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Sleep Quality

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1. CAFFEINE AND SLEEP DEPRIVATION

Sleep deprivation impacts cognitive processes, but in varied ways. For example, "sleep deprivation consistently impairs performance on vigilant attention tasks but has mixed effects for tasks that measure other aspects of cognition" (Stepan et al 2021 p1).

Two main theories have been proposed to explain the relationship between sleep deprivation and cognitive processes - vigilance hypothesis, and the neuropsychological hypothesis (Stepan et al 2021). The former holds that sleep deprivation produces direct deficits in vigilant attention, and consequently indirect impacts on other cognitive processes. The neuropsychological hypothesis proposed that "sleep deprivation effects are akin to specific neuropsychological deficits in a range of cognitive processes and cannot be solely explained by general attention deficits" (Stepan et al 2021 p2).

The two theories can be compared with studies using caffeine to counter the effects of sleep deprivation (appendix 1A). Caffeine combats vigilance attention deficits when the Psychomotor Vigilance Task (PVT) (Wilkinson and Houghton 1982) is used. Participants must press a computer key every time a certain stimulus appears during a certain period of time. Sleep-deprived participants who received caffeine made fewer attentional lapses (ie: miss the stimulus) than controls (Stepan et al 2021).

"Placekeeping" is another cognitive process impaired by sleep deprivation. It is "a cognitive control process required when a set of steps or sub-tasks must be performed in a specified order, without repetitions or omissions, despite interruptions that make it difficult to remember one's place in the correct sequence" (Stepan et al 2021 p2). The effect of caffeine here is mixed (Stepan et al 2021).

Stepan et al (2021) reported their experiment on caffeine, sleep deprivation, and cognitive performance which had three variables:

a) Sleep deprivation for one night vs rested - Participants slept at home or stayed awake in the laboratory.

b) 200 mg caffeine pill vs placebo - Pills were given at 12.30 am, 4.30 am, and 8.30 am in the sleep-deprived group, and 8.30 am in the control group.

c) Type of cognitive task - Vigilant attention vs placekeeping. The former was measured by the PVT, which involved watching a blank computer screen for a large red circle which appeared for 0.5 seconds, every 1 to 10 seconds over a 10-minute period. The participants pressed the computer key as fast as possible (with 500 ms which was set as the threshold for a lapse).

Placekeeping was measured by the UNRAVEL task (Altmann et al 2014), which was a seven-step procedure lasting about 20 seconds (with a distraction) (table 1.1). The steps were learned prior to the experiment.

- A stimulus is presented with a letter and a number. A series of steps (answers to questions) must be performed in order - U, N, R, A, V, E, L.

- U - Underlined or Italicised
- N - Near to or Far from start of the alphabet
- R - Red or Yellow ink
- A - Above or Below a line
- V - Vowel or Consonant
- E - Even or Odd (number)
- L - Less than or More than 5

(Based on figure 1 Stepan et al 2021)

Table 1.1 - The UNRAVEL task.

The experiment was both independent and repeated measures design. In the latter case, all participants did both types of cognitive tasks, while there were four independent groups - sleep/placebo, sleep/caffeine, sleep-deprived/placebo, and sleep-deprived/caffeine.

The participants were 276 undergraduates at Michigan State University. Baseline measures were taken at 10 pm, and then again at 9 am the next day.

Overall, sleep deprivation impaired performance on both tasks, and caffeine improved it compared to baseline.

But the general patterns hid that caffeine affected performance selectively. A small number of participants (poor performers) did not follow instructions on the UNRAVEL task, and analysis that removed them (and the poorest PVT performers) produced different findings - namely that "caffeine selectively improved visual vigilant attention but not, for the large majority of participants, the cognitive processes required for placekeeping" (Stepan et al 2021 p9).

The findings were more supportive of the neuropsychological hypothesis than the vigilance hypothesis.

So, on the PVT caffeine does help after sleep deprivation, but sleep-deprived UNRAVEL task scores only improved by caffeine for individuals whose performance deteriorated most after lack of sleep. Stepan et al (2021) applied their conclusions to occupational settings - "our results suggest that where sleep deprivation and tasks requiring placekeeping (such as procedures) are prevalent and placekeeping errors are costly, caffeine is unlikely to provide much benefit beyond a small proportion of individuals for whom sleep deprivation effects are especially strong" (p10).

