Stages of sleep have distinct influence on process of learning and memory

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Research on the sleeping brain has revealed some fascinating stage-dependent interactions between areas involved in formation and storage of long term memories. The study, published by Cell Press in the February 26th issue of the journal *Neuron*, may also provide a framework for further understanding the role of sleep in memory.

Mammalian sleep occurs in two discrete stages, slow wave sleep (SWS) and rapid eye movement (REM) sleep. One of the many ways in which SWS and REM sleep differ is in the level of synchronous firing in the hippocampus. Previous research has suggested that coordinated activity between the hippocampus (a brain area critical for memory formation) and the neocortex (where long-term memories are stored) may be critical for memory formation.

"Given the importance of synchrony and spike timing in synaptic plasticity, and given the putative role of sleep in learning and memory, a key question is whether consistent spike timing relationships exist across cortico-hippocampal circuits during sleep, and whether these differ in SWS versus REM sleep," explains senior study author, Dr. Athanassios G. Siapas from the California Institute of Technology. Dr. Siapas and colleagues used sophisticated recording and computational techniques to examine the activity of neurons in the hippocampus and prefrontal cortex in sleeping rats.

The researchers observed highly consistent directional interactions between the hippocampus and neocortex during SWS, but only during discrete bursts of activity in the hippocampus known as "ripples", suggesting that these bursts may represent a basic unit of information transfer. There was a non-linear relationship between the magnitude of hippocampal signals and the patterning of prefrontal responses, suggesting that variations in the strength of hippocampal bursts may lead to qualitatively different cortical responses.

Interestingly, the coupling between the hippocampus and prefrontal cortex was greatly reduced during REM sleep. Previous computational models of memory consolidation have supported a need for gradual transfer of memory traces from the hippocampus to the neocortex and for a reorganization of memory traces without external input. The current findings suggest that transfer and reorganization may be met by SWS and REM sleep, respectively.

The researchers went on to speculate that the disconnection between the hippocampus and prefrontal cortex during REM sleep may explain some of the persistent mysteries associated with REM sleep. "It's possible that the scarcity of coordinated cortico-hippocampal spiking during REM sleep may explain why the awake-like neural activity in the prefrontal cortex during REM does not interact strongly with the hippocampus and therefore why dreams are, on the whole, forgotten," offers Casimir Wierzynski, a graduate student in Dr. Siapas's lab and lead author of the paper.

Source: Cell Press