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大鼠癫痫电网络重建中海马神经元原发性单位后放电脉冲间隔特征

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本文旨在探讨跨不同神经结构癫痫电网络形成中，海马（hippocampus, HPC）神经元原发性单位放电形式及其瞬时时间编码（temporal coding）特征。实验用雄性SD大鼠117只，体重150~250g。急性强直电刺激（60 Hz, 2s, 0.4~0.6mA）右侧后背HPC（acute tetanization of the right posterior dorsal hippocampus, ATPDH）或右侧尾壳核（acute tetanization of the right caudate putamen nucleus, ATRC），记录HPC 深部电图或新皮质EEG，细胞外同步记录同侧或/和对侧前背HPC单位放电。重点分析HPC原发性单位后放电脉冲间隔时间（interspike interval，ISI）、ISI(n, n+1)和放电串内频率。结果：（1）ATPDH或ATRC可以诱导HPC电图（70~150Hz）或新皮质电图（90~280Hz）高频电振荡，伴有HPC神经元原发性单位后放电。（2）后放电期间，低小密集的ISI点分布成“头”部、高大分散的ISI点形成“尾”部，“头”、“尾”的强度和比例反映了神经环路输出的兴奋和抑制效应。（3）ATPDH诱导61.40%（35/57串）原发性单位后放电呈现“尾头”式ISI点分布，“尾”与“头”的持续时程不同（P<0.05）；而ATRC诱导54.55%（12/22串）原发性单位后放电呈现“头尾”式ISI点分布，“头”与“尾”的持续时间也有明显差异（P<0.05）。（4）ATRC诱导双侧HPC神经元出现交互的原发性单位后放电，其ISI点分布也具有“头尾”或“尾头”的交互特征。（5）施加多个ATPDH或ATRC串后，均可以诱导同侧HPC神经元重复出现“尾头”式ISI点分布的原发性单位后放电，ATRC诱导的单位后放电ISI点分布各串间“头”、“尾”持续时间的差异显示出更大的可塑性特征。结果提示：电刺激诱导的HPC神经元原发性单位后放电特定的ISI和ISI(n, n+1)点分布形式可能是网络癫痫发作样电振荡形成中重要的神经信息基础。

Characteristic interspike intervals of hippocampal primary unit afterdischarges during epileptic network reconstruction in rats

The purpose of our present work was to study the firing and temporal coding pattern of hippocampal primary unit afterdischarges during epileptic network reconstruction. Experiments were performed on 117 male Sprague-Dawley rats weighing 150-250g. Acute tetanization (60Hz, 2s, 0.4~0.6mA) of the right posterior dorsal hippocampus (ATPDH) or the right caudate putamen nucleus (ATRC) was used to induce seizures. Hippocampal or neocortical electrographs, simultaneously with ipsilateral or/and contralateral hippocampal unit discharges were recorded. The interspike intervals (ISI), ISI(n, n+1) and firing rate of hippocampal primary unit afterdischarges was focused on. The results included: (1) high frequency hippocampal EEG (70~150Hz) or neocortical EEG (90~280Hz) oscillations induced by the ATPDH or the ATRC, companying with hippocampal primary unit afterdischarges; (2) the lower and dense ISI spots of primary unit afterdischarges formed “head” part, while the higher and sparse ISI spots produced “tail” part, which reflected the inhibitory or excitatory output effects of necessary neural circuits; (3) 61.40% (35/57 trains) ATPDH-induced primary unit afterdischarges in different duration of ISI “tail” and “head” distribution (P<0.05); 54.55% (12/22 train) ATRC-induced primary unit afterdischarges in different duration of ISI “head” and “tail” distribution (P<0.05); (4) ATRC-induced primary unit afterdischarges interacted between contralteral and ipsilateral HPC with characteristic “head-tail” or “tail-head” ISI distribution; (5) repeatable hippocampal unit afterdischarges with “tail-head” ISI distribution induced ipsilaterally by a series of ATPDH or ATRC trains, the latter manifested more plasticity. It suggests that the tetani-induced characteristic ISI or ISI(n, n+1) spot distribution of hippocampal primary unit afterdischarges might be the important neural information basis of epileptic network activity reconstruction.

关键词

海马单位后放电(hippocampal unit afterdischarges); 脉冲时间间隔(interspike intervals); 高频电振荡(high frequency oscillations); 电图(EEG); 电刺激(tetanization)