This is a view described as "selective caffeine effects", and it is supported by simulations of sleep deprivation (eg: Gunzelmann et al 2009), which "suggest that the cognitive mechanisms responsible for impairments on the PVT... are distinct from those responsible for impairments of declarative memory... Declarative memory does not play an obvious role in vigilant attention but plays a central role in placekeeping, in that it stores episodic items representing past performance and semantic items representing the step sequence" (Stepan et al 2021 p10).

The following methodological issues about Stepan et al's (2021) experiment can be considered:

i) Sample - Adults aged 18-26 years old at a US university, of which two-thirds were female.

ii) Cognitive tasks - Standardised experimental measures, but artificial tasks. Testing lasted 1-2 hours each time.

iii) Sleep deprivation - Only one night. These participants had to stay in the laboratory all night, even if they could watch TV, for example, whereas the controls went home.

APPENDIX 1A - ADENOSINE

Caffeine delays sleep by blocking the action of adenosine. As energy is expended during wakefulness, adenosine builds up through the breakdown of the metabolic molecule adenosine triphosphate (ATP), for example, and produces the sense of sleepiness (Burke 2021). The signalling pathway here is the same one that light works upon - ie: light turns the pathway on while adenosine inhibits it (Jagannath et al 2021).

REFERENCES

Altmann, E.M et al (2014) Momentary interruptions can derail the train of thought Journal of Experimental Psychology: General 143, 215-226

Burke, K.L (2021) Fixing broken biological clocks American Scientist 109, September-October, 262-264

Gunzelmann, G et al (2009) Sleep deprivation and sustained attention performance: Integrating mathematical and cognitive modelling Cognitive Science 33, 5, 880-910

Jagannath, A et al (2021) Adenosine integrates light and sleep signalling for the regulation of circadian timing in mice Nature Communications 12, article 2113

Stepan, M.E et al (2021) Caffeine selectively mitigates cognitive deficits caused by sleep deprivation Journal of Experimental Psychology: Learning, Memory and Cognition (https://doi.apa.org/doiLanding?doi=10.1037%2Fxlm0001023)

Wilkinson, R.T & Houghton, D (1982) Field test of arousal: A portable reaction timer with data storage Human Factors 24, 4, 487-493

2. SLEEP AND PREGNANCY

Sleep disorders are common in pregnancy (eg: half of women report insomnia) (Felder et al 2017). But is there a relationship to pre-term births?

Felder et al (2017) tried to answer this question with the analysis of medical records of around three million pregnant women in California between 2007 and 2012. The sample was drawn from all live singleton births during this period. Sleep disorders information was taken from hospital admission during pregnancy or delivery hospital discharge records using official ICD-9 CM criteria (AMA 2008) (table 2.1). Other measures included maternal age of delivery, smoking during pregnancy, other health problems, and body mass index. A reference group of women without sleep disorders was established. The final samples were 2172 in each group.

ICD-9 CM code	Diagnosis
327.0	Organic disorders of initiating and maintaining sleep (organic insomnia)
307.41	Transient disorder of initiating or maintaining sleep
307.42	Persistent disorder of initiating or maintaining sleep
780.52	Insomnia, unspecified

(Source: Felder et al 2017 table 1 p575)

Table 2.1 - Example of ICD-9 CM categories for insomnia.

A delivery before 37 weeks of gestation occurred in 15% of the women with a diagnosed sleep disorder and 11% of the reference group. Birth before 34 weeks gestational age, 5.3% of women with diagnosed sleep disorder compared to 2.9% without such diagnoses.

Specifically, for insomnia, the risk of delivery before 34 weeks was nearly double. Insomnia increased the risk of pre-term birth by 30%, and sleep apnea by 40%.

This study had a larger sample size than previous research, and it controlled for major confounders (Felder et al 2017).

The researchers were dependent on the hospital records (ie: collected by others). They noted that the "sleep disorder prevalence in the current sample is lower than previous reports, possibly reflecting under-detection and under-diagnosis. Specifically, the sleep disorder prevalence in the current sample was 0.08% compared with previous work documenting prevalence rates of 12.6% for insomnia diagnosis, more than 50% for clinically significant insomnia symptoms, and 11.1% on a self-report measure of risk for sleep apnea. Those with a sleep disorder on their hospital discharge record may represent patients with the most severe presentation" (Felder et al 2017 p580).

