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The Effectiveness and Enhancement of Sleep Deprivation as a Tool in Military Interrogations to
Ensure Optimum Results and the Short-Term Psychological and Neurological Impact on the
Prisoner

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Sleep is a very important aspect of life. It affects the functionality of nearly every biological system in one way or another. Without sleep, people as well as animals would not operate at full efficiency. Loss of sleep can affect many things such as reaction time, physical performance, alertness, and the ability to perform complex cognitive tasks (Saletan, 2008). If these particular skills are impaired, it could lead to injury, or even death in the most extreme situation. In today's society, prolonged wakefulness is a recurring problem. While the U.S. is constantly striving to move forward in all aspects, little time is left for its citizens to rest. Time normally allotted for sleeping is used instead for studying to pass the next test, working late to get the next promotion, struggling to climb the corporate ladder, or simply staying up late to party. Children are being pressured to perform better in school, lest they fall behind and miss life's many opportunities. The constant global need to succeed, combined with the known problems associated with sleep deprivation, has drawn many researchers worldwide to the topic in one way or another.

The field of military sleep research is of particular interest. Many countries are investing a growing number of resources into sleep studies, determining positive and negative effects and how to utilize research results to their full effectiveness. Soldiers in the heat of battle are rarely given a chance to rest, and many find themselves unable to sleep out of sheer paranoia. United States researchers are investigating ways to keep soldiers on the front line focused and aware even in extreme states of sleep deprivation, potentially saving thousands of lives. Consequently, sleep deprivation can also be utilized as what some would call "torture". Forcing a prisoner to remain awake and alert for days at a time can have a dramatic effect on their cognitive ability, and may cause temporary increases in stress, depression, and hallucinations. If done correctly,

sleep deprivation as a tool in military interrogation will increase stress levels in the prisoner, increasing the chances they might divulge important information.

While some might view sleep deprivation research as a somewhat harmless method of interrogation, others claim it violates the third Geneva Convention. Passed in 1949, the third Geneva Convention contains many regulations for the humane treatment of prisoners of war, including acts prohibiting interrogators from depriving a prisoner of their basic needs such as food, water, and sleep. Deprivation is a form of torture and is illegal (Geneva Conventions, 1949). The protocols of the Geneva Conventions, if fully upheld, may make it difficult to interrogate a prisoner in the most efficient manner, even when lives are held in the balance. Thus, the question is posed whether or not to treat someone fairly (per Convention protocol) even when the “enemy” may not have done the same.

Sleep deprivation (SD) is a term used to describe what occurs when an organism does not sleep for the amount of time their body requires to function at full efficiency. In humans, the amount of sleep needed differs greatly depending on many factors. Infants need around 16 hours of sleep, while teenagers need around 9. Genetics play a key factor in sleep response. Some adults only need six hours of sleep while others need ten. On average, researchers find the amount of time needed for a majority of adults is seven to eight hours of sleep a night (Saey, 2009). Failure to gain enough sleep per night can produce a wide array of effects ranging from daytime sleepiness, to clumsiness, to general decreased cognitive performance (Alhola, 2007). SD can be separated into two distinct categories: chronic, partial SD and acute, total SD. Acute, total SD occurs after even one night with little to no sleep, while chronic, partial SD is the consequence of many consecutive nights garnering less sleep than required. While few studies have compared the effects of the two, generally acute, total SD produces more short-term,

temporary side effects such as drowsiness, fatigue, irritability, and hallucinations. Chronic, partial SD, on the other hand, increases the risk of obtaining long-term side effects such as depression, increased blood pressure, and even type 2 diabetes (Gottlieb, 2005). While the two differ in how they come about, it is clear they share many detrimental side effects as well.

Before the 1950's, people thought sleep was a dormant process. However, through the results of extensive studies, researchers have determined such is not the case. Sleep is a very active process, affecting many physical and mental pathways in ways just beginning to be understood. The brain is composed of thousands of neurons firing off signals and releasing neurotransmitters. These neurotransmitters act as signaling molecules, giving cues for nearly every process in the body, including sleep. Neurons in the brain release neurotransmitters such as serotonin and norepinephrine to keep the brain alert and awake during the day. During sleep, different neurons fire, inhibiting daytime signals and promoting rest (NINDS, 2007).

Electroencephalography (EEG) provides an opportunity to gain a better view of the electric activity in the brain during sleep. With so many neurons in the brain, many of them synchronize their activities to some extent to what researchers know as brain waves. With a visual representation of brain waves, it becomes much easier to determine what the brain is doing at any given time. EEGs are made possible thanks to small electrodes attached to the head, recording the electrical activity of neurons (Electroencephalography, 2011).

