Theta waves in the hippocampus and the deep layer of the entorhinal cortex become more phase-locked with increasing locomotive speed

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The theta rhythm modulates activity in hippocampus and entorhinal cortex. In the CA1 region of hippocampus, the interaction between theta and place specificity leads to a temporal code wherein the phase of firing is related to the animal's position. We hypothesized that in order for the deep layer of entorhinal cortex (dEC)—the downstream region to CA1—to faithfully respond to the temporal code, its theta wave must register to the hippocampal theta wave ('phase locking'). Four rats were implanted with electrodes in CA1 and dEC and trained to run in a T-shaped track. Both the position of the animal and local field potentials were recorded. Morlet wavelet coefficients at the peak theta-wave frequency were computed, which captured instantaneous amplitude and phase of the theta waves. The positive correlation between the power of theta waves in dEC and CA1 increased as the locomotive speed increased. More striking was the phase locking between the theta waves at the two loci. The degree of phase locking increased as the locomotive speed increased. This observation was statistically significant across all electrode pairs of all animals. Preliminary analysis suggests this strengthening of phase locking is not due to an increase in coupling between the two oscillators. Instead this is consistent with a model wherein external drive to dEC and CA1, perhaps from the medial septum, becomes more coherent at higher velocities to reduce systematic errors in registration between the two brain structures.

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