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Introduction

This video segment, called *Interrupted Sleep: The dangers of restricted sleep* is a segment of Catalyst, a science journalism television (TV) show that screens for 30 minutes twice a week on the ABC1 free-to-air channel.

It is a good example of a lay presentation of the current state of research and visits an operating research laboratory in a presently dynamic field, sleep research.

From the Catalyst About page:

- "At Catalyst we know that science is a dynamic force for change.
- Each week Catalyst brings you stories from Australia and around the world.
- Our passion to meet scientists at the forefront of discovery is matched by our fascination with science breakthroughs however big or small.
- Science changes all our lives.
- For better or worse, we are committed to showing you what our future holds."

Sleep research in general is interesting because sleep is a phenomenon that everyone experiences, but that no-one knows very much about. We know a fair amount about what happens when sleep is restricted or removed, but very little about its normal function.

Neuroscientific Context

Sleep, The Final Frontier

- Sleep that knits up the ravell'd sleeve of care,
- The death of each day's life, sore labour's bath,
- Balm of hurt minds, great nature's second course,
- Chief nourisher in life's feast.
All humans sleep, to some extent or another- if you don't, you're probably dead (Benca et al, 2009). The average human spends slightly less than a third of their life sleeping, although the scientific community is presently split on what the healthiest length of time is to spend asleep each day (Bogels et al, 2010), more precisely known in this context as a cycle of the Circadian rhythm.

So What Is Sleep, Really?

According to Purves (2004), the textbook defines sleep "behaviorally by the normal suspension of consciousness and electrophysiologically by specific brain wave criteria". As there are numerous other pathways by which the suspension of consciousness can be achieved, the "specific brain wave criteria" are a more precise and reliable method to determine if a mammal is sleeping. Each of the five stages of sleep (discussed below) has a stereotypical brain wave pattern that can be easily detected by electroencephalogram (EEG).

Sleep is linked to recovery (Shapiro et al, 1981; Banks et al, 2010), normal metabolism (Leproult, Spiegel and Van Cauter, 1999), consolidation of memory (Chan et al, 2006), and various other processes. With all that said, little is truly understood about the nature and purposes of sleep.

Stages of Sleep

In 1953, Aserinsky and Kleitman set out to record the specifics of the strange eye movements during sleep that had been observed by several researchers before them. In order to separate their electromyographic measurements of eye movements from brain wave activity, they concurrently measured that brain wave activity- and entirely accidentally made a discovery with far-reaching impact. They discovered that sleeping subjects had distinct phases of brain activity, which we now know as Stage 1, Stage 2, Stage 3, Stage 4, and Rapid Eye Movement (REM) sleep.

Sleeplessness

"Healthy" Sleep Duration

The amount of time we need for healthy sleep varies among individual's genetics, sex, age, race and location in the world. As a particular example some countries have informal "siestas" in the afternoons. Research has shown that naps can be very helpful in reviving people for short periods of time (Axelsson et al, 2010). Holm (2005) showed that a short rest could improve performance on tasks for 15 minutes afterwards. In the "stop, revive, survive" campaign for drivers on the road for extended periods of time, drivers are recommended to take 15 minute breaks every hour during long road trips, and the RTA suggests that 8 hours is a healthy amount of sleep each night (RTA NSW, 2008).
The Mayo clinic suggests (Kenneth, 2008):

- Preschoolers: 11 hours
- School-age children: 10 hours
- Teens: 9 hours
- Adults: 7-8 hours
- Seniors: 7-8 hours

Other sources suggest between 5 and 10 hours. Close to 7-8 hours are correlated with the lowered risk of cardiovascular disease. Bear (2007) suggests that 68% of young adults should get between 6.5 and 8.5 hours of sleep. Healthy sleep has been correlated with improved job satisfaction and better general well-being (Bingol and Karagozoglu, 2008).

**Partial Sleep Deprivation**

Sleep deprivation is a common feature of many lifestyles. Some, such as shift workers, emergency service personel or military personel, expect irregular sleep deprivation as just 'part of the job'. Others, such as students (Bogels et al., 2010) and office workers, may experience regular partial sleep deprivation as an unintended consequence of lifestyle pressures.

Partial sleep deprivation has been shown to have impacts as diverse as degraded ability to reason about moral decisions (Eid, Olsen, and Pallesen, 2010), increased food intake (Brondel et al., 2010), and academic performance (Bogels et al., 2010).

**Effect of Sleep Deprivation**

Effects of sleep loss include (Gehrman et al., 2010):

- Day-time sleepiness,
- increased reaction time,
- secondary depression,
- increased physiological stress,
- neuronal damage,
- early ageing,
- increased risk of cardiovascular disease and hypotension,
- decreased immune system action,
- decreased metabolism,
- increased risk of insulin resistance and diabetes,
- and impairment of pituitary-gonadal axis.
**Insomnia**

Insomnia is defined by Drake et al (2003) as "the experience of inadequate, insufficient, or nonrestorative sleep despite ample time in bed". Affecting 10-15% of Americans, insomnia causes symptoms outside the nocturnal period as well as the disturbance of sleep. Insomnia sufferers report significantly impaired work performance (Leger et al, 2002), impaired ability to function physically and socially (Leger et al, 2001) and an overall reduction in quality of life (Katz and McHorney, 2002).

