Encoding episodes in a specific temporal context depends on the reduction of interference by extending representations in dentate gyrus

Randal A. Koene & M.E. Hasselmo
Center for Memory and Brain,
Department of Psychology & Program in Neuroscience
Boston University, 2 Cummington Street, Boston, MA 02215
randalk@bu.edu

January 9, 2006

Interleaved learning is not possible during on-line episodic encoding when the presentation of input cannot be controlled [5]. In this case, sets of simultaneously spiking neurons in the dentate gyrus that represent input in a specific temporal context [1] need to be largely non-overlapping to avoid catastrophic interference [4]. Largely non-overlapping representations must be established even though input connections with previously encoded items may exist during later occurrences of similar input. Immediate multiple instantiation is required, so that a novel acquisition can be maintained during an encoding process that may take several seconds.

We propose that unrelated arbitrary spikes that occur at about the same time as the spiking of a known item elicited by novel input – coincidental coactivators – enable immediate multiple instantiation [2]. By recruiting some of the coincidental coactivators into the representations formed by patterns of spiking neurons, largely non-overlapping representations may be formed for sequence encoding. The resulting representations may be reactivated in the same order by the output of a non-synaptic short-term memory, so that the sequence of spike patterns can strengthen synapses in a target network through spike timing dependent potentiation [3]. The amount of activity that has been observed in the medial temporal lobes during tasks that involve episodic encoding is adequate to provide the necessary coincidental coactivators [6]. Once synapses are strengthened between neurons in the extended representations, a sequence can be acquired and encoded with minimal interference.

Supported by NIMH MH60013, NIMH MH61492, NIH NIDA DA16454 and the NSF Science of Learning Center SBE 0354378 “CELEST”.

[1] Hasselmo, M. and Eichenbaum, H. Hippocampal mechanisms for the context-dependent retrieval of episodes. *Neural Networks*, 2005. 18(9):1172–1190.

[2] Koene, R. *Functional requirements determine relevant ingredients to model for on-line acquisition of context dependent memory*. Ph.D. thesis, Department of Psychology, McGill University, Montreal, Canada, 2001.

[3] Koene, R., Gorchetchnikov, A., Cannon, R., and Hasselmo, M. Modeling goal-directed spatial navigation in the rat based on physiological data from the hippocampal formation. *Neural Networks*, 2003. 16(5-6):577–584.

[4] McCloskey, M. and Cohen, N. Catastrophic interference in connectionist networks: The sequential learning problem. In Bower, G., editor, *The psychology of learning and motivation*. Academic Press, New York, 1989 .

[5] Rumelhart, D. *Brain Style Computation: Learning and Generalization, In An introduction to neural and electronic networks*. Academic Press, New York, 1990.

[6] Wallenstein, G. and Hasselmo, M. GABAergic modulation of hippocampal population activity: Sequence learning, place field development, and the phase precession effect. *Journal of Neurophysiology*, 1997. 78(1):393–408.