MASTER 2 Computational Neurosciences

Internship proposal 2025-2026

(internship from January to June 2026)

Host laboratory:

Institut des Sciences Cognitives Marc Jeannerod,

67 Bd Pinel, 69675 Bron Cedex, France

Host team :

Neural basis of spatial cognition and action,

https://www.benhamedlab.org/

Internship supervisors :

Suliann Ben Hamed, Research director, benhamed@isc.cnrs.fr

Project title :

Modeling prefrontal neuronal computations using recurrent neural networks

Project summary : *5-10 lines*

This project aims to model prefrontal cortical (PFC) computations using recurrent neural networks (RNNs) inspired by recent neuroscience findings. It focuses on replicating key spatiotemporal mechanisms, such as theta and alpha oscillations and neuronal dynamics, observed in PFC activity. The project will train RNNs on cognitive tasks, analyze their internal dynamics, and compare these with experimental data to validate task representations and flexible computation. Insights from studies on task-specific neural states and shared dynamical motifs will guide the RNN design and analysis. Tools like dimensionality reduction and dynamical systems analysis will be employed. The expected outcomes include biologically plausible RNNs and deeper understanding of how PFC encodes and processes information for attention and task switching. This work bridges computational modeling and experimental neuroscience, offering predictions for future validation.

Related publications :

- Chen, G., Gong, P., 2022. A spatiotemporal mechanism of visual attention: Superdiffusive motion and theta oscillations of neural population activity patterns. Science Advances 8, eabl4995. https://doi.org/10.1126/sciadv.abl4995
- Gaillard, C., Ben Hadj Hassen, S., Di Bello, F., Bihan-Poudec, Y., VanRullen, R., Ben Hamed, S., 2020. Prefrontal attentional saccades explore space rhythmically. Nat Commun 11, 925. https://doi.org/10.1038/s41467-020-14649-7
- Yang, G.R., Joglekar, M.R., Song, H.F., Newsome, W.T., Wang, X.-J., 2019. Task

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representations in neural networks trained to perform many cognitive tasks. Nat Neurosci 22, 297–306. https://doi.org/10.1038/s41593-018-0310-2

- Mouille, A., Gaillard, C., Astrand, E., Wardak, C., Hamed, S.B., Amengual, J.L., 2023. Distinct neural states encode task identity in frontal eye field and interact with its core spatial properties. https://doi.org/10.1101/2023.09.05.556340
- Driscoll, L.N., Shenoy, K., Sussillo, D., 2024. Flexible multitask computation in recurrent networks utilizes shared dynamical motifs. Nat Neurosci 27, 1349–1363. https://doi.org/10.1038/s41593-024-01668-6
- Amengual, J.L., Di Bello, F., Ben Hadj Hassen, S., Ben Hamed, S., 2022. Distractibility and impulsivity neural states are distinct from selective attention and modulate the implementation of spatial attention. Nat Commun 13, 4796. https://doi.org/10.1038/s41467-022-32385-y