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A Spiking Model of Hippocampus for Guiding Behavior

(NIDA R01-DA016454 FY 02)

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This grant has supported development and testing of models of neural firing patterns in the hippocampus, entorhinal cortex and prefrontal cortex which guide goal directed behavior of virtual animals performing tasks in virtual environments. Collaboration between the Hasselmo laboratory and Robert Cannon at Edinburgh has developed the java simulation package CATACOMB. CATACOMB and MATLAB simulations have replicated features of single unit spiking activity and field potentials in the hippocampus and prefrontal cortex (Hasselmo, 2005a, 2005b; Hasselmo and Eichenbaum, 2005, Koene and Hasselmo, 2005). In a collaboration between the Eichenbam and Hasselmo laboratories, experiments have tested explicit predictions from the models about the phase of firing of hippocampal units during performance of a continuous spatial alternation task. Consistent with the models, hippocampal units do show differences in phase of firing for task components where prior responses must be encoded versus task components where retrieval is required (Griffin et al., 2005). However, testing also revealed a striking, novel result in that the rate maps for hippocampal CA1 units show a systematic forward shift toward goal locations in the task (Lee et al., 2005). The model has been revised to include a potential mechanism of this forward shift based on persistent activity in entorhinal cortex neurons (Fransen et al., 2006). Models of the prefrontal cortex (Hasselmo, 2005; Koene and Hasselmo, 2005) use different phases of encoding and retrieval dynamics. Unit recording motivated by this modeling demonstrates that prefrontal units show phasic firing relative to hippocampal theta rhythm, and this phasic firing differs dependent on the current goal on a linear track (Hyman et al., 2005).

Project (or PI) Website

http://people.bu.edu/hasselmo

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Publications

1. Hasselmo, M.E. (2005a) What is the function of hippocampal theta rhythm? - Linking behavioral data to phasic properties of field potential and unit recording data. *Hippocampus*, 15(7):936-49.

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

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4. Koene, R.A. and Hasselmo, M.E. (2005) An integrate-and-fire model of prefrontal cortex neuronal activity during performance of goal-directed decision making. *Cereb. Cortex* 15(12): 1964-1981.

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6. Fransen, E., Tahvildari, B., Egorov, A.V., Hasselmo, M.E. (2006) Mechanism of graded persistent cellular activity of entorhinal cortex layer V neurons. *Neuron* 49(5):735-46

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8. Gorchetchnikov, A., Versace, M., Hasselmo, M.E. (2006) A model of STDP based on spatially and temporally local information: Derivation and combination with gated decay. *Neural Networks* 18(5-6): 458-466.

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Conference papers and abstracts

1. Lee, I., Griffin, A.L., Aggarwal, P., Eichenbaum, H., Hasselmo, M.E. (2005) Forward shift of spatial representations across time in the hippocampus on a continuous T-maze alternation task. *Soc. Neurosci. Abstr.* 31: 72.6.

2. Griffin, A.L., Lee, I., Eichenbaum, H. and Hasselmo, M.E. (2005) Phase relationship between single unit firing in CA1 and theta rhythm on a continuous T-maze alternation task. *Soc. Neurosci. Abstr.* 31: 72.7.

3. Koene, R. and Hasselmo, M.E. (2006). An integrate-and-fire model of temporal context specific episodic encoding and retrieval in the hippocampal formation. In Proceedings of the Computational and Systems Neuroscience (COSYNE) Meeting 2006, 80. Salt Lake City, UT. (#90).

4. Hasselmo, M.E. and Zilli, E. (2005) Hebbian synaptic modification in cortical circuits and memory-guided behavior in spatial alternation and delayed non-match to position. Proc. Int'l Joint Conf. Neural Networks, IEEE publishers.

5. Koene, R.A. and Hasselmo, M.E. (2005) An integrate and fire model of prefrontal cortex provides a biological implementation of action selection in reinforcement learning theory that resuses known representations. Proc. IJCNN, Montreal, CA, IEEE Publishers.

6. Gorchetchnikov, A., Versace, M. and Hasselmo, M.E. (2005) A spatially and Temporally Local Spike-Timing-Dependent Plasticity Rule. Proc. IJCNN, Montreal, CA, IEEE Publishers.