

Prêmio

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Theta-phase modulates different high-frequency oscillations in the CA1 region of the hippocampus during both waking and rapid-eye movement sleep.

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Resumo

Recent evidence suggests that not only the brain rhythms per se, but also the interactions among them are involved in the execution of cognitive tasks, mainly those requiring selective attention, information transmission and memory consolidation. However, still little is known about the general characteristics of cross-frequency coupling (CFC) in several brain regions. In the present work, we aimed to characterize phase-amplitude CFC in the CA1 region of rats ($n=9$) during different stages of the sleep-wake cycle: wake (WK), slow-wave sleep (SWS), and rapid-eye movement sleep (REM). Local field potentials were recorded using multielectrode arrays implanted in the dorsal hippocampus for chronic neural recordings. Electrode positioning was verified by histological analysis of cresyl-stained brain sections. Phase-amplitude coupling was assessed by means of the comodulogram analysis, a CFC tool we have recently developed. Our results show that (1) each sleep-wake state contains characteristic patterns of phase-amplitude CFC that are robust across all animals studied. (2) The CFC patterns obtained during WK and REM are similar and characterized by theta-phase (5 – 10 Hz) modulation of multiple higher frequencies; on the other hand, comodulograms from SWS period exhibited a distinct pattern, characterized by the modulation of very fast oscillations (> 100 Hz) by delta-phase (0 – 4 Hz), consistent with the occurrence of sharp wave-ripple complexes. All these patterns were stable across electrodes and days. Interestingly, during WK and REM, our results indicate that (3) theta-phase modulation comprises two non-overlapping, circumscribed higher frequency ranges: oscillations in the high-gamma (HG, 60 – 100 Hz) frequency range and oscillations between 120 – 160 Hz, which were defined as high-frequency oscillations (HFO). Moreover, (4) theta-phase preferentially modulated more HG or HFO depending on the spatial position of the electrode, with a clear switching between one and another as a function of electrode location, which was also stable across days. Further analyses indicated that (5) electrodes exhibiting HG or HFO modulation during WK and REM can also be differentiated by other electrophysiological features, such as power spectrum, phase-relations, and SWS comodulograms. We argue that the HFO we observed, though presenting overlapping frequency range with ripple oscillations, are distinct from the latter, which only appear in periods of rest and sleep associated to sharp-wave complexes. Therefore, while characterizing the patterns of rhythmic interactions in different cognitive states, the present work also reveals novel hippocampal oscillations that could only be detected by the use of the new CFC tools. We speculate that the different amplitude-modulated bands correspond to different biophysical processes occurring in CA1: HFO would result from entorhinal synaptic inputs to CA1, and HG from CA3 inputs.

Palavras-chave: Comodulogram, high frequency oscillation, hippocampus, theta