Capacity enhancing mechanisms in a hippocampal online learning model

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The hippocampal formation is involved in the online storage of episodic memories. The challenge for such a memory is to encode a continuous stream of patterns presented only once, while retaining a high-fidelity trace of each stored pattern for the longest possible holding time. Using a simplified model of the CA3-CA1 Schaffer collateral pathway, we set out to identify (or propose) circuit, cellular, and synaptic properties that help maximize the system's online storage capacity. Three principles have guided our search, and have suggested capacity-enhancing strategies. They are: (1) The principle of uniform trace strength, which favors the use of binary-valued synapses, uniform subunit thresholds, and normalization circuitry to ensure that a constant number of subunits is devoted to the storage of each pattern; (2) The principle of trace resource minimization, which leads to an LTP variant requiring that synapses be strengthened only in cohorts of sufficient size; and (3) The principle of trace resource synchronization, where through the use of synaptic tagging and age-ordered synaptic depression, the system can synchronously recover the resources consumed by patterns that have reached the end of their storage lifetimes. Each of these mechanisms has been tested in our model (representing a 2.56 million synapse chunk of the hippocampus), and has led to substantial increases in storage capacity. We will discuss the biophysical mechanisms that could contribute to these capacity enhancing strategies.