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DI PADOVA

HORIZON EUROPE
PROJECTS FUNDED AT THE UNIVERSITY OF PADOVA

BRAINICIP - Brain-wide Criticality and Information Processing

The brain is an adaptive system that efficiently performs unique functions in complex and continuously changing environments.

Nearly two decades of empirical observations suggest that the brain self-organizes to operate near criticality, a state located at the border between order and disorder, characterized by peculiar features such as long-range correlations and scale invariance of activity, maximal variability of spatio-temporal patterns, and wide response range to perturbations. Theoretical arguments and numerical models indicate that criticality could support optimal computational capabilities by providing a favorable trade-off between reliability and flexibility needed to achieve collective neural behaviors that underlie complex brain functions. Despite signatures of criticality in brain dynamics across spatial scales and systems, the alleged functional role of criticality in brain functions currently lacks direct in vivo empirical confirmation. In this project we aim to investigate in vivo functional advantages of brain criticality, elucidating the relation between emergent brain-wide critical dynamics and brain functions in Zebrafish larvae. Due to their small size and transparency, Zebrafish remain the only vertebrates permitting whole- brain imaging of neural activity with cellular resolution during behavioral study. To probe the functional role of brain-wide criticality in vivo, we will develop a combined theoretical-experimental approach to follow and perturb in near-real time collective neural dynamics during processing of sensory stimuli—and associated behavioral response—, learning, and memory retrieval, while quantifying function, identifying signatures of criticality, and evaluate the relation with information processing. This will consist of a criticality estimator for the online decoding of neural activity, and a finely tunable closed-loop optogenetic stimulation strategy to drive the system away from criticality and assess its functional role.

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