An EEG waveform consists mainly of four different types of waves, differing in frequency as well as amplitude. Beta waves are present in an awake, alert individuals and are of the largest frequency. When a person is not sleeping, the dominant rhythm is beta. When one closes their eyes and begins to relax, alpha waves emerge. They diminish when the eyes are

opened or when the brain exercises mental effort, such as complex calculations. Therefore, alpha waves are thought to represent the level of cortical activity in that a higher level of alpha waves represents a lower level of activity. Theta waves aren't found present in awake adults, but they are found in awake adolescents. They are found in all sleeping individuals. Generally, researchers separate theta waves into two categories. Low theta waves represent decreased arousal and increased drowsiness while high theta waves represent memory. Delta waves are the dominant wave during later stages of sleep and have the highest amplitude. While it is currently impossible to determine exactly what each of the waves represent, a conclusion has been reached. In most cases, higher activity of the brain is concurrent with high frequency, low amplitude waves (Electroencephalography, 2011).

Sleep is divided into five distinct stages: stages 1-4 and rapid eye movement (REM) sleep. Stages 1-4 are often characterized as non-REM (NREM) sleep. Throughout the course of a night, sleep cycles through stages 1-4 and REM sleep frequently. Stage 1 indicates drowsiness, decreasing beta activity, increasing alpha activity, and drifting in and out of consciousness. If someone in stage 1 sleep were awakened, they might claim they were never asleep in the first place. Sometimes people in stage 1 sleep experience a jerk in their sleep known as hypnic myoclonia, often preceded by the sensation of falling. The eyes move very slowly and muscle activity slows as well. In stage 2, eye movement stops completely and irregular theta wave activity is prominent in the form of occasional K-complexes and sleep spindles. In stages 3 and 4, delta waves are predominant, differing between the two that in stage 3, delta waves are present 50% of the time, while stage 4 is composed of nearly exclusive delta waves. It is difficult to wake someone in stages 3 or 4, thus they are collectively known as "deep sleep" stages. People awakened during deep sleep often feel groggy and disoriented (NINDS, 2007)

REM sleep is the stage of sleep most often associated with dreams. Breathing becomes more rapid, the eyes jerk rapidly and randomly, and neurons in the spinal cord are ceased from firing, causing a temporary paralysis. Heart rate and blood pressure increase, and males develop penile erections. During REM sleep, the EEG is very similar to that of stage 1 sleep. Production of the neurotransmitters norepinephrine, serotonin, and histamine are ceased as well, entering the body into a state known as REM atonia, inhibiting motor neurons from firing, paralyzing the muscles and allowing the brain to dream without fear of muscular movement (Fryer, 2009). In the beginning of a sleep cycle, REM sleep lasts about 20 minutes. As sleep progresses into the night, the amount of time spent in REM sleep increases while the amount of time in deep sleep decreases. While REM sleep is an important part of the sleep cycle, it was determined meeting one's daily quota of stage 4 sleep is the driving factor for the sleep cycle (Tilley, 1985).

The brain contains four parts that are attributed to actively contributing to sleep; the anterior hypothalamus (basal-forebrain area), posterior hypothalamus (midbrain area), the reticular formation (reticular activating system), and the caudal reticular formation (Pinel, 2007). The basal-forebrain area plays a large role in sleep, while the midbrain plays a role in wakefulness. In one study, lesions were discovered on the basal forebrain of rats having difficulty sleeping. The same lesions were found on the midbrain area of rats having problems staying awake (Saper, 2001). The reticular formation was discovered to play a part in wakefulness through the experimentation of sleep cycles in cats. A French researcher by the name of Bremer severed the brain stems of cats between their inferior and superior colliculi (cerveau isole preparation) to discover that the cat's EEG showed nearly continuous deep sleep. Later, in another cat, a different incision was made under the first one, at the caudal brain stem, severing the brain from the rest of the nervous system (encephale isole preparation). The EEG of

this cat showed no changes in normal sleep activity. Through the results, Bremer determined a structure for maintaining wakefulness lay somewhere in-between the two cuts (Bremer, 1936). Later studies indicated said structure was the reticular formation. It was discovered that a *cerveau isole* preparation only affects the EEG if the reticular formation core has been severed. Cuts made around the core did not affect the EEG (Lindsey, 1949). It was also discovered that electrical stimulation of the reticular formation in sleeping cats would awaken them and produce an irregular EEG for a long period afterwards (Moruzzi, 1949). From these results, it was determined low reticular formation activity promoted sleep, while high levels produce wakefulness. For this reason, many call the reticular formation the reticular activating system. The last area controls REM sleep and is located in the caudal reticular formation. Differing nuclei scattered around the caudal reticular formation control different aspects of REM sleep including the eye movements associated with REM, cardiorespiratory changes, muscle relaxation, and so on (Siegel, 1983). The scattered nuclei are important in understanding the structure of REM sleep – only activated when all the parts of a whole come together. Likewise, independent parts of REM sleep might act independently of each other. For example, penile erections present during REM sleep may present themselves in deep sleep if the part of the brain controlling penile erections is stimulated. Also, slow waves normally found in deep sleep may be found in wakefulness after bouts of total SD. This suggests that REM sleep, deep sleep, and wakefulness are not controlled by a single mechanism, but instead by the interactions of several mechanisms that are capable under certain conditions of operating independently (Pinel, 2007).

