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Cholinergic modulation of neuronal excitability underlies differential dynamics and roles of NREM and REM sleep during sleep dependent memory consolidation.

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Across vertebrate species, sleep states are known to cycle consistently from non-rapid eye movement (NREM) to REM sleep. However, the functional significance of these transitions is unknown. We use a simplified biophysical network model to show that state-specific changes in cholinergic signaling during NREM and REM sleep can mediate dramatic changes in network dynamics and subsequently can play differential and critical role in sleep dependent memory consolidation. Specifically, we show that the sequential, bidirectional changes in cholinergic neuromodulation during these sleep states plays a vital role in memory consolidation, particularly when multiple memory traces are being stored simultaneously. The low-ACh (NREM-like) state, mediates rapid recruitment of new cells into the memory engram, and their consequent enlargement, while subsequent high-ACh (REM-like) state suppresses activity among newly recruited excitatory pyramidal neurons during prior NREM, leading to the orthogonalization of newly enhanced representations of different memory traces. We further find that, this iterative sequence of state-specific network dynamics is essential for memory storage in the network.

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