The severity of the sleep disorder was not measured, nor was the details of the onset of the problem (ie: before or during pregnancy). "Information about diagnostic method was unavailable; thus, it is unknown whether clinicians utilised gold standard methods and established clinical criteria to diagnose sleep disorders. Treatment information was also unavailable..." (Felder et al 2017 p580).

In terms of causality: "Researchers say that a lack of sleep is unlikely to be a direct cause of early births, but it could trigger other processes, such as inflammation, that eventually result in prematurity" (Maxmen 2017 p145).

REFERENCES

AMA (2008) International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9 CM) Chicago: American Medical Association

Felder, J.N et al (2017) Sleep disorder diagnosis during pregnancy and risk of pre-term birth Obstetrics and Gynecology 130, 3, 573-581

Maxmen, A (2017) Early births tied to poor sleep Nature 548, p145

3. SLEEP QUALITY AND ADDICTIONS

"Substance use disorder" (SUD) is the diagnostic category for the everyday idea of addiction. The symptoms include "tolerance, withdrawal syndrome, risky use, having related individual/social problems, decreased attention for fulfilling social roles, prolonged and increased frequency of usage, multiple recurrences, related bio-psychological problems and the urge to use the substance" (Saffari et al 2022 p1). "Problematic internet use" (PIU) (or "internet addiction") is "a continuous and recurrent internet use that causes addictive symptoms, such as irritability when not being online, inattention to time when using the internet (tolerance), preoccupation and withdrawal-related mood fluctuations" (Saffari et al 2022 p1). There are a small number of individuals that suffer from both.

Saffari et al (2022) investigated sleep quality and quality of life among such individuals in Taiwan. The participants, who were recruited from addiction out-patient clinics (n = 319), completed five validated measures:

i) The Smartphone Application-Based Addiction Scale (SABAS) (Csibi et al 2018) - Six items (eg: "My smartphone is the most important thing in my life"), each scored "strongly disagree" (1) to "strongly agree" (6). A score of 21 and above (out of 36) is an indicator of problematic smartphone usage.

ii) The Bergen Social Media Addiction Scale (BSMAS) (Andreassen et al 2016) - Six items (eg: How often during the last week have you spent thinking about social media or planned use of social media?"), each scored "very rarely" (1) to "very often" (5). A score of nineteen and above (out of 30) is an indicator of problematic social media use.

iii) The Internet Gaming Disorder Scale - Short Form (IGDS9-SF) (Pontes et al 2015) - Nine items (eg: "Do you feel more irritability, anxiety, or even sadness when you try to either reduce or stop your gaming activity?"), each scored "never" (1) to "very often" (5). A score of 32 and above (out of 45) is an indicator of problematic gaming.

iv) The Pittsburgh Sleep Quality Index (PSQI) (Buysse et al 1989) - Nineteen items covering sleep quality in the last month (eg: "During the past month, how would you rate your sleep quality overall?").

v) The World Health Organisation Quality of Life Brief Version (WHOQOL-BREF) (Skevington et al 2004) - 26 items (eg: "How satisfied are you with the conditions of your living place?").

Overall, 14% of the sample were categorised as problematic smartphone use, 2% problematic social media use, and less than 1% problematic gaming, while 56% has sleep problems.

Problematic smartphone use was significantly associated with poor sleep quality, and poor sleep quality was subsequently associated with lower quality of life (as were problematic social media use, and problematic gaming).

In summary, individuals with SUD and PIU had poor sleep quality, and consequently quality of life.

The sample of this study, however, was not representative of the population as a whole. It was a convenience or opportunity sample, which was 85% male, over half single, and with a mean age of 42 years.

Sleep quality was self-reported (as were all the measures) with no independent verification or triangulation with other means (eg: objective measures of sleep problems).