Commonly agreed upon, subjective arousal as well as brain activity diminish with long periods of wakefulness. Also confirmed by multiple studies is both the desire to sleep and the intensity of EEG waves upon falling asleep are dependent on the period of time spent awake

(Borbély, 1982). The process of becoming more and more tired throughout the day is attributed to the neurotransmitter adenosine and its effects on the brain. Basal forebrain and mesopontine cholinergic neurons, neurons that play a large part in EEG arousal (Steriade, 1990), are inhibited by endogenous adenosine. As extracellular adenosine concentration increases, so does inhibition of the cholinergic neurons. There are many compelling reasons to believe adenosine satisfies all the requirements of producing the effects of tiredness. Adenosine concentration in the brain has been linked to neural metabolic activity, and neural metabolism is much higher during wakefulness than during deep sleep. Also, caffeine is known to block electrophysiologically relevant adenosine receptors, reducing the effects of adenosine and promoting arousal both in the subject and the EEG waveforms (Porkka-Heiskanen, 1997). To avoid buildup of adenosine in the basal forebrain over long periods of time, it is broken down during sleep by the enzyme adenosine deaminase (Mackiewicz, 2003).

While adenosine plays a large role in the tired feeling gained after prolonged wakefulness, the neurotransmitter histamine plays a large role in keeping one awake. Large amounts of histamine neurons are located in the hypothalamus and project to areas of the brain that are involved in emotion, sleep, temperature, and memory. A study funded by the National Institute of Neurological Disorders and Stroke (NINDS) investigated histamine concentrations during narcolepsy and cataplexy. Narcolepsy is a disease in which the subject is rendered to random disabling sleepiness throughout the day. Cataplexy is a disease in which one retains wakefulness but suffers episodes of complete muscle paralysis. In the NINDS study, dogs were genetically bred to carry narcolepsy. Histamine neuron activity was found to continue during cataplexy but stopped during narcolepsy, indicating histamine is a key ingredient to waking. Serotonergic and norepinephrinergic neurons were found to shut off during cataplexy, causing

the muscle paralysis. The job of histamine is also apparent in the form of antihistamines. These cold and flu medicines cause drowsiness and impair alertness when taken (John, 2004).

Tampering with levels of either histamine or adenosine in the brain could serve as a form of forced sleep deprivation.

Increases and decreases in adenosine and histamine levels might also be attributed to an aspect of the sleep-wake cycle known as a circadian rhythm. Circadian rhythms are based upon the concept that the body's physiological processes run on an internal clock. Humans take advantage of the day to fulfill most of their biological needs, and use the night to sleep. Nocturnal animals do the exact opposite, sleeping during the day and fulfilling their needs at night. And although the sleep-wake cycle is the most obvious example of rhythmicity, it is difficult to find a physiological process that does not contain some type of circadian aspect (Gillette, 2005). Our body is kept on track by environmental cues known as zeitgebers, a German word meaning "time givers". In a laboratory setting, it is possible to shorten or lengthen physiological cycles by adjusting the duration of zeitgebers. The most common zeitgebers are light and dark, but in places of constant light or dark, other cues exist. For example, hamsters living in continuous light or dark still follow a cycle of daily social interaction, exercise, hoarding, and eating (Mistlberger, 1996). Processes which throw off the natural cycle can disrupt circadian rhythms, such as jet lag and shift work. Jet lag occurs when the zeitgebers controlling light response are shifted forward in an eastbound flight, and shifted backward during a westbound flight. It typically takes one 10 days to adjust to the shift in sleep-wake cycles required for a Tokyo-to-Boston flight. During shift work, the zeitgebers stay the same, but the subject is forced to be the most active when they would normally be sleeping, leading to a larger

number of errors in the workplace than usual. Some heavily researched professions requiring shift work are air traffic controllers, sleep technicians, and medical workers (Pinel, 2007).

Through recent studies, it has been determined if zeitgebers are non-existent, the body can still follow a strict cycle in the absence of environmental cues. The first breakthrough came in 1967, when Richter discovered that lesions in the medial hypothalamus disrupted circadian cycles in rats. Afterwards, it was discovered these lesions were specifically affecting suprachiasmatic nuclei (SCN) of the medial hypothalamus. Although lesions in SCN do not affect the amount of time spent sleeping, it does disrupt the periodicity of sleep-wake cycles. SCN also display circadian cycles of electrical, chemical, and metabolic activity entrained by the light-dark cycle (Pinel, 2007). The idea of SCN maintaining circadian cycles was further solidified in 1990, when an experiment by Ralph and his colleagues removed the SCN from fetuses of hamsters who had an abnormally short sleep cycle of 20 hours. They then placed those SCN in the brains of adult hamsters whose sleep-cycles had been abolished by SCN lesions. They found that the adult hamsters now had a 20 hour sleep-wake cycle (Ralph, 1990). Although SCN play a huge role in the circadian clock, other mechanisms play a part as well.

