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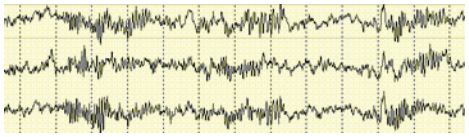
# Sleep Spindles and Motor Procedural Memory

REM sleep is important in memory consolidation. However, the idea that only REM sleep and no other stage of sleep is important in memory consolidation was a result of some of the early studies during the 1970s and 1980s that demonstrated that REM sleep would increase after learning but the same increase would not be seen for slow wave sleep.[1 2 3] More recently studies have attributed a role for part of the memory consolidation process to slow wave sleep and the sleep spindles of stage II sleep. Sleep spindles are crescendo, descrescendo waves that buzz along at twelve to fourteen cycles per second during stage II sleep and come and just as quickly go over the course of several seconds.[4] Despite the fact that the amount of time spent in stage II sleep is greater than any other stage of sleep, for the most part the function of sleep spindles and stage II sleep has really been a mystery.

Despite the fact that sleep spindles were initially thought to be shutting down the cortex as it descends into slow wave sleep, during sleep spindles neurons in the cerebral cortex receive strong excitation from the thalamus. Spindles trigger an influx of calcium ions into cortical neurons.[5 6] This calcium influx may also be involved with gene expression in these neurons which could then lead to changes such as making new proteins required for making new synapses with other neurons.[7 8]

The pursuit rotor task is a motor procedural task. In one study, college students learned this task, were allowed to sleep for the first half of the night, and then were either exposed to either specifically REM sleep deprivation or total sleep deprivation during the last half of the night. Upon next day testing, the pursuit rotor task was poorly remembered by the group that obtained the least amount of stage II sleep. The control group who slept normally had the most stage II had the best pursuit rotor scores.[9]

Another study involving a simple finger tapping task demonstrated that learning was



improved by 20% if subjects were allowed a night of sleep between training and retesting. This study also observed that there was a very high correlation between post-sleep performance and the amount of stage II sleep. In this study, this was especially true for the stage II sleep that was obtained in the last quarter of the sleep night.[10] Why this is true is unclear but it may have something to do with the fact that the greatest amount of REM sleep is seen during the last quarter of the night and it may be the succession of stage II sleep before this crucial REM sleep time that is important. It may be that the sleep spindles of stage II sleep are setting the stage just prior to the greatest amount of REM sleep. This idea awaits experimental confirmation.[11]


In another study involving a series of procedural motor tasks in human subjects that included the pursuit rotor task, a motor task involving dexterity with a ball and cup, a direct trace task, and while playing the fine manual dexterity game "Operation", where the subject has to remove "body parts" such as the "funny bone" from the "patient", there was a marked increase in the total number of sleep spindles for the groups that did well on post training retesting. Subjects that were not exposed to the tasks showed no change in number of spindles. These results support the idea that sleep spindles have something to do with the memory processing of motor procedural tasks,[12] or tasks that involves manual dexterity. The oscillatory buzzing of the sleep spindles may be priming the neurons in the cerebral cortex for getting ready to make new connections with other neurons.[13 14]

Stage II may be specifically important in motor procedural skills, a mandatory transitional stage, or it may also have a priming effect that sets the stage immediately before the dance of memory associations seen during REM sleep. Only time and more research will tell.

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