Neural mechanisms of rule-based executive control

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How is the human brain able to be so flexible, i.e. to explore, adjust and exploit multiple behavioral strategies for a same task, depending on a changing context? A task set is an active representation of behavioral strategy, a context-dependent stimuli-response mapping rule. One of the lab's research group develop behavioral models explaining how we can learn multiple task rules, switch between them, create new ones, and link those with neural activity in the prefrontal cortex. However, models' parameter setting appears to be quite difficult, as neural hardware is not considered. Moreover, the implementation of task set is already assumed. This PhD project aims at understanding the neural implementation of task sets and the plasticity mechanisms leading to their development. It is constructing a biologically constrained rate-based network model of neural activity in the prefrontal cortex. This project is new in the lab, and involves also Dr. Koechlin's group, from which we are using human behavioral experiments.

The first model is composed of two interacting neural circuits with mixed selectivity of neurons:

The "associative" network, learns one to one associations between visual stimuli and outcome of action, but cannot learn the task sets.

The "context" network learns the representations of temporal contexts thanks to Hebbian and Temporal Sequence Learning mechanisms.

Finally, the second model we are exploring is an unstructured chaotic network that could also learn such a task.

This way, the PhD project is linking functional level and neuronal level in neurosciences with a bottom-up approach.

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