BRAIN SLEEP MEMORY PRODUCTIVITY

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Chapter 1

Classification of Memory

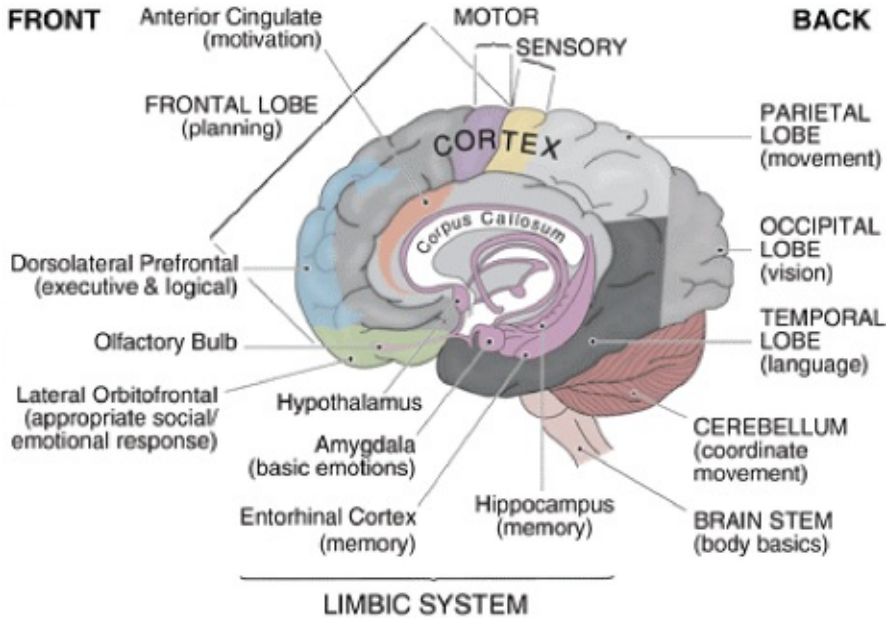
Long Term Memory: Declarative memories composed of Semantic memory for facts and events are encoded in Hippocampus, entorhinal cortex and Perirhinal cortex within the medial Temporal lobe. Declarative memories are consolidated and stored in the temporal cortex and elsewhere. It is well established that the Medial Temporal Lobe (MTL) is critical for long-term declarative memory formation and retrieval. Several researchers have summarized evidence showing that MTL is engaged in short-term tasks. Memory: Enduring Traces of Perceptual and Reflective Attention [8]

Declarative memory comprises of episodic memory based on specific events, or episodes and semantic memory. Semantic memory is the ability to recall facts and concepts, often referred to as common knowledge. Stress can have a significant impact on the formation of declarative memory.

Episodic memory is the capacity to experience an event. It is the memory of Autobiographical events such as times, places, associated emotions, and other contextual who, what, when, where, why knowledge, that can be explicitly stated or conjured. It is the collection of past personal experiences that occurred at a particular time and place. Episodic memory is sometimes confused with autobiographical memory, and while autobiographical memory involves episodic memory, it also relies on semantic memory. It has to be encoded and consolidated. Episodic memory can be affected by trauma to the brain and can be affected by other brain disorders. Episodic memory is sustained by medial temporal lobe (MTL) and hippocampus. Episodic memory stores specific personal experiences, while semantic memory, stores factual information. The brain while storing a memory, also decides how important that memory is.

Procedural memory or implicit memory is a part of the long-term **memory**. It stores information on how to perform certain procedures, such as walking, talking and riding a bike. Procedural memories are formed when repeated signals

reinforce synapses. Procedural memories do not involve the hippocampus but are encoded and stored by the cerebellum, putamen, caudate nucleus and the motor cortex, all of which are involved in motor control. Damage to certain areas of the brain such as the cerebellum and basal ganglia can affect procedural learning. These learned motor activities can be assimilated even after a long spell of not practicing.



*Picture adopted from Brian Waves

Spatial memory is the part of **memory** responsible for recording information about one's environment and **spatial** orientation. For example does the individual remember where the car is parked in the parking area? Studies using functional magnetic resonance imaging (fMRI), for example, show that the hippocampus is involved in the navigation of large-scale virtual worlds and in learning the location of objects placed in a virtual arena. Spatial representations of the environment include the hippocampus and surrounding medial temporal lobes. This area covers episodic memory as well. Scientists believe that the memories formed by the hippocampus get stored in various areas of the cerebral cortex also known as grey matter. So the preservation of the large synapses could be a basis of this necessarily resilient memory. [9]

Researchers have demonstrated that procedural and declarative memory formation appears to be controlled by different parts of the brain. In addition, these memory systems can function independently. Long term memory is stored in different parts of the brain.