REFERENCES

Andreassen, C.S et al (2016) The relationship between addictive use of social media and video games and symptoms of psychiatric disorder: A large-scale cross-sectional study Psychology of Addictive Behaviours 30, 2, 252-262

Buysse, D.J et al (1989) The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research Psychiatry Research 28, 193-213

Csibi, S et al (2018) The psychometric properties of the Smartphone Application-Based Addiction Scale (SABAS) International Journal of Mental Health and Addiction 16, 393-403

Pontes, H.M et al (2015) Measuring DSM-5 internet gaming disorder: Development and validation of a short psychometric scale Computers in Human Behaviour 45, 137-143

Saffari, M et al (2022) Effects of sleep quality on the association between problematic internet use and quality of life with substance use disorder BJPsych Open 8, e155, 1-8

Skevington, S.M et al (2004) The World Health Organisation's WHOQOL-BREF quality of life assessment: Psychometric properties and results of the international field trial, a report from the WHOQOL group Quality of Life Research 13, 299-310

4. FRUIT AND VEGETABLE INTAKE AND SLEEP QUALITY

Godos et al (2021), in a systematic review, found that a healthy diet generally was linked to higher sleep satisfaction, while other have found this specifically with higher intake of fruit and vegetables (eg: university students in twenty-eight countries; Pengpid and Peltzer 2020).

In a longitudinal study (Jansen et al 2021), women in Pennsylvania, USA, with chronic insomnia, who increased their intake of fruit and vegetables by three servings per day for three months, were twice as likely to no longer report insomnia compared to controls.

Pengpid and Peltzer (2022) took these findings and investigated the topic in rural South Africa. Data were taken from "Health and Ageing in Africa: A Longitudinal Study of an INDEPTH Community in South Africa" (HAALSI), which began in 2014-15 with over five thousand over 40 year olds (Wave 1). Wave 2 data were collected in 2018-19.

The outcome variable of poor sleep was measured by the Brief Version of the Pittsburgh Sleep Quality Index (B-PSQI) (Sancho-Domingo et al 2021) (table 4.1). Various aspects of sleep in the past month are covered, and scores range from 0 to 15, while five or above is categorised as poor sleep quality.

- During the past month, how often have you had trouble sleeping because you:

  (a) Cannot get to sleep within 30 minutes

  (b) Wake up in the middle of the night or early morning

  (c) Cannot breathe comfortably

- Response options:
  Not during the past month
  Less than once a week
  Once or twice a week
  Three or more times a week

(Source: Famodu et al 2018 appendix)

Table 4.1 - Example of items from B-PQSI.

The exposure variable was fruit and vegetable intake in a typical week (number of days, and number of servings per day). Eleven control variables were measured, including tobacco and alcohol use, body mass index, physical exercise, and depression.

Overall, 7.6% of the sample had persistent poor sleep quality (ie: both Waves 1 and 2), while 11.1% of individuals had poor sleep quality at Wave 2 only.

Contrary to most previous research, Pengpid and Peltzer (2022) found a positive association between fruit and vegetable intake and poor sleep (ie: more intake = more poor sleep). But this was the case for men only, while "higher fruit but not vegetable intake was associated with poorer sleep quality among both men and women" (Pengpid and Peltzer 2022 p1).

Pengpid and Peltzer (2022) offered this explanation: "It is possible that poor sleep quality increases emotional distress, leading to more fruit consumption, potentially reducing negative mood, which points to a possible bidirectional relationship between fruit and vegetable consumption and poor sleep quality" (p5). Another possible explanation was that "higher fruit intake was strongly associated with higher wealth status..., and higher wealth status may also be associated with high calorie-dense food, which is related to poor sleep quality" (Pengpid and Peltzer 2022 p5).

This study had two key weaknesses:

i) Self-report measures, particularly of sleep, and "not verified by actigraphy or polysomnography, which may have led to an over- or under-estimation of poor sleep quality" (Pengpid and Peltzer 2022 p5).

ii) Relevant unmeasured or uncontrolled variables - eg: personality; perceived stress; general diet including calorie-dense food intake (Pengpid and Peltzer 2022).

