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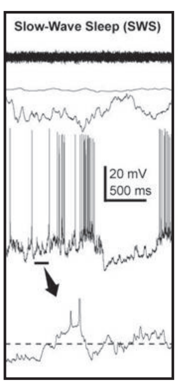
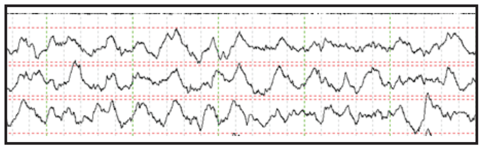
Slow Wave Sleep and Memory

Stage II sleep may be important for memory consolidation, especially for motor procedural tasks like playing the game "Operation". Slow wave sleep is also important in memory. The lion's share of slow wave sleep is in the first part of the night. This is because the first sleep cycle contains the greatest percentage of slow wave sleep and this percentage decreases with each sleep cycle as they progress through the night. It stands to reason that if one stage was for uploading new memories and another stage was for processing and assimilating them into the store of existing memories, then the stage responsible for the initial upload should occur first. All the mazes and wheels of rat studies have taught us that the hippocampus is crucial for the temporary storage of memory.[1] However, over time, memories gradually become independent of the hippocampus.[2 3 4 5]



The trickiest thing to realize about slow wave sleep is that it is not at all what it initially seems to be. When reading a sleep study, it seems to be just what it has been named: slow wave sleep. The brainwaves are very slow, usually one to two cycles per second and in comparison to other brainwaves, very large in amplitude. The key is that embedded within each wave of slow wave sleep is the firing of many, many fast spiking brainwaves. The reason that they appear to be slow is that the whole cortex at once is firing together in synchrony. The majority of the neurons that are responsible for the summed contribution that leads to slow waves reside in the cortex and it seems that most arise predominantly from the frontal lobes. It is this predominantly frontal lobe synchronous firing resulting in the appear-

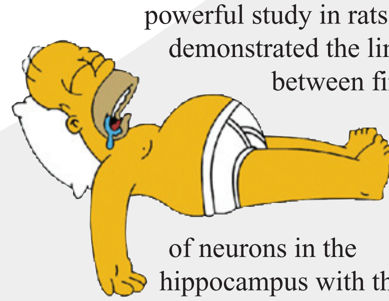


ance of slow wave sleep that is crucial for the acquisition of new memories.[6 7 8]

Not surprisingly, there is a link in timing of these slow waves and firing patterns of cells in the hippocampus. With each ebb and tide of these slow waves, lapping the cortex with information like waves washing up on the beach, hippocampal memories may be "uploaded" back into the cortical networks from which they were initially experienced. This leads to the sprouting of new connections among neurons that provides the formation of long-term memories.[10]

The sleep spindles of stage II sleep may be priming the cortex for the reception of information brought by the lapping slow waves. There is even data to support the idea that the firing of individual neurons in the cortex during slow waves drives spindle activity from the thalamus back to the cortex.[11] The system feeds itself. In this way, the hippocampus is able to broadcast its message to the cortex.[12]

Apparently all of the action isn't limited to the frontal lobes. A really powerful study in rats demonstrated the link between firing



of neurons in the hippocampus with those of the sensory parietal cortex in the back sensory part of the brain. It seems that the neurons in the sensory cortex that were actually firing during the actual experience lived by the rat as it explored a new environment were linked with the firing patterns in the hippocampus that housed the temporary storage of that experience. The magic is that this exact pattern of linked firing simultaneously seen in both the hippocampus and the sensory cortex was then repeated during slow wave sleep.[13] This study is so powerful because it now links the temporarily stored memories of the day with what the brain is about to dream during REM sleep. The dream may be incorporating the temporary memories of the day; seen not only in dream diaries but now also in the actual neurons involved in the process.[14]

Thus, REM sleep, the sleep spindles of stage II sleep, and the slow undulating waves of slow wave sleep are all important in memory consolidation, for different, but complimentary reasons.

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