Stated previously, both acute and chronic SD are linked to detrimental side effects. While chronic SD is more common in everyday life, total SD is much easier to devise an experiment around, and therefore is studied more thoroughly. Studies on sleep deprivation cover a wide range of measures including sleepiness, cognition, motor performance, physiological function, and even molecular function. Throughout the studies, sleep deprivation of even three or four hours has been found to consistently produce three effects. First, subjects report being sleepy, having a larger desire to sleep during the day, and fall asleep more quickly if given the opportunity. Second, subjects consistently display disturbances on written tests of mood. Over

time of SD, subjects' moods change in one way or another. Third, subjects display poor performance in tests of vigilance, such as listening to a series of tones and distinguishing one from the rest (Lim, 2010). It has also been determined that lack of sleep does not elicit the same cortical responses characteristic of physiological stress. Functions requiring a high degree of cerebral input are most seriously affected by sleep loss, while biochemical and physiological functions operating under a lesser degree of cerebral control are more resistant to the effects of SD (Fiorica, 1970).

While results of total sleep deprivation on some tasks are quite uniform, results for studies assessing complex cognitive processes after SD are much less consistent. One of the main problems associated with the inconsistencies is the lack of data. Researchers prefer to assess performance in simple, dull, monotonous tasks such as the aforementioned vigilance tests. Recently suggested, perhaps only some complex cognitive functions are affected by SD. Tasks involving logic such as critical thinking aren't affected by the disruptive effects of sleep loss, while tests of executive function are not as immune. Executive function refers to a group of complex cognitive abilities depending on the prefrontal cortex (Nilsson, 2005). Some abilities of executive function include fully understanding changing information, updating plans and strategies, insightful thinking, innovative thinking, and memory required for task-related skills (Chee, 2006).

While SD in a laboratory setting may not produce the same physiological responses as a stressful environment would, the two often go hand in hand. Many people become overwhelmed with the responsibilities of daily life, and often find themselves unable to sleep as a result. Therefore, many of the effects of a stressful situation are often attributed to not getting enough sleep. A good example is a study conducted by Rechtschaffen and Bergmann in 1995. Using a

device known as a carousel apparatus, two rats – an experimental rat and its yoked control – were forced to stay awake. The carousel apparatus contains two chambers with a disk in each chamber for the rat to stand on. Every time the experimental rat's EEG indicated sleeping patterns, the disk would rotate. If the experimental rat did not awaken immediately, it would fall into water. On the other hand, the control rat could merely walk the other way to avoid being submerged. Often, the experimental rats would die after several days, while the control rats would stay reasonably healthy. The rats' deaths were most likely attributed to the stress induced by the inability to sleep for constant fear of falling into the water. The rats' postmortem examination showed swollen adrenal glands, gastric ulcers, and internal bleeding – all signs of extreme stress (Rechtschaffen and Bergmann, 1995). The same method was also used on pigeons with similar, but less profound, results (Newman, 2006).

Partial SD has been linked with a large number of side effects such as depression, increased blood pressure, and type-2 diabetes. There are many studies linking chronic SD with increases in blood glucose levels along with the hormones leptin and ghrelin. Leptin and ghrelin are two opposing hormones who play a key role in mediating appetite. Leptin is a modulator of energy balance, suppressing food intake and promoting weight loss. On the other hand, ghrelin is a fast-acting hormone seemingly initiating meal intake. In obese subjects, leptin levels have been found to be high, while ghrelin levels are low. Results indicate that obese subjects are leptin resistant (Klok, 2007). One study finds sleep deprived subjects have elevated levels of ghrelin, decreased levels of leptin, and a higher body mass index. Whether the results truly correlate, or if they are merely a coincidence, remains to be seen (Taheri, 2004). A different study finds one night of total sleep deprivation increases levels of ghrelin, while decreasing leptin levels, promoting appetite and increasing food intake. Again, the results may be a coincidence, as

subjects may be eating to pass the time normally spent sleeping (Brondel, 2010). Another study links sleep restriction with increased indications of diabetes mellitus and impaired glucose tolerance (Gottlieb, 2005). Yet another study links sleep restriction with increased insulin resistance, a hormone regulating carbohydrate metabolism (Spiegel, 2005). With studies constantly being conducted, the connection between sleep deprivation, obesity, and diabetes is becoming stronger and stronger.

As stated earlier, subjects undergoing total SD experience changes in mood. In the case of depression however, said mood changes seem to be therapeutic. Manipulations of the sleep-wake cycle, whether of duration or timing, have rapid effects on depressed mood in 60% of patients with all types of affective disorders. Relapses after recovery sleep are less intense when patients are receiving medication and/or therapy (lithium, serotonergic antidepressants, full-spectrum light) (Wirz-Justice, 1999). A study performed in 1980 by Vogel and colleagues discovered an abnormal temporal distribution of REM sleep, representing a damaged sleep cycle and a circadian rhythm disturbance. REM sleep deprivation in individuals with depression “fixed” the temporal distribution, correcting one aspect of the circadian disturbance (Vogel, 1980). In 1982, Borbely created a 2-process model to account for the depressive sleep patterns as well as the therapeutic effect of SD on depression. The model proposes a sleep-dependent process of sleep regulation, termed process S, is deficient in depression. The lack of sleep and trouble staying asleep are contributed to the lack of process S. An alteration in the processes monitoring NREM and REM sleep is thought to result in the depressive sleep pattern. The antidepressant effects of SD are attributed to the increase of process S during prolonged wakefulness (Borbély, 1982).