Semantic memory refers to general world knowledge such as facts, ideas, meaning and concepts that can be articulated and is independent of personal experience. This includes world knowledge, object knowledge, language knowledge, and conceptual priming. The part of the brain responsible for semantic memory is the anterior temporal lobe.

Neuroimaging has shown that “Short term memory (STM) depends on left inferior frontal and left parietal cortices; spatial STM on right posterior, dorsal frontal and right parietal cortices; the neural correlates of the reputed separability of STM buffers and object/visual STM on left inferior frontal, left parietal, and left inferior temporal cortices. Verbal STM shows a marked left hemisphere preference, whereas spatial and object STM can be distinguished mainly by a dorsal versus ventral separation in posterior cortices. So the preservation of the large synapses could be a basis of this necessarily resilient memory. Brain mechanism in short term memory tasks can be completed only with storage buffers, various focus of attention concentration and different levels of activation

Verbal encoding appears to be strongly left-lateralized in the medial temporal lobe of the human brain; however, its functional neuroanatomy can vary between individuals. [10] Memory loss is often due to neuronal deterioration. Currently, these illnesses are irreversible, but research into stem cells, psychopharmacology, and genetic engineering hold much promise. Alzheimer’s leads to an uncontrolled inflammatory response brought on by extensive amyloid deposition in the brain, which leads to cell death in the brain. This gets worse over time and eventually leads to cognitive decline, after the loss of memory. It is suggested that Pioglitazone may improve cognitive impairments, including memory loss and protect long term and visuospatial memory caused by Neurodegenerative Diseases. However keep in mind it is a medication for Diabetes. Pioglitazone improved cognition in a pilot study Research Gate [11].

Biological underpinnings at the cellular level: Long-term memory, unlike short-term memory, is dependent upon the construction of new proteins. This occurs within the cellular body, and concerns the particular transmitters, receptors, and new synapse pathways that reinforce the communicative strength between neurons. The temporary expulsion of magnesium frees NMDA (N-methyl-D-aspartate) receptors to release calcium in the cell, a signal that leads to gene transcription and the construction of reinforcing proteins. For more information, see long-term potentiation (LTP). Also, Brain-derived neurotrophic factor (BDNF) is important for the persistence of long-term memories. By *Costa-Mattioli M, Sonenberg N; Sonenberg 2008* [12] Further research by

Bekinschtein, Pedro; Cammarota, Martin; Katche et.al., suggests that “BDNF is essential to promote persistence of long-term memory storage” This is reported by Proceedings of the National Academy of Sciences of the USA. [13]

Entorhinal cortex works independently of hippocampus. The scientists discovered that apart from the hippocampus, the sMEC was also firing neurons during sleep and waking states. As Prof. Csicsvari explains, these results change our understanding of memory formation. The entorhinal cortex could be a new system for memory formation that works in parallel to the hippocampus.

The hippocampus alone does not dominate how memories are formed and recalled. Despite being interrelated, the two regions may recruit different pathways and play different roles in memory according to researchers.

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Chapter 2

Sleep cycles and patterns

Sleep is important to a number of brain functions and important to maintain the functioning of neurons (including how nerve cells (neurons) communicate with each other.) In fact, brain and body stay remarkably active during sleep. Recent findings suggest that sleep plays a housekeeping role that removes toxins in the brain that build up while awake. Everyone needs sleep, but its biological purpose remains a mystery. Sleep affects almost every type of tissue and system in the body – from the brain, heart, and lungs to metabolism, immune function, mood, and disease resistance. Research shows that a chronic lack of sleep, or getting poor quality sleep, increases the risk of disorders including high blood pressure, cardiovascular disease, diabetes, depression, and obesity.