REFERENCES

Famodu, O.A et al (2018) Shortening of the Pittsburgh Sleep Quality Index survey using factor analysis Sleep Disorders 2018, 9643937

Godos, J et al (2021) Association between diet and sleep quality: A systematic review Sleep Medicine Reviews 57, 101430

Jansen, E.C et al (2021) Changes in fruit and vegetable consumption in relation to changes in sleep characteristics over a three-month period among young adults Sleep Health 7, 3, 345-352

Pengpid, S & Peltzer, K (2020) Fruit and vegetable consumption is protective from short sleep and poor sleep quality among university students from 28 countries Nature and Science of Sleep 12, 627-633

Pengpid, S & Peltzer, K (2022) Fruit and vegetable intake and incident and persistent poor sleep quality in a rural ageing population in South Africa: Longitudinal study BJPsych Open 8, e149, 1-6

Sancho-Domingo, C et al (2021) Brief version of the Pittsburgh Sleep Quality Index (B-PSQI) and measurement invariance across gender and age in a population-based sample Psychological Assessment 33, 111-121

5. CLIMATE CHANGE AND SLEEP

Climate change will impact health directly and indirectly. One example of the latter is via sleep. Increasing temperatures will disrupt sleep, and shorter sleep duration will impact physical and mental health.

The research on environmental (ambient) temperature and sleep tends to be short-term controlled laboratory studies, or self-reports of real-life events. In an example of the latter, US data presented a picture of higher night-time temperatures and insufficient sleep (reported in Minor et al 2022). "However, retrospective self-reported sleep outcomes are notoriously imprecise, unreliable, and have been shown to have questionable internal validity. Thus, it remains an open question whether, and to what extent, ambient thermal and weather conditions might affect objective repeated measures of individual sleep duration and timing across a global adult population" (Minor et al 2022 p535).

In their work, Minor et al (2022) made use of a dataset from accelerometry-based sleep-tracking wristbands between 2015 and 2017 (over seven million daily records from over 47 000 individuals in 68 countries) [1]. The measures of sleep were duration, timing of onset, and waking, while data on temperature came from the Global Historical Climatology Network [2].

In a nutshell, Minor et al (2022) found that "adults fall asleep later, rise earlier, and sleep less during hot nights" (p535). For example, fourteen minutes less sleep per night when the temperature is greater than 30 °C compared to lower temperatures. While temperatures over 25 °C increase the risk of less than seven hours sleep per night by 3.5 percentage points compared to 5-10 °C.

The impact of increasing temperature at night was worse for older adults (compared to younger), for females than males, and globally poorer (versus richer) individuals. Minor et al (2022) stated that they "do not find evidence of sleep adaptation to warmer temperatures within days, between days, across summer months, or between climate regions. Indeed, the sleep impact per degree of temperature increase in warmer locations is significantly larger than in colder locations. Our results imply that sub-optimal ambient temperatures likely already erode human sleep considerably early in

[1] Minor et al (2022) admitted: "Our dataset contains more people who are middle-aged, male, and from high- and upper-middle-income countries" (p543).

[2] The nature of the data meant that there was no information on the impact of temperature on different types of sleep (ie: REM and NREM).

the 21st century" (p535).

In terms of the future, Minor et al (2022) predicted a loss of 50-58 hours of sleep per person-year by 2099 with a greater burden on poorer individuals. But, from the perspective of a single night: "Mere minutes of sleep per night" (Ivana Rosenzweig in Vaughan 2022).

REFERENCES

Minor, K et al (2022) Rising temperatures erode human sleep globally One Earth 5, 534-549

Vaughan, A (2022) Climate change means people are losing 44 hours of sleep per year New Scientist 28th May, p15

6. STUDENTS, SLEEP AND COVID-19

An Egyptian study investigated stress, insomnia, and the quality of sleep among university students during the covid-19 lockdown (Dongol et al 2022).

An online questionnaire was sent to all undergraduates at one university in June 2020, and 2474 completed it. The insomnia severity index (ISI), and the Pittsburgh sleep quality index (PSQI) were included.

Just over half the sample reported diagnosed sleep problems before the pandemic, and around two-thirds had a change in sleep pattern or qualities since covid-19 arrived.

A moderate level of perceived stress was the average, but one-quarter did report a high level (appendix 6A). Only one-fifth overall were classed as "good sleepers" (20.7% had a score of <5 out of 21 on the PSQI), and about one-third of the sample had symptoms for a diagnosis of chronic insomnia (31.3% had a score of ≥15 out of 28 on the ISI). The level of insomnia among students in other studies prior to the pandemic ranged from 9% to 38% compared to 4% to 22% in the general population (Dongol et al 2022).

