciences

Internship proposal 2025-2026

(internship from January to June 2026)

Host laboratory:
Lyon Neuroscience Research Center CRNL. Inserm U1028 - CNRS UMR5292 - UCBL.
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Host team: COPHY (Computation, Cognition, Neurophysiology)

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Project title: From alpha rhythm modulations to visual perceptual decisions

Project summary: Brain activity is characterized by rhythms that, in all cortical and subcortical structures, express in specific frequencies and are dynamically modulated by task requirements as well as endogenous factors. The most prominent cortical oscillation is arguably the alpha rhythm associated with visual processing.

In line with theories of cortical computation, namely “predictive coding” and “perception as (Bayesian) inference”, converging evidence support the idea that the amplitude of this rhythm reflects the local cortical excitability, such that the lower the alpha amplitude, the higher the gain afforded incoming sensory information.

Importantly, the amplitude of the alpha rhythm at a given time can be modulated in two ways that are non-mutually exclusive:
(i) by adjusting the phase of the alpha rhythms;
(ii) by adjusting its power or intensity.

Obviously the first mechanism can only be deployed when the time of occurrence of a relevant stimulus can be fairly anticipated. In contrast, regarding the second mechanism, maintaining a low alpha power (i.e., high cortical excitability) is associated with a high energy cost. We therefore assume that performance optimization, for example in the case of difficult visual detection or discrimination tasks, relies on a context-dependent balance between these two mechanisms.

In this internship, we intend to test the above hypothesis by acquiring data in healthy volunteers using EEG or MEG, during a challenging visual perception task where the temporal predictability of the stimulus is manipulated. We expect the phase and power of alpha activity to be modulated according to our above predictions.

In a second step, we aim to refine and confront an original generative model of the task, which would predict both the behavior (choice and reaction time) and the alpha features (phase and power) over trials.

The future intern will be in charge of the following tasks:

- Completing the data acquisition;
- Analyze the behavioral data and use them to assess a Bayesian model of perceptual decisions to explain individual performances;
- Analyze the electrophysiological data to extract alpha feature modulations over trials and assess our main hypothesis;
- If time allows, contribute to the above second objective, by developing and evaluating a generative model of both behavior and brain alpha rhythm.

This interdisciplinary project calls on a number of skills brought together within the team, which motivates the proposed co-supervision.

Related publications:

1. Lecaignard F, Bertrand O, Caclin A, Mattout J. Neurocomputational Underpinnings of Expected Surprise. *J Neurosci*. 2022;42(3):474-486. doi:10.1523/JNEUROSCI.0601-21.2021

2. Köksal Ersöz E, Chossat P, Krupa M, Lavigne F. Dynamic branching in a neural network model for probabilistic prediction of sequences. *J Comput Neurosci*. 2022;50(4):537-557. doi:10.1007/s10827-022-00830-y

3. Bonnefond M, Jensen O, Clausner T. *Visual Processing by Hierarchical and Dynamic Multiplexing Supported by Phase Coding*. PsyArXiv; 2023. doi:10.31234/osf.io/9q7f4

4. Bonnefond M, Jensen O. Alpha Oscillations in Resisting Distraction. Published online January 15, 2024. doi:10.31219/osf.io/v79dk

5. Kilner, J. M., Mattout, J., Henson, R., & Friston, K. J. (2005). Hemodynamic correlates of EEG: A heuristic. *NeuroImage*, *28*(1), 280–286. https://doi.org/10.1016/j.neuroimage.2005.06.008