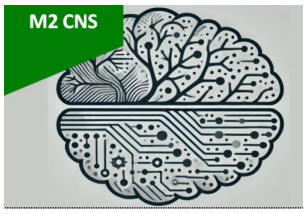

MASTER 2 Computational Neurosciences

Internship proposal 2026-2027

(internship from January to June 2027)

Host laboratory: Lyon's Neurosciences Research Center (U1028/UMR5292)

Host team : EDUWELL Team, CRNL, https://www.crnl.fr/fr/equipe/eduwell

Internship supervisors : *name + position + email*

Antoine LUTZ, Director of Research, Eduwell team: antoine.lutz@inserm.fr

Françoise LECAIGNARD, tenured scientist, Cophy team: francoise.lecaignard@inserm.fr

Project title : Neurocomputational Mechanisms of Mindfulness Meditation: Impacts on Perception and Stress within a Predictive Processing Framework

Project summary : *5-10 lines*

Understanding human cognition through predictive processing, as well as its implementation in the brain, offers an integrated account of perception, attention, learning and action [1]. This framework describes the brain as a Bayesian inference system that actively anticipates and regulates sensory signals from the body and environment to keep the organism in viable states. From this perspective, attention can be understood as the selective allocation of precision to sensory, interoceptive or cognitive signals: inputs treated as more reliable are up-weighted and exert greater influence over perceptual inference, whereas uncertain or less relevant signals are down-weighted [2]. Meditative practice may therefore be described as a systematic retraining of precision-weighting, increasing sensitivity to present-moment bodily and sensory information while reducing the automatic dominance of high-level, self-related and temporally extended priors that sustain rumination, anticipation and mind-wandering [6,7]. By making thoughts, emotions and percepts appear as transient constructed events rather than transparent descriptions of reality, meditation may weaken maladaptive expectations and allow internal models to become less rigid and more responsive to ongoing experience [6]. In this internship, the candidate will test a neurocomputational framework on an existing EEG datasets from novice and expert meditators. The central hypothesis is that meditation-related regulation of attention and emotion depends on changes in predictive processes, especially in how confidence is assigned to predictions and sensory inputs. By combining time-resolved computational modeling, sophisticated statistical approaches and links to phenomenology, the project will clarify mechanisms through which mindfulness may influence perception, stress regulation and clinically relevant vulnerability to mood and anxiety disorders. By implementing this novel analytical approach, this project could identify new neural markers of stress and emotion regulation.

Background:

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Mindfulness research is increasingly relevant to medicine, psychology and neuroscience because anxiety, depression and stress-related disorders remain leading sources of disability, and many patients require complementary non-pharmacological approaches. Mindfulness-based interventions have shown value for relapse prevention in depression and for reducing stress, emotional distress, anxiety, addiction-related symptoms and chronic pain burden [3-5]. However, their mechanisms of action remain insufficiently characterized at experiential, cognitive and neurophysiological levels, which limits optimization, mechanistic prediction of therapeutic response, and treatment personalization for patients with distinct attentional or affective vulnerabilities.

The proposed project addresses this gap through a clinically relevant and mechanistically precise question: does intensive mindfulness practice alter the temporal dynamics of sensory prediction and deviance detection, and are these neural changes linked to the experienced dynamics of attention and awareness?

This internship will be conducted at the CRNL, within the Eduwell team, which specializes in the neurophysiological mechanisms of attention, meditation and other forms of mental training, and in how these mechanisms can improve well-being, health and learning.

Methodology :

The candidate will implement and compare mechanistic models of the auditory mismatch negativity (MMN), an automatic brain response to violations in regular sound sequences and a marker of auditory prediction/deviance detection, in a cross-sectional EEG oddball dataset [8] with safe and threat-induced anxiety periods. Building on the strengths of a previous time-resolved dynamic modeling work [9], the project aims to model trial-by-trial dependencies in successive latency windows rather than relying only on averaged ERPs (event-related potential). This is important because recent animal studies suggest that MMN-like components may emerge from different mechanisms and evolving timescales along the evoked response and across the auditory hierarchy [10]. Feasibility is supported by the findings during a prior M2 internship, which revealed a successful proof of concept: preliminary analyses captured latency-specific neural dynamics and revealed a significant latency-by-condition (safe/threat) interaction, not detected by the original average-ERP analysis [8]. This suggests that the time-resolved modeling framework is more sensitive to condition-dependent effects than traditional averaged ERP analyses. This internship will extend this framework to the full factorial design — safe versus threat, meditative states versus control, and novice versus expert groups — using generalized additive mixed models (GAMMs) to test whether temporal MMN trajectories are modulated by anxiety and meditation. This approach may also allow mechanistic prediction of trait anxiety at the individual level and establish temporal MMN trajectories as candidate biomarkers of anxiety.

Relevant publications:

[1] Friston, K., & Kiebel, S. (2009). Predictive coding under the free-energy principle. Phil. Trans. R. Soc. B, 364, 1211-1221.

[2] Feldman, H., & Friston, K. (2010). Attention, uncertainty, and free-energy. Frontiers in Human Neuroscience, 4, 215.

[3] Teasdale, J. D., Segal, Z. V., Williams, J. M. G., Ridgeway, V. A., Soulsby, J. M., & Lau, M. A. (2000). Prevention of relapse/recurrence in major depression by MBCT. J. Consulting and Clinical Psychology, 68, 615-623.

[4] Tang, Y.-Y., Holzel, B. K., & Posner, M. I. (2015). The neuroscience of mindfulness meditation. Nature Reviews Neuroscience, 16, 213-225.

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[5] Van Dam, N. T., van Vugt, M. K., Vago, D. R., Schmalzl, L., Saron, C. D., et al. (2018). Mind the hype. Perspectives on Psychological Science, 13, 36-61.
[6] Lutz, A., Mattout, J., & Pagnoni, G. (2019). The epistemic and pragmatic value of non-action. Current Opinion in Psychology, 28, 166-171.
[7] Pagnoni, G. (2019). The contemplative exercise through the lenses of predictive processing. Progress in Brain Research, 244, 299-322.
[8] Fucci, E., Abdoun, O., & Lutz, A. (2019). Auditory perceptual learning is not affected by anticipatory anxiety except for highly anxious individuals: EEG evidence. Clinical Neurophysiology, 130, 1135-1143.
[9] Poublan-Couzardot, A., et al. (2023). Time-resolved dynamic computational modeling of human EEG recordings reveals gradients of generative mechanisms for the MMN response. PLOS Computational Biology.
[10] Parras GG. Et al. (2017). Neurons along the Auditory Pathway Exhibit a Hierarchical Organization of Prediction Error. Nature Communications, 8.
[11] Poublan-Couzardot, A. (2022). Neurocomputational mechanisms of meditative practice. Doctoral thesis, Universite de Lyon.
[12] Demarchi, G., Sanchez, G., & Weisz, N. (2019). Automatic and feature-specific prediction-related neural activity in the human auditory system. Nature Communications, 10, 3446.