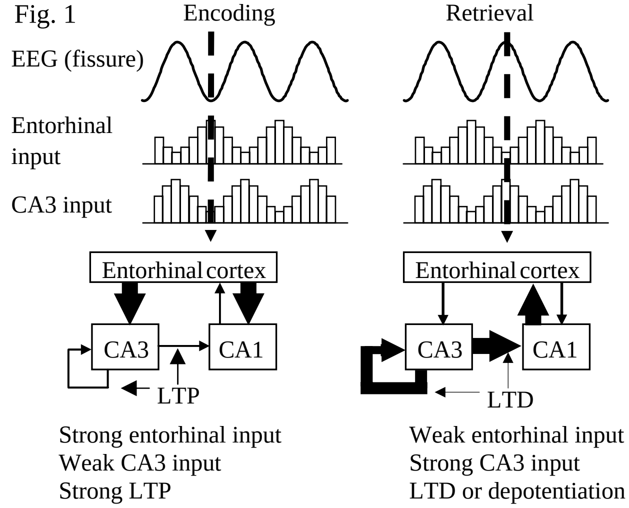
OSCILLATORY MULTIPLEXING OF ENCODING AND RETRIEVAL

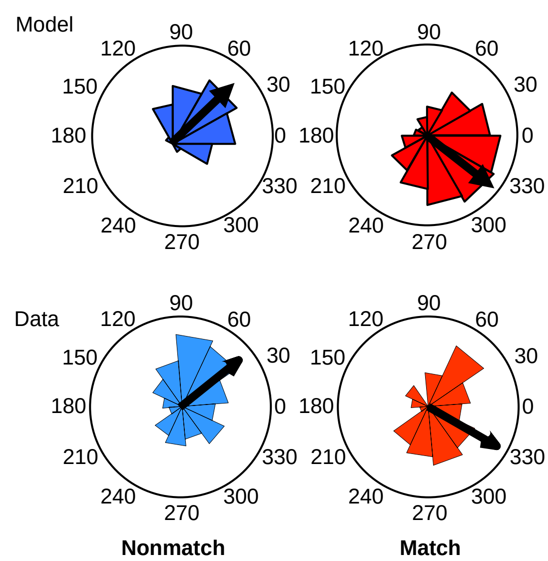
Research in thrust 4 of CELEST has developed models of the neural mechanisms for memory-guided behavior in rats. These network models demonstrate the need for separate phases of encoding and retrieval. The separate encoding and retrieval dynamics could be provided by different phases of the theta rhythm oscillation (a 4-7 Hz oscillation present in the EEG of the hippocampus and prefrontal cortex of rats performing memory-guided tasks). In the model (Fig. 1), encoding requires a strong influence of afferent sensory input (Entorhinal input) and learning in the form of changes in the strength of synaptic connections (long-term potentiation - LTP) between neurons in the hippocampus, but requires weak spread of retrieval activity from CA3 in order to avoid interference. In contrast, retrieval requires a strong spread of activity across previously modified synapses from CA3, with a reduction in learning in order to prevent retrieval from interfering with new information being encoded. These requirements fit with the oscillatory changes of synaptic transmission and synaptic modification observed during theta rhythm oscillations in the hippocampus.

Fig. 1



Our model predicts that neural spiking activity in the hippocampus should occur at different phases during the encoding of new stimuli versus the retrieval of familiar stimuli. This was tested in a behavioral odor recognition task, in which rats sniff a sample odor, and are subsequently exposed to both a match odor (which matches the sample odor) and a non-match odor (which differs from the sample). The match odor should evoke more retrieval than the non-match odor, and the model predicts that spiking in response to the match odor should occur at a different phase than for the non-match odor (see Fig. 2 Model for polar plots of spike phases). This prediction has been supported by new experimental data from the Eichenbaum laboratory (see Fig. 2 Data for plots of spike phase during nonmatch and match), supporting the model of encoding and retrieval dynamics.

Fig. 2



The understanding of EEG mechanisms involved in encoding and retrieval enhances our understanding of network dynamics necessary for effective learning processes. Understanding these mechanisms could allow better understanding of both pharmacological and behavioral techniques for enhancing learning.