466.5

IONIC MECHANISMS UNDERLYING SYNCHRONIZED OSCILLATIONS AND TRAVELING WAVES IN A MODEL OF FERRET THALAMIC SLICES

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A network model of thalamocortical (TC) and thalamic reticular (RE) neurons was developed based on electrophysiological measurements in ferret thalamic slices. Single-compartment TC and RE cells included voltage- and calcium-sensitive currents described by Hodgkin-Huxley type of kinetics. Synaptic currents were modeled by kinetic models of AMPA, $GABA_A$ and $GABA_B$ receptors. The model reproduced successfully the characteristics of spindle and slow bicuculline-induced (SBI) oscillations. The most critical parameters were: (a) the mutual recruitment between TC and RE cells, due to their reciprocal connectivity. The time course of GABAergic IPSPs from RE to TC determined the frequency of oscillations (8-12 Hz spindle or 2-4 Hz SBI). (b) Cooperativity in the activation of $GABA_B$ responses, which are absent during spindles. If the intra-RE $GABA_A$ IPSPs were suppressed, the stronger discharges of RE cells enhanced $GABA_B$ IPSPs in TC cells, recruiting TC and RE neurons in the slower highly synchronized SBI oscillations. (c) A TC origin for the "waning" of these oscillations, through the upregulation of I_h by intracellular calcium, leading to a refractory period in these cells. (d) Local axonal arborization of the TC-RE and RE-TC projections, which allowed traveling phenomena to occur. The model predicts that intrinsic properties of TC and RE neurons and their reciprocal connectivity establish a highly excitable structure; stimulation at any location can induce a oscillatory travelling wave through the reciprocal recruitment of TC and RE cells. The presence of a refractory period in TC cells accounts for the waxing and waning properties of the traveling waves, collisions between waves and the slower propagation of highly synchronized SBI oscillations.