COMPUTATIONAL MODEL OF CARBACHOL-INDUCED DELTA, THETA AND GAMMA OSCILLATIONS IN THE HIPPOCAMPUS.

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Field potential recordings from the rat hippocampus contain distinct frequency bands of activity, including delta (0.5-2 Hz), theta (4-12 Hz), and gamma (30-80 Hz), that are correlated with the behavioral state of the animal. The cholinergic agonist carbachol (CCH) induces oscillations in the delta (CCH-\(\delta\)), theta (CCH-\(\theta\)), and gamma (CCH-\(\gamma\)) frequency range in the hippocampal slice preparation. Specifically, with increasing CCH-concentration asynchronous CCH-\(\theta\), synchronous CCH-\(\gamma\), and synchronous CCH-\(\delta\) is found [Fellous JM, and Sejnowski TJ, Hippocampus 10:187-197(2000)]. In a network model of area CA3, the time scale for CCH-\(\delta\) corresponds to the decay constant of the gating variable of the calcium dependent potassium (K-AHP) current, that of CCH-\(\theta\) to an intrinsic subthreshold membrane potential oscillation of the pyramidal cells, and that of CCH-\(\gamma\) to the decay constant of GABAergic inhibitory synaptic potentials onto the pyramidal cells. In model simulations, the known physiological effects of carbachol on the muscarinic and K-AHP currents, and on the distribution of the strengths of excitatory postsynaptic potentials can reproduce the transition from asynchronous CCH-\(\theta\) to CCH-\(\delta\), and from CCH-\(\delta\) to synchronous CCH-\(\theta\). The simulations also exhibit the nested CCH-\(\gamma\)-CCH-\(\delta\) and CCH-\(\gamma\)-CCH-\(\theta\) that were observed in experiments. The model also predicts a state with all three frequency bands present, which has not yet been observed experimentally.

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