Many people believe the adverse effects of sleep deprivation indicate we need all the sleep we get. However, another interpretation is based on the new awareness of the plasticity of the human brain. Perhaps instead of needing a certain amount, the brain adapts to the level of sleep it usually gets – even though it might be more than is necessary – and any deviation from this level is a disturbance. Through experimentation, studies have determined the latter to be the case. One study consisted of 16 subjects sleeping only 5.5 hours a night for 60 days, with the only anomaly being a slight deficit in auditory vigilance (Webb, 1974). Another study concludes that 15 minute naps every four hours or so may be more efficient than sleeping in 6-8 hour blocks (Smith, 2007).

Regardless of the most efficient way to sleep, sleep deprivation arises from a deviation in the level of sleep the body has recently been accustomed to. There are many disorders which contribute to a lack of proper sleep. Often lack of sleep is voluntary. Drugs such as amphetamines, adderall, Ritalin, caffeine, antihistamines, and benzodiazepines can all alter the sleep-wake cycle in one way or another (Pinel, 2007).

Most drugs affecting sleep fall into two different groups: hypnotic and antihypnotic drugs. Hypnotic drugs are drugs which increase sleep, and include benzodiazepines, antihistamines and possibly serotonergic drugs. Benzodiazepines act as an agonist of the neurotransmitter GABA, the main inhibitory neurotransmitter of the body. Increasing amounts of GABA in the body leads to sedation, decrease in anxiety, hypnotic effects, and muscle relaxation (Page, 2002). Benzodiazepines can be used to decrease the time it takes to fall asleep, reduce the number of awakenings during sleep, and increase total sleep time. However, prescriptions of benzodiazepines are only prescribed for short periods of time, and are not recommended for long term use. The body develops a tolerance, so patients must progressively take more for the same

effect. Also, a sudden halt in benzodiazepine therapy can lead to withdrawal symptoms of insomnia (Lader, 1999). Antihistamines act as histamine antagonists, counteracting the wakeful effects of histamine. Long term use is also not recommended for antihistamines, as they carry the same risks as benzodiazepines. Evidence has found that serotonergic drugs have therapeutic effects on SD in cats and rats, but have yet to find any benefit in treatment of human insomnia (Borbély, 1983).

Antihypnotic drugs take two forms: stimulants, (such as cocaine, amphetamine, and caffeine) and tricyclic antidepressants. Both stimulants and tricyclics increase the activity of catecholamines (norepinephrine, epinephrine, and dopamine) by either increasing their release, blocking their reuptake from the synapse, or both. Raising dopamine levels in the blood activates the reward center in the brain, explaining why many antihypnotic drugs have addictive properties and are dangerous to use for long periods of time, as they can cause physical dependence and withdrawal symptoms. In the case of caffeine, it has been documented that people sometimes ingest so much caffeine to counteract sleepiness they inherit a sleeping disorder known as “caffeine induced sleep disorder” (APA, 1994).

A large number of reported sleep deprivation cases are caused by the patient’s inability to fall asleep. Any disorder causing difficulty falling asleep or staying asleep is placed in a category of sleep disorders known as insomnia. In various sleep surveys, 30% of respondents report having sleep-related problems. However, many complaints of sleep disorders come from people whose sleep appears completely normal in laboratory tests. These people are getting a normal amount of sleep, but not as much as they think they should be getting. As a result, they go to bed earlier, laying in bed until they are able to fall asleep. The anxiety of not being able to fall asleep

often makes falling asleep more difficult, leading to reported sleep problems (Espie, 2002). However, a large number of SD cases are caused by legitimate problems.

Many cases of insomnia are unknowingly created by physicians. Discussed previously, benzodiazepines can be an effective short-term treatment, but continuous prescription can lead the brain to combat the effects of the drug by providing responses of its own, leading to increased tolerance and higher required dosages. Once the patient is taken off the benzodiazepines, the brain is still producing responses to the drug, creating withdrawal symptoms similar to those of insomnia, creating the same problem the drug was intended to stop in the first place (Pinel, 2007).

