Modeling delayed spatial alternation behavior in the rat using a combined model of prefrontal cortex and medial temporal episodic memory function

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May 16, 2003

A model of goal directed function in prefrontal cortex (PFC) was combined with a model of episodic memory function based on interactions of the entorhinal cortex and hippocampus. This allowed simulation of behavior in a T-maze spatial alternation task, including behavioral elements that depend upon an intact hippocampus and hippocampal-independent behavior.

In the model of PFC, spike timing dependent synaptic plasticity (STDP) encodes transitions between sensory input states and motor actions which are all represented by individual cortical minicolumns. Transitions are represented by sparse intercolumnar connections linked with dense intracolumnar connections. Working memory (WM) is needed to encode associations between states visited and actions performed at arbitrary time intervals. This WM function is modeled on the basis of intrinsic membrane currents allowing ordered repetition and replacement (Jensen and Lisman, 1996). Once a sequence that reaches a goal is encoded, it can be retrieved by associative spread from the goal, allowing selection of the appropriate next action at each state. Thus, the model corresponds to a cortical implementation of state-action mappings in reinforcement learning.

In the delayed alternation task, the rat must remember its preceding behavior to find a reward in the alternate location. Episodic memory of preceding action is recalled through access to a network of entorhinal and hippocampal regions that provide sequence encoding and retrieval in distinct phases of theta oscillations. The combination of PFC and medial temporal models allows effective representation of hippocampal-independent (learning of a fixed goal location) as well as hippocampal-dependent (delayed spatial alternation) functions in the T-maze. Supported by NIMH MH 60450, MH60013, MH61492 and DA16454.