Medical Xpress

# Asleep at the wheel: Investigating sleep deprivation's effect on cognition

August 24 2011, By Blake Cole

The next time you choose to pull an all-nighter, cramming for a test or preparing for a work presentation, think again—you're likely damaging the exact neurological systems you hope to utilize for success. The negative effect of a lack of sleep on cognitive abilities like memory may not seem like news. In fact, it is anecdotally taught to us from a very young age. But until now there has been limited understanding of the behind-the-scenes biological explanation for the deficits.

"The main interest of my lab is how memories are stored," says Ted Abel, Brush Family Professor of Biology and Director of the Biological Basis of Behavior Program. "In particular, how the neural circuits and molecular mechanisms in the brain that enable us to remember long-term can change over time and become stronger and modified. Sleep deprivation offers a window into this world."

In order to study the effects of sleep deprivation, Abel's team trained mice to explore certain objects in a field. Once the mice had become familiar with the specific locations, researchers tested the animals' memory the next day by moving a certain object. When fully rested, the animals remembered where the objects had initially been. Intrigued by the movement of a single object, they investigated it with heightened interest—much like a human might.

Next, using a method called gentle handling—petting the mice to keep them awake longer than usual—their ability to remember if and when a certain object was moved was again evaluated. As a consequence of losing sleep, the object that had once fascinated the mice no longer appealed to them, suggesting they no longer recalled its original position.

“It wasn’t even that drastic a level of sleep deprivation,” Abel says. “The mice got about half the amount of sleep they would regularly get. In humans it would amount to about four hours. It just goes to show that that amount of reduction alone is enough to have a drastic effect on memory.”

When they dug deeper into the processes responsible for this result, Abel’s lab set upon a neuronal support cell called glia—Latin for glue. The glial cells wrap around neuronal processes where synapses form. This is particularly important when the brain is being made to work extra hard. Sleep deprivation is a prime example—the longer you stay awake, the more your neurons fire, supplementing motor faculties and mental capabilities as the day wears on. The glial cells are trying to preserve the function of these overworked neurons.

“We discovered that one of the molecules released by glia—adenosine—was actually causing the effects of sleep deprivation,” says Abel. “We should all be familiar with adenosine in a cursory way—when we go to Starbucks to buy coffee, we’re actually blocking the effect of that molecule. So in essence this adenosine—by way of the glial support cells—is protecting our brain from running on empty, telling us in its own unique biological language to get some sleep.”

Studying neuronal function during sleep is crucial to better understanding memory storage. A common misconception is that when we sleep, the brain stands still—that it shuts down to recover. Nothing could be further from the truth. Neurons are actually firing at an incredibly high rate during sleep, even faster than during wakeful hours. In fact, these high-firing cells that activate during non-REM sleep are often the same ones that were firing during the spatial tests, Abel says, suggesting memories are replayed during sleep, possibly in the form of dreams.

"Because almost all sleep studies look at the removal of sleep, we'd like to study these processes in even further detail and concentrate on the addition of sleep—that is to say, what exactly is going on inside the brain that makes a good night's sleep so important? There's plenty of anecdotal evidence of sleep's recuperative value, but we'd like to dig deeper and study these interactions on a molecular level."

Abel's team hopes the research will offer insight into neurodegenerative diseases like Alzheimer's, and neuropsychiatric disorders like schizophrenia—both often associated with alterations in sleep. A better understanding of memory storage might eventually lead to the ability to supplement existing treatments and target the specific cognitive deficits associated with these diseases to improve quality of life.

Provided by University of Pennsylvania