Some cases of insomnia have specific medical causes such as sleep apnea, periodic limb movement disorder, and restless leg syndrome. Sleep apnea is a sleep disorder in which a patient stops breathing many times in a single night. The patient will awaken, begin to breathe again, and fall back asleep. Some are totally unaware of their sleep apnea, making it difficult to diagnose, especially if one sleeps alone. Those with sleep apnea often complain of daytime sleepiness, leading to a diagnosis of hypersomnia instead (constant sleepiness) (Stepanski, 1984). Periodic limb movement disorder (PLMD) is characterized by periodic twitching of limbs during sleep. Like sleep apnea, many suffering from PLMD are unaware they have it, and complain of daytime sleepiness. Restless leg syndrome is different from PLMD in the fact that people are fully aware of their problem, and often describe a tension in their legs keeping them from falling asleep. Once diagnosed, PLMD and restless leg syndrome are chronic and are often treated with dopamine agonists (Hornyak, 2006).

Sleep deprivation is present on the field of battle as well. Soldiers must constantly be on their guard for fear of impending danger. A near-death experience, death of a loved-one, or merely a shocking event could plague a soldier with nightmares, post-traumatic stress disorder, and insomnia for months, sometimes even years after the incident (Moore, 2007). Military personnel require a great deal of tact, coordination, mental acuity, and physical stamina to survive, and sleep deprivation negatively affects all those in one way or another. In preparing for battle, military commanders must take into account the negative impact on the effectiveness of their forces after extended periods of combat and wakefulness. A study done in 2003 followed groups of Navy Seals and Army Rangers in simulated warzone tasks, to assess a soldier's ability to perform after days of sleep deprivation. The Navy Seals fared the worst. In a test requiring vigilance and quick decision making, the errors made jumped from 1 to 2 to an astounding 15 or more. The Army Rangers performed poorly as well, "worse than if they had been intoxicated" one researcher speculates (Sabo, 2003). In another study, forty-nine West Point cadets were placed into two groups, a sleep deprivation group and a control group, and tested on their reaction time. Not surprisingly, the control group showed an increase in performance of 4.3%, while the sleep deprivation group showed a slight decrease of 2.4%. When the life of another is in one's hands, every percentage counts, and sleep deprivation is often a burden (Maddox, 2009).

With sleep deprivation being a common concern on the battlefield, it becomes obvious opposing forces must be experiencing the same circumstances. Therefore, the goal becomes finding a way to stress the opponent's state of exhaustion while keeping your own troops alert and efficient. The military has found common ways to combat SD, and in some cases is embracing it. A study conducted by the Military Nutrition Division in 2002 found after 72 hours of SD, 200 to 300 mg doses of caffeine mitigated many of the adverse effects of SD in Navy

SEAL trainees. Caffeine significantly improved visual vigilance, reaction time, repeated acquisition, self-reported fatigue and sleepiness. Marksmanship scores were not affected by caffeine (Lieberman, 2002). Military researchers are also looking into a class of drugs known as ampakines to reduce the effects of SD. A study funded by the Defense Advanced Research Projects Agency discovered a clear improvement in performance along with changes in fMRI patterns in monkeys treated with ampakines. In some cases, the results were on par with if not better than the responses of well-rested monkeys without ampakine treatment (Porrino, 2005). Ampakines are a class of drug which bind to glutamate AMPA receptors, simulating the effects of glutamate in the body. Glutamate is the main excitatory neurotransmitter of the body, increasing alertness and attention span. Military researchers are continuously striving to discover methods to combat sleep deprivation on the battlefield. A report released by the Pentagon's Office of Defense Research and Engineering in 2008 claimed 86 currently proposed "cognitive aids" had been evaluated (PODRE, 2008).

Some readers might be put off by the idea of human research for fear of its danger, dislike of the ethics involved with any type of human research, or a mixture of both. However, studies have shown no negative side effects of acute-total SD as long as efficient recovery sleep follows. As for studies determining the effects of chronic-partial SD, caution toward the subject may carry some merit. Since chronic SD has been linked to diseases such as depression and diabetes, researchers must exercise caution when performing studies with human subjects. Any biomedical study involving human subjects requires approval by a committee known as the Institutional Review Board (IRB), formed to protect the rights of all human research subjects. Research subjects must be informed ahead of time of any and all details involved in the study, including all possible known side effects. Subjects must also give informed consent to

participate. However, in other parts of the world, where lesser regulations are enforced, people surely carry a different perspective on research regarding human subjects. Thus, researchers often take a defensive stance when questioned about purposes of research, claiming “If we don’t do it, they will”. In the case of sleep research, the Pentagon report asks armed forces to monitor enemy activities in sleep research, while maintaining close understanding of open source sleep research.

While human research certainly has its risks, they are more than outweighed by the benefits. Animal research, while extremely useful, has its limitations. An example is the study mentioned previously involving the therapeutic use of serotonergic drugs in cats and rats, while having no effect in humans. Humans function differently than other animals and while systems may be similar, there are outstanding differences as well. Human research provides the most accurate and efficient results available, often with little risk involved. An extreme argument goes along the lines of, “a few men must be sacrificed to save the lives of many”. There are many questions of ethics when discussing human research and one must weigh the risks and rewards while deciding for themselves.

