Functions and brain mechanisms of sleep

Sleep, it is the state in which we spend much of our lives yet so little is known about it. It has long fascinated psychologists and many have sought to unravel its mysteries. Yet like all other behaviours sleep can be examined using the same biological, psychological and environmental methods that are so effective in other areas. Defined, sleep is a naturally recurring state which is characterized by reduced or absent consciousness, relatively suspended sensory activity, and inactivity of nearly all voluntary muscles. However this explains what is visible, over the years theorists tried to explain what is happening biologically during sleep.

Up until the 1950’s researchers believed that sleep occurred due to an overtaxing of the brain, that the constant sensory stimulation that bombards the brain during the day renders it unable to maintain a waking level of brain activity. They also believed that achieving this state was helped by the occurrence of the darkness and silence of night. Sleep at this time was also viewed as a homogeneous state and as a result of this many researchers viewed it as relatively uninteresting. This may be a reason why very little scientific attention was put on the topic for so long. In fact dream interpretation garnered far more attention at this time (Dement, 1998). This “ passive process theory” was only dropped when experimenters recorded eye movement and muscle tension during sleep. This led to the groundbreaking discovery that there were in fact two different classes of sleep, rapid eye movement (REM) and non-rapid eye movement sleep(NREM) (Watson, Breedlove & Rosenweig, 2010).

In this essay sleep, both rapid-eye movement and slow-wave, will be explored. Also set out will be the main functions of sleep and what can

happen when a person is deprived of sleep. Finally the sleep disorder narcolepsy will be discussed as it is an often misunderstood disorder which shows the mal effects when control over when to sleep is lost.

Sleep can be divided into 5 stages, 4 of these stages are during NREM with the final stage being REM sleep. These stages are measurable by the patterns of electrical activity in the brain. When awake the brain shows patterns of “ beta waves”. These have a high frequency and low amplitude. When in a state of relaxation the brain shows waves with lower frequencies, these are called “ alpha waves” (Passer & Smith, 2009)

Stage 1 of NREM occurs just as the body drifts into sleep. At this stage the brain begins to demonstrate “ theta waves”. These waves are slower again than those measured during a drowsy state and have irregular frequencies, the heart rate also slows and muscle tension is reduced. This stage normally lasts several minutes, giving way to stage 2. Here the brain shows short (1-2 seconds) periodic bursts of brain activity. These bursts are called sleep spindles. Interesting to note is that often people deny that they were even asleep if they are awakened during either the first or second stage. As the body drifts even deeper into slumber stage 3 is reached, here “ delta waves” are the most dominant. These are of an extremely low frequency and have large amplitude. Stage 4 is very similar to stage 3 and shows further lowering of frequency and expansion of amplitude. Stages 3 and 4 are also sometimes referred to as slow-wave sleep (SWS) by some researchers. After reaching this stage the body then cycles through the previous stages and generally after 60-70 minutes of falling asleep the body has gone through a cycle of stages 1-2-3-4-3-2. It is at this point that brain activity changes

alarmingly and a brand new and unique stage of sleep emerges. This new stage is called rapid-eye movement (REM) sleep (Watson et al, 2010).

This stage of sleep was discovered by Aserinky and Klietman in 1952 and is characterised by high brain arousal, rapid eye movement and frequent vivid dreaming. These researchers found that during this phase the sleeper showed bursts of muscular action which resulted in the persons eyes moving rapidly underneath the eye lid, this happened around every minute during REM sleep. People that were awakened during this stage frequently report having a dream, this is even true of people who before claimed to have " never dreamed" (Passer & Smith, 2009). Brain activity increases to daytime levels and the body also becomes physiologically aroused, with more rapid breathing and a swifter heartbeat. Another characteristic of this stage of sleep is that the bodies of both men and women become aroused, regardless of dream content, with penile erections in men and vaginal lubrication in women. The brain also can send signals to the muscles of the arms legs and torso which make them become very relaxed, they occasionally twitch but movement is not possible at this time. This is sometimes referred to as " sleep paralysis".

After an average of 90 minutes the body begins the cycle of stages anew, however with each recurrence REM sleep lasts longer, eating into the time previously spent in stage 3 (Passer & Smith, 2009).

