CONNECTING MEMORY AND REM SLEEP

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Many professionals who study sleep and its disorders can attest that the relationship between memory and sleep has been well established but the exact mechanisms involved in memory and sleep remain elusive. Several studies have confirmed the hypothesis that sleep contributes to processes of memory consolidation and brain plasticity. Human sleep has been shown to improve performance on motor-sequence memory tasks as compared to equivalent waking periods that produced no such improvement. Dynamic central nervous system (CNS) changes that occur during both REM and NREM sleep may contribute to memory encoding, memory consolidation and reconsolidation as well as brain plasticity. Recent studies specifically looking at REM sleep and memory have provided us with valuable information about the important potential role of REM sleep and memory. These findings have far-reaching implications regarding not only optimal daytime performance but also implications regarding certain prescription medication treatments of sleep disorders that suppress REM and rehabilitation following brain trauma or stroke. Of clinical importance is our ability to determine if the quality and quantity of our patient's REM sleep is sufficient to support optimal learning processes. In order to properly describe the relationship, if any, between learning and REM sleep, it will first be necessary to provide an explanation of what is currently known about memory, the related neural processes that occur in REM sleep and discuss recently published studies that provide us with information on what we now know about REM sleep and memory.

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What we now know that memory is separated into two basic categories: Long-term memory (LTM) and short-term memory (STM). It is felt that STM is converted to LTM where it can be retrieved later if the memory is sufficiently rehearsed and meaningful to the individual. This conversion is referred to as encoding and memories may be altered or lost if the memory was not sufficiently rehearsed or lacked sufficient meaning. This failure to encode is common because the storehouse of LTM is not limitless. Certain memories can often partially or completely fade over time as memories are no longer needed or meaningful to the individual. One may no longer remember what kind of cake was offered during their sixteenth birthday but they will remember the car they received as a gift that year. It is felt that memories become encoded into LTM through the action of the hippocampus which is an iron-laden area of the brain located in the medial temporal lobe of the brain as well as the prefrontal cortex; predominately the left hemisphere of.

Some researchers believe that one of the executive functions of the prefrontal cortex is in playing a key role in efficient memory storage and organization. Further, observed changes in the adult hippocampus seem to be responsible for the deletions of old memories and support for the formation of additional memories. The process by which encoding of memories in the central nervous system (CNS) occurs is still theoretical though scientists know that specific types of memory make it into LTM. The types of memory that become encoded are declarative memory, which is made up of episodic and semantic memory and, procedural or implicit memory.

Declarative memory is that aspect of memory that includes facts that can be discussed or "declared." The 2 categories of declarative memory include episodic memory and semantic memory. Memories of events, times, places and the emotions associated with these facts as well as concepts related to an experience are episodic memories. Semantic memories are updated aspects of episodic memories that come from multiple exposures to the original episodic memory. For example, when you think back to your first exposure to a CPAP machine the "episode" conjures up an image. Over time, your usage of CPAP may have allowed you to use multiple CPAP units which updated your initial reference and modified your original experience. Procedural or implicit memory is your ability to use long-term memories as skills. Your ability to appropriately titrate a patient with obstructive sleep apnea using CPAP makes use of procedural memory. Different mechanisms and brain circuits govern each type of memory and it seems that sleep assists in this regulation process.

Some studies that have downplayed the effect of REM sleep on memory consolidation citing the fact that people taking REM-suppressing drugs often do not report serious memory problems. Further anecdotal evidence to support this viewpoint includes the fact that retaining some memory following an all-nighter before a college exam is possible. However, REM sleep, most of which occurs during the latter one-third of the sleep period, seems to be related to improvement in pattern recognition providing a more efficient use of STM. Musicians often report that learning a difficult piece of music is made easier the morning after a good night's sleep. This type of improvement is also seen when learning a new language or the ability to play chess or other tasks where pattern recognition is essential. Researchers at Harvard and McGill universities showed that participants in an experiment performed better on a simple matching task if they were given the opportunity to sleep as compared to participants who did not sleep. This study indicated that per-

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haps insights that occur during sleep promote enhanced performance.

Following the discovery of REM sleep by Aserinsky and Kleitman in the 1950's, much research was devoted to trying to determine processes specific to REM sleep. Most of this early research dealt with dream content that ultimately did not provide significant insight into our knowledge of memory consolidation, and the study of REM sleep faltered for a few years. Lately however, the technology is now available to study the CNS in ways that provide information indicating that the portions of the CNS felt to be responsible for memory, the prefrontal cortex and the hippocampus, communicate with each other and that these communications may be unique to REM sleep.

The electrical activity of the prefrontal cortex and hippocampus in mice was monitored by researchers at MIT. They found that during sleep, certain electrical activity in the visual center of the neocortex was followed a fraction of a second later by a response in the hippocampus. That electrical response was a replay of electrical activity seen in the hippocampus that occurred during the day during a maze task. This apparent communication within the brain was felt to be an off-line conversation between the neocortex felt to be responsible for conscious learning while awake and the hippocampus. It seems likely that the visual center in the neocortex sent signals to the hippocampus asking for maze information and the hippocampus responded. The findings of this study are made more compelling since communication with the hippocampus occurred between the visual centers of the neocortex where eye movements may support visual messages. In 1998, researchers in Toronto recorded bursts of 4-7 Hz (theta) activity from a specific area in the hippocampus during REM sleep. While the meaning of this activity is still unclear, it suggests that some neurophysiologic process related to REM sleep occurs in an area of the brain felt to be responsible for the consolidation of memory. Since the hippocampus is known to contain large iron particles, it was felt that perhaps the hippocampus is acting as a large iron-core electromagnet responsible for encoding and decoding memory traces. Much like the recording of a videotape using magnetized electrical fields to place electrons on the surface of the tape, the hippocampus seems to be coding areas within the neocortex.

Going to sleep may be likened to simultaneously hitting the play and record buttons on a VCR to record the events of the day for declarative memory processing. Attaining REM sleep may be likened to sorting those recordings into packets that make sense and are easily retrievable for procedural memory usage. Researchers at Harvard University have suggested that memories stored in STM older than about 48 hours become diffuse, fragmented or completely lost following sleep deprivation. It was speculated that REM sleep acts a method of sorting memories into CNS areas responsible for holding these memories. Where visual memories are placed in the occipital lobe, emotions are placed in the frontal lobe and language is stored in the left temporal lobe much like sorting cards into a rolodex. However, this interpretation while compelling remains theoretical and speculative.

The research into sleep and memory has opened some exciting windows into the process and functionality of sleep in general. It does seem certain that dynamic processes within the brain are at work during sleep and that both states of sleep contribute to our knowledge of the world and our place within it. While there are several less than desirable effects of missing out on quality sleep, giving up on memory and subsequently cognitive function should provide a more compelling argument for optimizing sleep either through compliance with treatments for sleep-related breathing problems or obtaining the proper amounts of sleep to avoid minimizing REM. Clinically, knowing not only the quality but also the quantity of both REM and NREM sleep is critical in our understanding of the severity of our patient's sleep disorders and clinical studies that do not include this information may under serve our patients.

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