No matter the ethics involved in human research, there is one category of “research” a majority of the world resists abundantly clear: torture. Practiced all over the world, torture is defined by the United Nations Convention Against Torture as, “... any act by which severe pain or suffering, whether physical or mental, is intentionally inflicted on a person for such purposes as obtaining from him or a third person information or a confession, punishing him for an act he or a third person has committed or is suspected of having committed, or intimidating or coercing him or a third person, or for any reason based on discrimination of any kind, when such pain or suffering is inflicted by or at the instigation of or with the consent or acquiescence of a public

official or other person acting in an official capacity. It does not include pain or suffering arising only from, inherent in or incidental to lawful sanctions (UNCAT, 1984).” The third Geneva Convention of 1949 also prohibits withholding of basic needs such as food, water, and sleep (Geneva Conventions, 1949). With so many sanctions against torture, it is astounding how regularly it is practiced in all parts of the globe.

Sleep deprivation can be, and is, used as a very effective form of interrogation. Whether it is considered torture or not is up to interpretation. In 2009, the United States Justice Department released memos containing various methods of interrogation used by the Central Intelligence Agency against high-target prisoners. Among the interrogation methods was sleep deprivation. A prisoner was shackled in a standing position with his hands in front of his body, preventing him from falling asleep while giving him a couple feet to move around. In lieu of standing SD, a prisoner may be shackled sitting down on a stool. The stool would support the detainee’s weight, but would be too small to allow them balance to be able to go to sleep. It was concluded sleep deprivation does not cause severe physical pain nor does it greatly affect the senses, as long as it is used for limited periods. The maximum allowable duration of depriving a prisoner of sleep is 180 hours, after which the prisoner must be able to sleep for 8 uninterrupted hours. Sleep deprivation nor any of the other methods listed in the memos were classified as torture by United States Law. Another memo concluded the methods did not break any United Nations sanctions (Mazzetti, 2009).

Interrogators often dodge U.N. sanctions and codes by operating within the ambiguity surrounding definitions of certain words. No regulation scale is in place to measure when pain is “severe” and when it is not. Too often, interrogators place the importance of information over the safety of the prisoner, generally resulting in sickness and even death. Statements from former

and current detainee's hardly ever match up to official government reports. To truly understand what a prisoner must endure, one would have to endure the ordeal themselves. As a prisoner of the Russian NKVD, Menachem Begin, Prime Minister of Israel from 1977-83, underwent many different interrogation methods, SD among them. He described the ordeal as follows "In the head of the interrogated prisoner, a haze begins to form. His spirit is wearied to death, his legs are unsteady, and he has one sole desire: to sleep... Anyone who has experienced this desire knows not even hunger and thirst are comparable with it (Begin, 1957)." Begin describes the desire to sleep as strong, if not stronger, than that of hunger or thirst. Depriving a prisoner of food or water is in strict violation of the Geneva Conventions, bringing the legality of SD into question yet again.

The Bush administration of 2000-2008 tried especially hard to circumvent the articles proposed in the Geneva Convention. In 2006, a bill was proposed to essentially give the CIA more freedom when interrogating high-priority targets, while blocking the legal system from interfering. In the court case *Hamdan v. Rumsfeld*, the Supreme Court ruled a provision of the Geneva Convention applied to all aspects of the conflict with Al Qaeda. The proposed bill would have kept the courts from interfering with such procedures in the future. President Bush was quite adamant about keeping interrogation techniques legal, being quoted saying having the techniques available would be crucial to gain life saving information. To help defend their case, the Bush administration cited passages from Jim Horne's 1988 book "Why We Sleep". Passages involving the 180 hours one could be safely sleep deprived were cited, stating it would cause no severe physical pain. Horne, director of the Sleep Research Centre at Loughborough University, was shocked to hear his book was being used, and claimed the Bush administration severely understated the effects. "Prolonged stress with sleep deprivation will lead to physiological

exhaustion and physical collapse, with the potential for various ensuing illnesses," he said. "To claim that 180 hours is safe ... is nonsense." He added claims stating a person subjected to that level of sleep deprivation would unlikely be able to produce credible information (Newman, 2009). The proposed bill by the Bush administration makes it clear that the United States are not ready to abide by international legal processes, and move only to further their own agenda (Liptak, 2006).

Regardless of the morality behind it, inducing SD can be effective if executed correctly, and there are a few different methods to go about it, some described earlier. SD interrogation is meant to put the prisoner in a dependent state, and there are infinite methods of keeping people from sleeping entirely. Some examples are the shackling method described above, physical contact when prisoner begins to fall asleep, placing the prisoner in an extremely stressful situation, etc. Menachem Begin was kept awake for days at a time until he was permitted to sleep. Just as he fell asleep, he was awakened and questioned. Methods such as this are effective because they place something the prisoner has desired for days into the palm of their hand, and then takes it away immediately. It can be compared to giving a baby their bottle, then taking it away, yelling at them, and watching them cry. While a grown adult may not cry, it is certainly an unpleasant situation. A report leaked by the International Committee of the Red Cross contains details of interviews with fourteen "high-value" detainees, all transferred to Guantanamo Bay and interrogated by the CIA. Eleven of the fourteen interviewed reported being deprived of sleep at some point during their detainment from seven continuous days to intermittently continuing up to two to three months after initial detainment. Sleep was deprived in various ways ranging from loud music to long interrogation sessions to constant spraying of cold water. Abu Zubaydah, a Saudi Arabian terrorist, reported being chained to a stool for three weeks, with various forms of

SD implemented on him. The cell was kept at extremely low temperatures, guards constantly sprayed water on him, and loud music was replaced every now and then with loud hissing noises (ICRC, 2007).