The brain controls the passage of the body through sleep however no single part of it is solely responsible for it. Various mechanisms in the brain control the different aspects of the sleeping body, areas on the base of the forebrain

are connected with the act of falling asleep. Other sections in the brain active during sleep are certain areas in the brain stem which regulates REM sleep. Here neurons are contained which activate the other brain systems which are needed during REM such as those for the rapid-eye movement and muscular paralysis. Memories are accessed during REM sleep and this is also governed by these areas in the brain stem. This affects what is experienced during dreams(Watson et al, 2010).

Having explored the biology behind sleep it is now worth looking at the benefits of sleep, both physiological and psychological. There are two major branches of thinking which explore the question of why do we sleep? These are the restoration models and the evolutionary/circadian models (Passer & Smith, 2009).

According to the evolutionary models sleep recharges run-down bodies, it allows us to recover from physical and mental fatigue. This is largely supported by research in sleep deprivation. A good example of one of these studies is the world record attempt by Randy Gardener in 1964. He stayed awake for 11 days as part of a school science fair project and he allowed sleep researchers to study him during this period. Over the first few days he was irritable, forgetful and nauseous, by the fifth day he began to experience periods of disorientation and had mild hallucinations and by the end he experienced slurred speech and finger tremors (Gulevich, Dement & Johnson, 1966). This research clearly shows physiological and psychological problems that arise from sleep deprivation. However it has been proven that less sleep is needed as you age with older adults living healthy lives on only 5 or 6 hours sleep. In fact there is one example of a 70 year old woman who

could survive on 1 hour of sleep a night. Many researchers also believe that a cellular waste chemical called adenosine has a role in the restorative functions of sleep. Adenosine is produced as cells produce energy. At high levels adenosine inhibits brain functionality and levels of it decrease during deep sleep (Passer & Smith, 2009).

Evolutionary/Circadian models state that the main function of sleep is prolonging a species survival relative to its environmental demands. It backs up its evidence based on the fact that prehistorically our ancestors had very little to gain by being active at night as food gathering etc was much more easily accomplished in the day. The model puts forward the idea that over the course of the evolution of a species a “ circadian sleep” is developed. This is a wake pattern that becomes heredity due to certain factors such as its status in the predator prey relationship and its food requirements. Also researchers backing this model believe that sleep also evolved as a way of conserving energy, putting forward the fact that we use up to 25% less energy when asleep (Watson et al, 2010).

A controversial theory on a benefit of sleep is one that links it to memory consolidation. The purpose of REM sleep remains unknown and some have put forward the idea that it is a tool that the brain uses to consolidate memories, a process in which the brain transfers information to the long term memory. This consolidation hypothesis is however contradicted by the fact that studies show that even when a person has little or no REM sleep due to a side effect of anti-depressant drugs they show no impairment of long term memory capacity. This has led some to state that REM sleep is necessary on a purely biological level. These theorists believe that the body

uses REM sleep primarily to keep the brain from long periods of low arousal as they believe this could have damaging effects. The true purpose of REM sleep is still debated (Watson et al, 2010).

An interesting study by Paller and Voss provided evidence that suggests that when memories are accessed during dreaming they can be subtly altered by the dream. This has is to do with memory consolidation. There study showed that the brain does use dreams, at least on a small scale, to aid in memory consolidation as has been previously known. However that the brain can alter these dreams is intriguing to say the least (Paller & Voss, 2004).

Whereas it has been discussed how too little sleep can impair the body, here, the sleep disorder narcolepsy will be explored, showing how a inability to stay awake can also cause problems to an individual’s lifestyle. About 1 out of every 2000 people suffer from narcolepsy, those living with the disorder have to deal with daily bouts of sleepiness and uncontrollable sleep attacks where they can go into sudden sleep for less than a minute to a whole hour. Often these sleep attacks are accompanied by sleep paralysis or hypnagoic hallucinations. Some researchers believe that narcolepsy is a disorder involving an intrusion by REM sleep into waking life. It is believed that narcolepsy is cause because of a chemical imbalance in the hypothalamus. There is no cure but some ant-depressant drugs appear to be effective in reducing episodes, this could be due to their suppression of REM sleep.

In conclusion, research around sleep has come a long way since its humble beginnings. We now know far more about the biology behind sleep and yet much of it, including REM sleep still confounds many researchers.

This essay has also outlined the many benefits that sleep has, both physiological and psychological and has shown the difficulties that arise from a lack of it and has shed some light on the obscure and misunderstood sleep disorder narcolepsy. It is hoped that research will continue on in the future and hopefully the mysteries surrounding the state which we spend almost a third of our life in will be unravelled.