On top of those effects, insomnia carries with it an increased risk of developing a major depressive disorder. Depressed patients with sleep disorders tend to have higher rates of suicidal behaviour than patients without sleep disturbance (Agargun et al, 1997).

Insomnia has a high economic burden. Daley et al (2009) found that in Quebec, insomnia causes an economic loss of 6.6 billion USD per year, with 5 billion USD of that due to loss of productivity.

There is yet to be a major breakthrough with regards to the main causes of insomnia, though it has been linked to increased stress. In spite of this, treatments targeting insomnia do exist, including both pharmacological and behavioural treatments. Many insomnia sufferers turn to self medication (particularly alcohol) to help them sleep, with many of those reporting subsequent improvements. Studies on ethanol use as a hypnotic agent have shown that continued use leads to an increased tolerance and, following that, increased dosage of self medication (Drake et al, 2003).

**Sleep Apnoea**

Sleep Apnoea is a sleep disorder in which sufferers experience repeated disturbances in breathing during sleep. In most cases, the disruption is caused by a physical blockage of the upper airways. Some, however, are caused by disruptions in the functioning of the respiratory muscles- or even a mix of both problems.

During sleep, the airways are held open by cartilage, which provides structural rigidity and prevents collapse. The weak point of the upper airways during sleep is the pharynx, the structure of which is largely composed of soft tissue. Under normal circumstances, pharyngeal dilator muscles hold the the pharynx open, allowing inspiration to occur. These muscles are controlled centrally by respiratory centres in the brainstem and locally by mechanoreceptors.

The most common underlying cause of the collapse of the pharynx during sleep is caused by reduced activity of receptors in the brainstem. It been found that during both non-REM and REM sleep, activity of the dilator muscles is reduced, leading to either incomplete occlusion of the airways, causing snoring, or to complete occlusion, blocking the airways and forcing the patient to wake.

As sleep is essential for many restorative processes in the brain and the body, frequent disruption of sleep has been shown to have many negative effects on neurocognitive function, cardiovascular function and hormonal axis function (Attal and Chanson, 2010).
Mortality

Lack of sleep can be attributed directly to mortality and increased chance of mortality. Several pathways have been suggested by Grandner et al. (2010) and others.

- Animal models suggest that a direct relationship between short sleep and mortality could exist. Sleep deprivation in rats leads to death within weeks (Bergmann and Rechtshaffen, 2002).
- Sleep duration can be correlated with mortality. That is, short sleep results from a range of factors including socio-economic, environmental and physiological influences that also increase the risk of mortality, and that sleep may be a behavioural intermediate towards mortality (Adler et al., 1999).
- Sleep itself could cause the physiological and social outcomes which lead to increased risk of mortality. That is, sleep deficiency is an indicator for increased risk of complications such as cardiovascular disease, immune deficiency and obesity (Berkman and Kawachi, 2000).
- Short sleep could be associated with other characteristics which may lead to increased mortality, rather than being a causative factor in mortality itself. For example, mortality increases with age, as does a falling amount of sleep (Carskadon et al., 2004).
- Similarly, there is the possibility of reverse causality. Characteristics which lead to increased risk of mortality, also lead to decreased sleep (Grandner et al., 2010).

Slow Wave Sleep: Current Theories

Characterisation

Slow wave sleep is composed of stage 3 and 4 sleep. It is characterised by low frequency, large amplitude brain wave activity (known as delta waves) that can be easily recognised on EEG readings.

- Copyright (c) 2004 Sinauer Associates, Inc., from Purves (2004) [modified]

Slow Wave Sleep and Recovery

A recent study on recovery from sleep deprivation was the largest (159 subjects) sleep lab study to confirm that when subjects sleep for an extended period of time after having been deprived of sleep for several days, slow wave energy as a percentage of total sleep time increases markedly compared to non sleep deprived controls (Banks et al., 2010). The idea that slow wave sleep is a recovery mechanism has been around for decades; for example, Shapiro et al. (1981) studied marathon runners to confirm that after extreme physical exertion (i.e. a marathon), subjects would show increased slow wave sleep for several nights afterwards. Additionally, the runners’ subjective reports of feeling recovered were synchronous with the reduction of slow wave sleep towards normal levels.

Slow Wave Sleep, Glucose Metabolism, and Diabetes
Sleep is strongly linked to metabolism, including several specific metabolic processes that cycle in lock-step with various sleep stages. Individuals with high sleep debts are shown to have lower glucose tolerances than those with normal sleep patterns. Thyrotropin and cortisol, which are important metabolic hormones, are notably increased in low sleep individuals (Spiegel et al, 1999).