If one merely wanted information without the stressful effects, drugs could be used to allow a longer interrogation time without fear of the detainee growing tired. Complex information might require the detainee to be thinking as clearly as possible. Sleep deprivation decreases vigilance and complex thinking, so it probably would not be the best course of action. High efficacy stimulants would be effective in keeping prisoners awake and alert. Normally, while not a high efficacy stimulant, caffeine would be the stimulant of choice. Caffeine would block adenosine receptors, keeping the detainee awake while providing no positive effects. However, one must be careful when administering caffeine in large doses. Discussed previously, large amounts of caffeine in a short amount of time can produce a caffeine induced sleep disorder. It also might send the recipient into a state of psychosis, producing manic and schizophrenic episodes. Schizophrenic episodes can lead to delusions, among other things, and while this might be an effective way to deprive someone of sleep, the information they reveal will often be less than credible. Jim Horne also claims a prisoner deprived of sleep for more than 180 hours would be psychologically exhausted and unable to produce any credible information.

To avoid the uncertainty of information gained during caffeine induced psychosis, one might suggest waiting until the episodes pass. However, if one were to take this approach, there are other drugs available that provide much faster and more pronounced effects. Ideally, SD interrogations would require the detainee to be as tired as possible without the delusional side effects of drugs such as caffeine, desiring sleep so much they would do anything to obtain it. Normally, this would take a few days, although combining SD with other methods of

interrogation might reduce the time until the detainee “cracks”. Depending on the situation, every second counts and SD would not be the best choice. However, through the use of high efficacy stimulants, the time can be shortened dramatically. High efficacy stimulants such as cocaine or amphetamine act to keep the subject awake and alert. Repeated dosage of high efficacy stimulants in a short period of time (three days or so) would initially keep the detainee from falling asleep while in a state of euphoria. However, after administration of the drug has ceased, the detainee would experience heavy withdrawal symptoms, making the desire to sleep astronomical. These responses are confirmed in a study conducted by Johanson in 1999. Subjects were administered cocaine before bed for five nights. Afterwards, during the abstinence phase, subjects showed initial increased daytime sleepiness. Also, after 2 weeks, subjects’ sleep schedules remained different from those of age-matched controls (Johanson, 1999).

A problem associated with use of high efficacy stimulants is the euphoric effect they would have on the detainee. Stimulants such as cocaine and methamphetamine increase dopamine levels in the nucleus accumbens, the reward center of the brain (Hernandez, 1988). Giving prisoners cocaine might be seen as rewarding them. Many of these high efficacy stimulants are also illegal in a majority of the world, and are normally looked at in a negative light. An alternative to high efficacy stimulants might be histamine agonists. Discussed previously, histamine production has been linked to wakefulness, and shuts off during sleep. Drugs can act as antagonists by increasing production of histamine, blocking histamine reuptake by the synapse, or mimicking the effects of histamine by binding to histamine receptors in the brain. Histamine has four different receptors: H-1, H-2, H-3, and H-4. Studies show the H-1 receptor to be most associated with the sleep-wake cycle, and any drugs affecting the cycle would associate with these receptors. One study found the H-1 receptor agonist 2-

thiazolylethylamine (2-TEA) to increase wakefulness while decreasing REM and NREM sleep in rats (Monti, 1985). These histamine agonists might provide the same sleep deprivation enhancing effects as high efficacy stimulants without the sense of euphoria associated with them. Also, histamine agonists do not have the negative associations high efficacy stimulants have.

Sleep deprivation is a reoccurring problem around the world. The current trends make it abundantly clear it isn't going away anytime soon. With its cloudiness surrounding certain topics and potential therapeutic uses, it is clear more research must be conducted in all aspects of SD. More research might also open the door to a long-term cure for insomnia, or a procedure preventing future sleep troubles. As far as using SD as a tool for military interrogations, the only positive benefits to be derived from it are for the interrogator by producing a stressful environment for the detainee, making them more likely to reveal important information. If the detainee were willing to cooperate, there would be no need for an interrogation in the first place. It is unfortunate to think that many countries around the world, including the U.S.A., take part in such torturous acts when there have been so many decrees to outlaw them. However, it is difficult to ignore tales from the prisoners themselves, especially tales of such detail. It seems as long as people continue to have a need for information, they will stop at nothing to obtain the required data.

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