The Biopsychology of Sleep: The Restorative and Circadian Models

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Abstract

This paper explores the current literature regarding the need for sleep among mammals, and in particular humans. The two major models include the Circadian and Restorative theories as to the reasons why people sleep. The Circadian models focus mainly on the relationship between sleep patters and the concept of an inner biological clock set to approximately 25-hour sleep/wake cycles. The Restorative models focus mostly on the thought that sleep provides the body the opportunity rest and engage in "self-repair". Although the research indicates that the circadian models provide a better explanation as to when we sleep, the restorative models support the importance of subjective experience in regard to getting enough sleep.

Introduction

Although the question as to how much sleep we need seems to be a simple one, the answer does not seem to be a straightforward one. According to the National Sleep Foundation (NSF, 2007) the amount of sleep an individual needs is, well, individual. Factors such as age, gender, and lifestyle play a major role in determining how much sleep we need. The "need" is also subjective, in that a person may feel that they need more sleep but not actually have any sort of biological need for it.

This author proposes that this is a vital question in light of the increased demands on the time of individuals living in a modern society. As workers and students, we tend to be busy and seem to wish for more time. Even though the average American only gets 6.8 hours of sleep (National Sleep Foundation, 2005), there seems to be continued pressure to get more time out of the day.

According to the NSF, sleep is defined as a state of consciousness that follows a pattern of specific, measurable brain wave patters, as measured by an Electroencephalogram (NSF, 2007). During a normal night the sleeper will cycle between stages of REM (Rapid Eye Movement) and NREM (Non-Rapid Eye Movement) about every 90 minutes. NREM constitutes about 75% of the time spent sleeping.

Researchers in sleep have identified 4 distinct stages of sleep (and REM). The following table outlines each of these stages (NSF, 2007).

Stage 1 Sleep	Characterized by very light sleep, being in a state of between sleep and wake. May experience light sleep.
Stage 2 Sleep	Officially the onset of sleep. Sleepers become disengaged from their surroundings, body temperature drops, and breathing/heart-rate become regular
Stage 3-4 Sleep	Deepest and most restorative sleep. Muscle are relaxed, blood pressure drops, energy is restored
REM Sleep	Brain is active and resembles the brain activity of being awake. Dreaming occurs during this stage of sleep.

The NSF proposes that there is a subjective, restorative value to sleep that determines the amount of sleep that a person needs. They also identify Circadian Dips, periods of time during the 24-hour daily cycle where we seem to be biologically programmed to feel drowsy. This paper will explore both the restorative and circadian-related functions of sleep in an attempt to answer the question: Why do we need sleep?

The Biology of Sleep

According to Siegel (2005) there are similarities among all mammals in terms of their sleep patterns and in terms of the neurophysiology of sleep. An in-depth understanding of the underlying structures involved in sleep can provide clues as to the function of sleep.

Some cells in the forebrain have been identified as being very active during NREM sleep. It was found (Seigel, 2005) that stimulation of these cells brought about the NREM stage of sleep and that damage to this part of brain reduced sleep. Other neurons in the forebrain and brain stem have been identified as being active during the wake cycles.

The posterior and anterior hypothalamus has been identified as involved in sleep wake cycles. The reticular formation was also indicated as research supports that low

levels of activity in this area produce sleep while high levels in this area produce wakefulness (Moruzzi & Magoun, 1949).

The pons and midbrain region has been associated with the development of REM sleep (Moruzzi & Magoun, 1949). During REM there is a complete loss of muscle tone and a simultaneous inhibition and withdrawal of excitation of motoneurons in the brain. The suprachiasmatic nuclei of the medial hypothalamus is also involved in the regulation of various circadian rhythms and cycles, including sleep (Moruzzi & Magoun, 1949).

The Restorative Model

According to Pinel (2006) the Restorative Model of sleep attempts to relate the amount of sleep an animal needs to its size and activity level. There remains little evidence to support the restorative model of the description of sleep other than the subjective experience of the sleeper feeling refreshed (NSF, 2007).

There is evidence, however, that individuals deprived of NREM deep sleep do not experience the refreshed feeling that would normally follow a good night's sleep. According to the NSF, sleep helps us to "thrive by contributing to a healthy immune system, and can also balance our appetites by helping to regulate levels of the hormones ghrelin and leptin, which play a role in our feelings of hunger and fullness. So when we're sleep deprived, we may feel the need to eat more, which can lead to weight gain" (NSF, 2007).

Individuals who feel that they have not got enough sleep may nap or engage in polyphasic sleep. Luo & Inoué (2000) studied the relationship between napping and levels of emotion. They report that when compared to emotional expression prior to the nap, individuals were more expressive in anger, joy, and relaxation state. The results of

this study, despite having no specific biological correlate, seem to support that the subjective experience of getting enough sleep may impact mood levels.

Gillburg, Kecklund, Axelsson, & Akerstedt (1996) compared EEG sleepiness with subjective reports of sleepiness and with performance on a visual vigilance task. They reported that napping tended to positively impact both the report of sleepiness and the performance on the task.

Other research, as reviewed by Kripke (2004), has explored the restorative function of sleep by focusing on the relationship between the average amount of sleep an individual gets and mortality. Studies done both in Japan and in the US confirm that individuals who sleep less than 6.5 hours per night were of less concern for illness and early death than were individuals who slept more than 7.5 hours per night.

The Circadian Model

Circadian Rhythms are identified patterns in mental and physical characteristics that change throughout the day (Healthlink, 2007). Most people operate on a roughly 25-hour clock but because we see the sun, and light impacts the structures of the brain responsible for regulating these cycles, we usually operate based on the daily clock. These environmental cues entrain the animal to operate by the light-dark schedule of their environment.

These external cues have been found to be vital in determining the wake-sleep cycles in human beings (Colwell & Michel, 2003). Their research indicated that due to the high dependence on external cues to determine wake-sleep cycles, interventions and alternate schedules could be contrived to modify the cycles.

Morse & Sassone-Corsi (2002) identified a relationship between the suprachiasmatic nucleus function in bringing on sleep and the light-sensitive retinal ganglion cell structures where patters on light and dark cycles are first detected. They repot that these structures seem to be essential components of the inner mammalian circadian clock.

Strogatz, Kronauer, & Czeisler (1986) investigated the spontaneous timing of sleep wake patters in subjects and measured the time of the previous wake cycle and the subsequent duration of the sleep pattern. If the restorative function of sleep predominated then one would expect that the longer the wake cycle the longer the subsequent sleep cycle. In fact, the researchers found no relationship between the two factors. The results support an underlying circadian function.

Conclusions

Although it seems that the evidence for the causation of sleep patters favors the circadian models studies, the subjective reports of sleepiness provides support for the restorative models as well.

It is certain that particular brain structures, and their connections to our sensation of the light-dark cycles of the 24-hour day, play an important role in determining when we feel sleepy and when we ultimately fall asleep. However, the restorative models present a stronger argument in regard to an individuals' quest to determine how much sleep they should get. From the viewpoint of a physician, for example, whom a patient is asking if they are getting enough sleep, the subjective experience of being rested or having a "good night's sleep" are explored first…then, if problems persist, they

discussion can turn towards an examination of sleeping patterns. One may presume that if you felt rested after 5 hours of sleep then you have got "enough" sleep.

It could be concluded then, that both the circadian and restorative models of sleep are important albeit one is focused on the objective analysis of why we need sleep and the other the subjective analysis as to why we need sleep.

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