Reasons for sleep is for Energy Conservation; all the waste produced by brain to clean up after a day of intense cognitive activity. Repairs cellular structure, replenishes with necessary chemicals, removes metabolic waste products. Sleep promotes computational processing such as consolidation of memory (Acsády, & Harris, 2017 (14) accordingly, sleep has been linked to the underlying processes needed to carry out various aspects of cognition, including forgetting unnecessary information accumulated during the day. For example, Crick and Mitchinson in (1983) proposed that one of the functions of REM sleep may be to remove unhelpful information that accumulates during the day. The vivid images and strange story lines of dreams might be related to this review of and clearance of information. They termed this process “reverse learning”. REM sleep helps forgetting unwanted information. REM sleep may be to remove unhelpful information that accumulates during the day. The vivid images and strange story lines of dreams might be related to this review of and clearance of information. They termed this process “reverse learning. *Sleep* actually triggers changes in the *brain*.”

The brain needs a mechanism to preserve the most important learned

information while getting rid of unnecessary information. It is thus very important that the brain has a way of selectively strengthening and also weakening synaptic connections so that memory can remain flexible and stable as well.

1. Rapid Eye Movement (REM)
2. Non-Rapid Eye Movement (NREM) Sleep (also known as *quiet sleep. NREM IS further divided into three stages*

Beta waves are of low amplitude and of high frequency are indicative of an active cortex and an intense state of attention. Beta waves are those associated with day to day wakefulness. These waves are the highest in frequency and lowest in amplitude, and also more desynchronous than other waves. During periods of relaxation, while still awake, the brain waves become slower, increase in amplitude and become more synchronous. These types of waves are called **alpha waves** often associated with states of relaxation and peacefulness, manifested during meditation and biofeedback.

N1 (stage one) sleep is the transition from wakefulness to deeper sleep. This is the lightest stage of sleep, and people may not always perceive they are asleep during this stage. **Stage 1** non-REM sleep is the transition from wakefulness to sleep. During this short period (lasting several minutes) of relatively light sleep, the heartbeat, breathing, and eye movements become slow, and muscles relax with occasional twitches. The brain waves begin to slow down from their daytime wakefulness patterns. The hippocampus exemplifies this stage

As the individual moves to **stage 2** sleep theta wave activities continue, interspersed with two unusual wave phenomena. These phenomena, occur periodically every minute or so. The characteristics of stage 2 sleep are termed **sleep spindles** and **K complex**. The former is a sudden increase in wave frequency and the latter is a sudden increase in wave amplitude. Stages 1 and 2

sleep particularly slow-wave or deep sleep during the first few hours is also thought to be important in improving the consolidation of information in memory, and activation patterns in the sleeping brain, which mirror those recorded during the learning of tasks from the previous day, suggest that new memories may be solidified through such reactivation and rehearsal. Theta Waves improve people’s intuition, creativity, and make people feel more natural. Theta Waves are also involved in restorative sleep. As long as theta isn’t produced in excess during waking hours, it is a very helpful brain wave range.

- **Frequency range**: 4 Hz to 8 Hz (Slow)
- **Too much**: ADHD, depression, hyperactivity, impulsivity, inattentiveness
- **Too little**: Anxiety, poor emotional awareness, stress
- **Optimal**: Creativity, emotional connection, intuition, relaxation

Increase theta waves: Depressants

Stage N2: Non-REM sleep is a period of light sleep before an individual enters deeper sleep stage. The heartbeat and breathing slow down and muscles relax even further. The body temperature drops and eye movements stop. Brain wave activity slows but is marked by brief bursts of electrical activity. Individual spends more of the repeated sleep cycles in stage 2 than in other sleep stages. According to the American Sleep Foundation, people spend approximately 40 to 50 percent of their total sleep in this stage.

Stage N3 is characterized by **DELTA BRAIN WAVES** with a frequency of around 0.5–4 Hz, along with some sleep spindles, although less than in stage 2. Non-REM sleep is the period of deep sleep that one needs to feel refreshed in the morning. Deep sleep occurs for longer periods during the first half of the night. Heartbeat and breathing slow down to their lowest levels during this period of sleep. During this stage of sleep, the muscles are relaxed and it may be difficult to awaken a person who is asleep. The Brain waves become even slower. Stage 3 is characterized by delta brain waves with a frequency of around 0.5–4 Hz, along with some sleep spindles, although much less than in stage 2. During the Delta Stage Neurons which are involved with the processing of information are firing all at the same time. Therefore, the activity is synchronized. Waves are large and slow. Adequate production of Delta Waves help people feel completely rejuvenated after waking up from a good night’s sleep. If there is abnormal Delta activity, an individual may experience learning difficulties or have difficulties maintaining conscious awareness as found in Brain impaired cases.

