CELEST Nugget

Learning in concept formation and rule discovery

Virtually all complex, intelligent behavior depends on holding multiple thoughts and actions in memory simultaneously and keeping them in the right order. Whether we plan a simple errand or even a career, we need to keep track of the steps we need to execute. Coherent, goal-directed behavior is impossible without this fundamental ability. Yet most studies have only dealt with memory of one item at a time. The Miller Lab, in conjunction with CELEST colleagues, is exploring the neural substrate of sequence memory.

Complex goal-directed behaviors extend over time and thus depend on the ability to serially order memories and assemble compound, temporally coordinated, movements. Theories of sequential processing range from simple associative chaining to hierarchical models in which order is encoded explicitly and separately from sequence components. To examine how short-term memory and planning for sequences might be coded, we have conducted a series of experiments in monkeys using microstimulation to perturb neural activity in the supplementary eye fields (SEF) while animals held a sequence of two cued locations in memory over a short delay. We found that stimulation affected the order in which animals saccaded to the locations, but not the memory for which locations were cued, implying that the memory for sequential order can be dissociated from that of its components. Furthermore, stimulation appeared to bias sequence endpoints to converge toward a location in contralateral space, suggesting that the SEF encodes sequences in terms of their endpoints rather than their individual components. Effects were much weaker in the frontal eye fields (FEF), a more “primary” motor area for eye movements in the frontal cortex. This work is currently “in press” in Public Library of Science Biology, our first publication under CELEST-NSF. This work has been the subject of informational meetings throughout the year and one-on-one meetings with several computational students working under other CELEST thrusts. Data from this project and a companion neurophysiological project are simulation targets for several modeling projects of frontal cortex function.

These studies have identified neural substrates for the important ability of the brain to recognize, memorize, and produce the sequence information that is the foundation for virtually all complex, goal-directed, intelligent behavior. The CELEST thrust group on Learning in Concept Formation and Rule Discovery is coordinating plans for additional experiments and modeling projects on this and related topics.