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How insomnia reduces declarative and non-declarative memory consolidation

Kseniya Chumachenko

People have high levels of stress in their lives that lead to many sleep issues, and insomnia is a very common sleep disorder that people have. This sleep disorder not only affects the person's physical wellbeing, but also the mental wellbeing, because a good sleep equates to good memory consolidation, and insomnia causes problems in both declarative and non-declarative memory functions, because for each of these memory types, a good night's sleep equates to memories being consolidated during deep and rapid eye movement sleep, which is something that insomniacs lack in.

Insomnia is a chronic disorder associated with long-standing sleep restriction, a condition which can impair waking behavior even in healthy adults (Van Dongen, 2003). The common symptoms include difficulty falling or staying asleep, feeling tired when waking, or waking up too early in the morning. There are also two types of insomnia, primary and secondary. Primary is where a person has sleeping issues that are not connected to any other health conditions such as sicknesses. Secondary insomnia is where the sleep problems are connected to something else, like asthma, depression, cancer, arthritis, and even some medication can cause secondary insomnia. Since both of these deal with the underlying issue of sleep deprivation, both secondary and primary insomnia can have an effect on memory consolidation (Chanin, 2014).

Declarative memory is memories of facts and events, memories that can be consciously recalled. This type of memory is encoded by the hippocampus, entorhinal cortex and perirhinal cortex, but are consolidated and stored mainly in the temporal cortex. Non-declarative memory is procedural memory, and is the unconscious memory of skills and how to do things that include motor movements of the body. Examples of declarative memory include knowing how to play piano and knowing how to ride a bike. These are made of automatic sensorimotor behaviors that are deeply embedded in our brain so we are no longer aware of them but we are still able to perform the non-declarative task. Unlike declarative memory, procedural memory does not involve the hippocampus, and is encoded and stored by the cerebellum, putamen, caudate nucleus and motor cortex, all of which are involved in motor control. Learned skills such as

riding a bike are stored in the putamen; instinctive actions like grooming are stored in caudate nucleus, and cerebellum helps with timing and coordination of the motor skills (Mastin, 2010).

Memory consolidation is the process of stabilizing a memory trace after one first receives it, and in other words, transferring information from short term memory into long-term memory. It has a certain process, which undergoes “long-term potentiation”, which allows a synapse to increase in strength as there are increasing amounts of signals being transmitted between two neurons. Potentiation is the process by which synchronized firing of neurons makes them more likely to fire together in the future (Payne, 2004). This occurs long-term when the same group of neurons fire together so often that they become permanently sensitized to each other. As people go through new experiences that stimulate the brain, the brain makes more and more neural connections and pathways and may rewire itself by re-routing connections and rearranging its organization, and this makes the brain more capable of consolidating memory on a daily basis.

Scientists do a lot of research on how exactly sleep helps memory, and many studies say that it involves the brain’s hippocampus and neocortex, the part of the brain where long-term memories are stored. It is thought that during sleep, the hippocampus replays the events of the day for the neocortex, where it reviews and processes memories, which helps to keep them for a long time (Mastin, 2010).

The effects of insomnia can be detrimental to one’s mental wellbeing, as studies show it can have an effect on both declarative and non-declarative memory consolidation. Memories are known to become more stable during REM (rapid eye movement sleep) which is when most dreams occur. Some types of memories can also become stable during the slow-wave deep sleep. Insomniacs have a broken up sleep pattern where they may not enter REM at all sometimes, and also other stages of sleep.

The researchers, Nissen and collaborators studied the ensuing hypothesis that memory consolidation (*declarative*) is impaired in insomnia patients because their sleep is impaired. They studied whether this memory deficit is associated specifically with sleep, relative to a comparable period of wakefulness. The studies showed a selective advantage is observed for the nocturnal sleep interval in healthy controls. This study therefore provides objective evidence that, indeed, in insomnia the effects of sleep on memory performance are reduced. Nissen and his

fellow researchers believed that the influence of sleep on memory consolidation is related to specific molecular and neural processes associated with specific sleep events: non-rapid eye movement sleep slow waves and spindles, phasic REM sleep and its activity akin to animal pontine waves (Nissen, 2011).

In a study at Harvard Medical School, researchers were looking at how a full night's rest consolidates declarative memory. They investigated the consolidation of arousing and neutral episodic memory (*declarative memory*) across 12-hr periods containing either a night of sleep or an equivalent period of time awake, examining whether these effects varied between R and K responses. Furthermore, they determined whether sleep influenced not only the accuracy of memory recognition, but also memory bias (selection criterion), for R and K judgments of emotionally arousing and neutral picture. Their study contained 14 subjects, 8 females, 6 males, all with a mean age of 22. This study was one of the first to show that a dissociation of emotional memory consolidation across wake and sleep results in the selective overnight enhancement of memory accuracy for arousing material (Harvard, 2014)

In a University of Pennsylvania study, researchers studied the idea that REM sleep affected procedural (*nondeclarative memories*) and slow-wave sleep affected declarative memories. A procedural mirror tracing task was used, seven patients with primary insomnia and 7 healthy controls were studied during the experiment, patients with insomnia did clinical tests to ensure that they had insomnia. They all seemed to have varying intensity of insomnia, but overall dealt with the same underlying issue. All participants had to sleep a certain amount each night, and mirror tracing tasks were given to them. Their results were studied using biostatistics tests such as Mann-Whitney tests, which did not reveal significant differences between insomnia patients and healthy controls, however, there was enough data to suggest that significant group differences might have been detected in a larger sample.

One study took a slightly different approach but still deals with the idea that insomnia reduces memory abilities. This study aimed to show that people who were sleep deprived had to put more *effort* into recalling and consolidating memory. Seventy-seven university students, mostly women, with a mean age of 22 years were asked to memorize four strings of four random letters in 5 min while cardiovascular measures were obtained. They were asked to report their sleep habit and level of insomnia. Analyses indicated that self-reported insomnia severity was

associated with an increase in systolic blood pressure during the learning phase. Regarding memory performance, insomnia severity was unrelated to immediate recall but related to a decrement in delayed recall. It is important to note that short term tests were also administered, and those did not show any abnormal results, it was when the subjects were tested with long term memory tests was when they showed weakness if they had insomnia. (Schmidt, 2010)

Insomnia has many negative effects on people, not just physically but mentally as well. Even though many people might not realize this is one of the effects, memory consolidation depends on reaching REM sleep and deep wave sleep which is impaired in insomnia, and therefore people's memories may decline.

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