REM SLEEP (RAPID EYE MOVEMENT)

REM is 60 TO 70 Waves/sec. REM sleep makes up about 25% of sleep cycle and first occurs about 70 to 90 minutes after an individual fall asleep. Because one’s sleep cycle repeats, the individual enters REM sleep several times during the night. REM **sleep** first occurs about 90 minutes after falling asleep. The eyes move rapidly from side to side behind closed eyelids. Mixed frequency brain wave activity becomes closer to that seen in wakefulness. The breathing becomes faster and irregular, and the heart rate and blood pressure increase to

near waking levels. Most of an individual's dreaming occurs during REM sleep, although some can also occur in non-REM sleep. The arm and leg muscles become temporarily paralyzed, which prevents the individual from acting out the dreams. Memory consolidation most likely requires both non-REM and REM sleep. The time spends on REM sleep reduces as one advances in years.

During REM sleep brain and body are energized and dreaming occurs. REM is thought to be involved in the process of storing memories, learning, and balancing mood, although the exact mechanisms are not well understood. REM sleep begins in response to signals sent to and from different regions of the brain. Signals are sent to the brain's cerebral cortex, which is responsible for learning, thinking, and organizing information. REM sleep stimulates regions of the brain that are used for learning.

Lack of REM sleep has also been linked to certain health conditions, including migraines. The reason for dreaming during REM sleep is not understood. While some of the signals sent to the cortex during sleep are important for learning and memory, some signals seem to be random. It is these random signals that may form the basis for a "story" that the brain's cortex tries to interpret or find meaning in, resulting in dreaming. Sleep in general aids memory. REM sleep may favor the preservation of certain types of memories: specifically, procedural memory, spatial memory, and emotional memory. [15]

Sleep & Memory Time: Wed, 10:15 to 12:00 Prof. Dr. Björn Rasch, Division of Biopsychology University of Zürich (16)

Sleep disturbances are very frequent in depression with Reduced REM sleep / REM latency / SWS, early-morning awakenings.

Overnight memory consolidation occurs with sleep. Emotional memory consolidation also takes place. Napping after exposure therapy increases therapy success.

Sleep disturbances occur in almost all psychiatric disorders.

Study results

Sleep Disturbance	Sleep duration
Depression	6.1
Panic disorder, GAD, PTSD, Dysthymic, Bipolar	Sleep latency

in minutes

	Mean
Depression	68 + − 86min
Panic disorder	57 * − 43
GAD	52 + − 42
PTSD	52 + − 54

Summary of the study:

Take Home Messages from the study: as follows:
Healthy aging with regular sleep
Sleep related interventions improve memory functions.
Memory-related interventions to improve sleep.
Sleep disturbances occur in many psychiatric disorders.
Memory consolidation is impaired in patients with insomnia.

Chronic insomnia is a risk factor for depression and anxiety disorders.

Sleep disturbances are very frequent in depression with Reduced REM sleep / REM latency / SWS, early-morning awakenings.

Overnight memory consolidation occurs with sleep. Emotional memory consolidation also takes place. Napping after exposure therapy increases therapy success. Sleep disturbances occur in almost all psychiatric disorders.

Insomnia and Memory: Memory consolidation is impaired in insomnia for both declarative memory tasks and Procedural.

Memory consolidation of words is impaired in insomnia, only after interference.

Increased forgetting correlates with number of awakenings in insomnia patients.

Decreases in Hippocampal volume associated with insomnia.

Chronic Insomnia as a Risk Factor for Developing Anxiety and Depression Neckelmann MD, PhD1; Arnstein Mykletun, PhD2; Alv A. Dahl MD, PhD3

“Take home Messages” [17]

Sleep disturbances occur in many psychiatric disorders.
Memory consolidation is impaired in patients with insomnia

Chronic insomnia is risk factors for depression and anxiety
Sleep disturbances very frequent in depression
Reduced REM sleep? REM latency/SWS, early morning awakenings
Overnight memory consolidation is impaired
Emotional memory consolidation across sleep like phobia is likely

Napping after exposure therapy increases therapy success Prof. Björn Rasch 12.05.14

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