TITLE: **The Critical Brain in Action**

ABSTRACT (max 300 words):

An emerging and fascinating hypothesis in Neuroscience is that the brain at rest may be spontaneously driven closed to a critical phase transition (in a statistical physical sense), between the sub-critical regime with low activity, to the super-critical regime of high activations [1]. In brain systems, the concept of criticality is mainly supported by the following two experimental findings [2]: (i) the discovery of scale-free neural avalanches, as described by power-law distributions for the size and duration of the spontaneous bursts of activity in the cortex; (ii) the presence of long-range temporal correlations in the amplitude fluctuations of neural oscillations. This hypothetically "critical" architecture would translate into the ability of the brain, through a large spatial and temporal scale activity, to promptly respond to external stimuli by generating a coordinated global behavior, to maximize information transmission, sensitivity to sensory stimuli and storage of information [3]. In other terms, criticality would contribute to support the "binding" of neuronal populations across large spatial and temporal scales within the brain, thereby optimizing the "sparse" coding of information.

Learning entities (e.g. brain) need to modify their internal state to cope with external conditions, and they do so in a probabilistic manner. Through an analytical framework based in statistical physics and information theory and computational models (e.g. genetic algorithms), we have shown that the optimal response to a changing and complex environment occurs in systems organizing spontaneously—through adaptation or evolution—to the vicinity of a critical point [4].

We will explore experimentally our hypothesis by high-resolution electrophysiology and mesoscale optical imaging methods in mice and, in collaboration with M. Diamond (SISSA), S. Panzeri and T. Fellin (IIT)], by investigating brain activity for different types of environments and/or for a fixed environment, but different temporal histories.

REFERENCES (Max 5):

[1] De Arcangelis, L., Lombardi, F. and Herrmann, H.J., 2014. Criticality in the brain. *Journal of Statistical Mechanics: Theory and Experiment*, *2014*(3), p.P03026.

[2] Beggs, John M., and Nicholas Timme. "Being critical of criticality in the brain." *Frontiers in physiology* 3 (2012): 163.

[3] Muñoz, M. A. (2017). Colloquium: Criticality and dynamical scaling in living systems. *arXiv preprint arXiv:1712.04499*.

[4] Hidalgo, Jorge, et al. "Information-based fitness and the emergence of criticality in living systems." *PNAS* 111.28 (2014): 10095-10100.

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Collaborators: Matthew Diamond, Stefano Panzeri, Tommaso Fellin.

EXPERIMENTAL DATA:

To be acquired	
Already acquired (ready to be used)	X

If data need to be acquire, please provide a brief description of the Experimental setup, methods, instruments and scheduling (e.g. # of subjects, images/signals…): max 300 words

ETHICS COMMITTEE:

Obtained	
Conditioned submission*	Expected time response (in months):
Not required	

* request will be submitted only if a PhD student will be associated to the project