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Τίτλος ομιλίας: Region-specific transformations enable distributed computations of flexible decisions

Abstract: Cognitive flexibility is thought to rely on the prefrontal cortex controlling other regions. However, recent evidence shows that information required to compute flexible decisions is distributed across multiple regions ("everything is everywhere", 2025; International Brain Laboratory, 2025). This shift raises some questions: is 'everything is everywhere' compatible with different task variables being first computed within specific regions and then broadcasted? If so, how to identify which information is communicated across specific regions to ultimately enable flexible decisions? Here, we tackle these questions by analyzing the dynamics within and between six brain regions of the monkey brain engaged in a context-dependent decision-making task (Mante & Susillo et al., 2013). De-coding from this dataset has previously found task-relevant information across all the recorded regions (Siegel et al., 2015). Using population analyses and data-constrained recurrent neural networks (RNNs) we found significant differences in within-region dynamics not captured by classical decoding analyses. Inspecting communication subspaces (Semedo et al., 2019) inferred with low-rank RNNs, we found that the dimensionality of within regional dynamics was higher than what is communicated downstream in sensory regions (e.g. V4 and MT), replicating previous results in early visual cortex (Semedo et al., 2019). In contrast, within- and across-regional dimensionality did not differ in frontal regions (i.e. LIP, FEF and PFC). Additionally, we found that overall encoding dimensionality reduced with hierarchical position, suggesting progressively more abstract transformations as information propagated downstream. Finally, in-silico perturbations revealed how choice computation abruptly emerged with stronger cross-regional interactions, in contrast to stimuli encoding which remained stable. Perturbing inputs to sensory regions confirmed a bottom-up flow of task-stimuli into the frontal regions. Altogether, using population analyses that go beyond decoding and data-constrained RNN we show that despite task-variables being broadly encoded, each region performs different computations during flexible decision making.

Bio sketch: Joao Barbosa is a group leader at the Neuromodulation Institute (INM) and NeuroSpin (Paris). He has been an independent researcher at INM since 2024 and INSERM researcher since 2025. For over a decade, he has built biologically grounded models of cognition using electrophysiology from rodents, monkeys, and humans. His group develops interpretable machine-learning methods, especially neurally constrained, low-rank RNNs, to infer how information flows across brain regions during complex behavior. Central to this work is neural geometry: analyzing low-dimensional dynamics, manifolds, and shape metrics of population activity to reveal distributed architectures beyond single-region accounts. By extracting distributed architectures from large-scale, multi-modal recordings, he moves beyond single-region explanations toward causal network mechanisms of behavioral flexibility.