Proportional excitatory and inhibitory conductances are maintained during gamma oscillations

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Gamma oscillations, the synchronous spiking of neurons at 30-80 Hz, occur in many cortical areas and are thought to play a role in sensory processing. Several studies focusing on the mechanisms underlying these oscillations demonstrate that both inhibitory and excitatory neurons in cortical networks participate in these rhythms. Experiments also indicate that the amplitude of gamma oscillation cycles is modulated in a behaviorally relevant manner. Here we investigate how inhibition and excitation varies during the modulation of gamma oscillation amplitude.

Recordings were performed both in vivo and in acute hippocampal slices from 2-5 week-old rats. Gamma oscillations were induced pharmacologically in vitro (50-250 nM kainate) and monitored using an extracellular electrode placed in the stratum radiatum of area CA3. To directly compare the amplitude of inhibition and excitation on a cycle by cycle basis, we recorded inhibitory postsynaptic currents (IPSCs) in one CA3 pyramidal cell, voltage-clamped at the reversal potential for excitation, while simultaneously recording excitatory postsynaptic currents (EPSCs) in a second neighboring pyramidal cell, voltage-clamped at the IPSC reversal potential. Both excitation and inhibition occurred rhythmically with a period of approximately 30ms. During each oscillation cycle, IPSCs occurred after EPSCs with an average latency of 1.5ms, consistent with pyramidal cells exciting interneurons during each oscillation cycle. Furthermore, we found that the peak amplitude of both inhibitory and excitatory conductances changes from cycle to cycle yet their ratio remained constant. In fact, the inhibitory conductance was proportional to the excitatory conductance within each cycle for conductances ranging over an order of magnitude (0.2 to 8 nS and 1 to 20 nS for excitation and inhibition respectively). Our data suggest that area CA3 maintains proportionality between excitation and inhibition during gamma oscillations.

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