Bocconi

5 NOVEMBER 2024
12:00 PM
Room 2-E4-SR03
Via Röntgen 1, Milan, 2° floor

Neural mechanisms of optimal performance

Speaker

Luca Mazzucato
Associate Professor
University of Oregon

Abstract

When we attend a demanding task, our performance is poor at low arousal (when drowsy) or high arousal (when anxious), but we achieve optimal performance at intermediate arousal. This celebrated Yerkes-Dodson inverted-U law relating performance and arousal is colloquially referred to as being "in the zone." Despite decades of investigations, the underlying neural mechanisms are unknown. In this talk, I will share new experimental and theoretical results elucidating the behavioral and neural mechanisms linking arousal and performance under the Yerkes-Dodson law in a mouse model. We found that mice during auditory and visual decision-making tasks express an array of discrete strategies, including optimal, suboptimal and disengaged ones. The optimal strategy occurs at intermediate arousal, measured by pupil size, consistent with the inverted-U law. Using Neuropixels recordings from large neural populations in the auditory cortex (A1), we found optimal sound encoding at intermediate arousal, suggesting that performance modulations occur as early as primary sensory areas. To explain the computational principle underlying this inverted-U law, we modeled the A1 circuit as a spiking network with excitatory/inhibitory clusters, and found that arousal induces a transition from a multi-attractor (low arousal) to a single attractor phase (high arousal), whereby performance is optimized near the critical region. The model further predicts stimulus- and arousal-induced modulations of neural variability, which we verified in the data. Our theory suggests that a single unifying principle, phase transitions in cortical dynamics, underlies both the inverted-U law of optimal performance and state-dependent modulations of neural variability. Time permitting, I will outline a novel application of this theory to multi-tasking recurrent neural networks.

Università Bocconi
DEPARTMENT OF COMPUTING SCIENCES