Beihl et al (2009) found a strong relationship between sleep duration and risk of developing type 2 diabetes. The study showed a U shaped relationship in models with sleep as an independent factor. Short sleep duration also showed a strong relationship in multivariate models.

**Analysis**

- "What we know about sleep is if you don't get it, you start to suffer."

  - Professor Ron Grunstein

The first thing Professor Grunstein tells us in the video is a good one-line summary of the state of sleep research. A simplification, certainly, but not an inaccurate one; the existing data from sleep research is all about what goes wrong when people sleep too much (some) or too little (most). There are some theories developing about the actual physiological function of sleep, but nothing solid.

Catalyst is a series broadcast on the ABC's free-to-air television channel, ABC1. It's scheduled for Thursdays at 8pm and Fridays at 11am. The 8pm slot, in particular, is prime time television. Between these factors, Catalyst is showing when a substantial portion of the Australian TV audience is watching, and as such is being served to a general audience of a range of ages and education levels.

The segment attempts to demonstrate the effects of shortened and interrupted sleep by presenting case studies of the show's presenters, a technique designed to help the audience relate to the scientific process. While this is probably an effective technique, it also invites the strongest single criticism of the segment: several conclusions made are drawn directly from those case studies, and presented with phrasing that suggests generalisability. For example, one of the primary conclusions given is, "Well what this tells us is that for driving ability the slow wave sleep component is not important." The conclusion is drawn directly from a graph comparing the two case studies from the segment, with language such as "for driving ability" rather than "for your driving ability" giving the impression of generalisation. It should also be noted that the graph presented only shows two data points for each subject, an obvious simplification.

**Specific Criticisms**

- "There's a relationship between disrupted sleep and the risk of obesity, the risk of diabetes, and the risk of heart attack."

This is consistent with numerous recent studies and reviews (Attal and Chanson, 2010; Brondel et al, 2010; Gehrman et al, 2010; Leproult, Spiegel and Van Cauter, 1999). The information as provided is quite
simple, mechanisms being largely glossed over. However, the phrasing does not strongly suggest causality, and remains truthful and not oversimplified.

Some additional detail is entered into later in the video, regarding "metabolically active hormones" and specifically growth hormone. Growth hormone is a term that is relatively familiar in a lay education; it gives the audience something specific that they can understand, and is consistent with research findings (Purves et al., 2004).

- "People a hundred years ago thought it was sort of like your brain just went dead. Um, and didn't understand about different stages of sleep. I mean the, the understanding of stages of sleep wasn't really refined till the fifties."

Again, Professor Grunstein's statements are consistent with the findings of the field. The first classification of stages of sleep was by Aserinsky and Kleitman in 1953. The idea that sleep is a "little death" is a very old one; the traditional Jewish prayer to be said upon waking, Modeh Ani, begins "I offer thanks before you, living and eternal King, for You have mercifully restored my soul within me". The segment's simple illustration of neural activity in a sleeping subject has educational value for an audience with little scientific background.

- "I was waking up forty-eight times per hour. These are awakenings that you're not aware of. They're not conscious awakenings. It's just, you're falling out of deep sleep, so you're not getting any quality sleep."

The presentation of a sleep apnoea sufferer is valuable as an example of a pathological condition in which sleep is interrupted. While it is again a case study, and presents no statistical information about the condition, it serves to give a human face to the problem without becoming sensationalistic.

- "My body processed the lipids 25 per cent better."

The explanation of the effects on metabolism of restricted sleep fail to actually explain the nature of any of the metabolites mentioned. "Lipid" is not a common term among the general population; either the use of the term "fats", or an explanation of what lipids actually are, might have been more appropriate.

**Conclusion**

*Interrupted Sleep: The dangers of restricted sleep* is a good layman's view of some of the complications that can arise from restricted sleeping patterns, with a focus on impaired cognitive ability, as shown in the simulated driving activity. It gives accurate scientific information when statements are made without over-
complicating the subject for a general audience. However, it has a severe weakness in that it spends a significant portion of its air time dealing with case studies rather than data from larger population samples, particularly given the availability of statistics calculated on an intent-to-treat basis that would be particularly applicable to an audience that does, in fact, constitute a large population sample itself.

Appendix

Search Strategy

Discarded Ideas

Our initial attempt to find a media item involved first choosing a topic (Phineas Gage, a case study in which a group member expressed interest) and then finding an appropriate related video or other media. Using both global (e.g. Google search, an internet search engine) and site-local (e.g. the search feature in YouTube, a large video hosting site) we found several interesting videos about the case study. Upon critical examination of the material, we decided that none of the items found contained enough scientific information or even conjecture to be of interest for this project. We also examined segments of the documentary series Fight Science, hosted by the National Geographic Channel. Fight Science was similarly discarded for lacking in actual scientific content because it was overly popularised with any scientific contexts removed.

Final Selection Process

During the process of selecting a topic, a group member suggested looking at the web site for ABC's Catalyst series. We examined several of the segments available on the site, selecting based on neuroscientific content and the amount of apparent scientific data presented. We were fortunate to discover the video we finally selected quite early on.

References

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