SLEEP AND MEMORY

Memory consolidation…while you are sleeping

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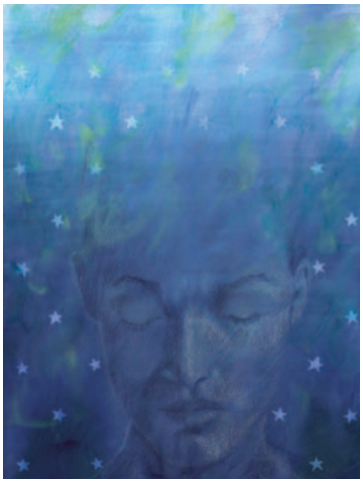

During the first phase of sleep our brain is occupied with our last awake experiences. Does this 'revisiting' of events consolidate these experiences as memories? In *Nature Neuroscience,* Ji and Wilson have now shown that the firing patterns during awake experiences are replayed in the hippocampus and cortex in a coordinated manner during slow wave sleep (SWS), suggesting a mechanism for memory consolidation.

SWS describes the low frequency of brain waves recorded by electroencephalography (EEG); it is characteristic for deep sleep, which normally occurs within the first 3 hours of a night's sleep. Multiple studies have shown that recent experiences are replayed (sleep reactivation) during this first phase of sleep. The current theory for memory consolidation assumes that crosstalk between brain regions transforms recent memory in the hippocampus into long-term memory in the cortex. Ji and Wilson have investigated whether sleep reactivation is involved in the processing and formation of episodic memory by recording and comparing firing patterns in the hippocampus and the visual cortex of rats during sleep prior to a task, during task performance (maze-running) and during sleep after the task. The animals used in these studies were trained daily over a period of up to 3 weeks in this sleep–run–sleep pattern before recordings took place.

Initially the researchers showed that there was a direct correlation between the firing patterns that occurred in the visual cortex and the hippocampus during SWS and that this correlation was independent of when the sleep session occurred. Cortical firing patterns always preceded hippocampal firing patterns, indicating that the cortex drives the hippocampus.

During the maze-running task, the researchers observed that cells of the visual cortex have spatially localized firing patterns, very much like the 'place cells' in the hippocampus, which are active if the rat is in a specific location. This finding allowed them to compare the firing sequence of cells during task performance and during sleep replay in both brain areas. The researchers showed that during SWS, firing patterns occuring in the visual cortex and the hippocampus reflected the patterns that had been expressed during awake behaviour. But differences between memory reactivation in the cortex and hippocampus emerged. Although reactivation was detected in the cortex during all sleep sessions, the hippocampal reactivation was most robust during sleep that immediately followed awake behaviour, suggesting that cortical traces tended to reflect older memories, whereas hippocampal traces tended to reflect recent memories. The cortex also seemed to lead the hippocampus in the initiation of these memory replay events, but the hippocampus seemed to lead the cortex in the detailed replay of the memory sequences themselves, suggesting different roles for these structures in the memory dialogue. Therefore, the authors concluded that cortical and hippocampal replays are coordinated to match the same awake experience during SWS.

These findings support a bidirectional interaction model between the hippocampus and the cortex for memory consolidation. It would also be interesting to see whether semantic memory, the recollection of facts and concepts, follows the same principle of memory consolidation as

ORIGINAL RESEARCH PAPER Ji, D. & Wilson, M. A. Coordinated memory replay in the visual cortex and hippocampus during sleep. *Nature Neurosci.* **10**, 100–107 (2007)

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