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Neural circuit mechanisms of short-term memory[1]

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Memory over time scales of seconds to tens of seconds is thought to be maintained by neural activity that is triggered by a memorized stimulus and persists long after the stimulus is turned off. This presents a challenge to current models of memory-storing mechanisms, because the typical time scales associated with cellular and synaptic dynamics are two orders of magnitude smaller than this. While such long time scales can easily be achieved by bistable processes that toggle like a flip-flop between a baseline and elevated-activity state, many neuronal systems have been observed experimentally to be capable of maintaining a continuum of stable states. For example, in neural integrator networks involved in the accumulation of evidence for decision making and in motor control, individual neurons have been recorded whose activity reflects the mathematical integral of their inputs; in the absence of input, these neurons sustain activity at a level proportional to the running total of their inputs. This represents an analog form of memory whose dynamics can be conceptualized through an energy landscape with a continuum of lowest-energy states. Such continuous attractor landscapes are structurally non-robust, in seeming violation of the relative robustness of biological memory systems. In this talk, I will present and compare different biologically motivated circuit motifs for the accumulation and storage of signals in short-term memory. Challenges to generating robust memory maintenance will be highlighted and potential mechanisms for ameliorating the sensitivity of memory networks to perturbations will be discussed.

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