Female students were significantly more likely to have high perceived stress, poor sleep quality, and clinical insomnia ("severe" group). Individuals who consumed three or more cups of caffeine-containing drinks per day were also in this group, as well as students who lived in a household with three or more older members and/or a family member with a chronic disease.

This "severe" group were more likely to fear covid-19, and all these were correlated - fear of covid-19 and perceived stress, and insomnia score, and PSQI score. "Having chronic diseases, previous sleep disorder (before covid-19), change of sleep pattern (after covid-19), or direct relationship with covid-19 were significantly associated with higher levels of stress and impaired sleep patterns..." (Dongol et al 2022 p352).

APPENDIX 6A - STUDENT STRESS DURING THE PANDEMIC

The impact of covid-19 and lockdowns on different groups in society is being studied, including students [3]. For example, university students generally reported

[3] A study for "NHS Digital" found an increase in having a "probable mental disorder" among 17-19 year-olds during the pandemic, for example. In 2019, the figure was around 10%, then around 15% in 2021, and closer to 25% in 2022 (Donnelly 2022).

increased stress, depressive and anxiety symptoms (eg: Keyserlingk et al 2022), as well as specifically medical students (eg: Zhang et al 2021) (Lu et al 2022).

Even more specifically, Lu et al (2022) surveyed international medical students in China. An online survey was completed by 519 such students at China Medical University in November 2020. Depressive symptoms were measured by the "Patient Health Questionnaire-9" (PHQ-9), which covers nine symptoms scored as "not at all" (0) to "nearly every day" (3). A total score of 10 is a cut-off point: mild symptoms (10-15), moderate (16-21), and severe (22-27).

Covid-19 pandemic-related stress was measured by five items (eg: worry about being infected"). Measures were also made of coping style, and perceived social support.

Overall, 15% of the sample scored ten or above on the PHQ-9. After controlling for variables, like age, and outbreak in locality, covid-19 pandemic-related stress was positively correlated with depressive symptoms. A negative coping style (eg: "relying on somebody else to solve the problem") (compared to positive or active coping) exacerbated the situation, while perceived social support improved it.

REFERENCES

Dongol, E et al (2022) Sleep quality, stress level and covid-19 in university students; the forgotten dimension Sleep Science 15, Special 2, 347-354

Donnelly, L (2022) Pandemic hits mental health of 1 in 4 teenagers Daily Telegraph 30th November, p8

Keyserlingk, L et al (2022) Stress of university students before and after campus closure in response to covid-19 Journal of Community Psychology 50, 285-301

Lu, L et al (2022) Association of covid-19 pandemic-related stress and depressive symptoms among international medical students BMC Psychiatry 22, 20

Zhang, Q et al (2021) Impact of the perceived mental stress during the covid-19 pandemic on medical students' loneliness feelings and future career choice: A preliminary survey study Frontiers in Psychiatry 12, 666588

7. INSOMNIA IN FORENSIC HOSPITALS

Sleep problems can be a risk factor with violent offenders in forensic hospitals. For example, Van Veen et al (2020) found that, whereas self-rated aggression declined in such patients generally over a year, it increased among those with poor subjective sleep quality.

Insomnia is the most common sleep disorder (appendix 7A), and it can exacerbate mental disorders (Tijnster et al 2022).

Tijnster et al (2022) investigated sleep disorders, and in particular insomnia among 281 patients in Dutch forensic psychiatric hospitals in 2017-18. Aspects of sleep were measured by four standardised questionnaires:

i) The Insomnia Severity Index (ISI) (Bastien et al 2001) - Seven items covering the last month (eg: "difficulty falling asleep"; "difficulty staying asleep"), each scored 0 ("no problem") to 4 ("very severe problem"), and giving a total of 0-28 (where ≥10 is the cut-off for insomnia).

ii) The Pittsburgh Sleep Quality Index (PSQI) (Buysse et al 1989) - Nineteen items covering the last month (eg: frequency of "cannot get to sleep within 30 minutes" and "have to get up to use the bathroom"), converted to a global score of 0-21, where >5 is defined as poor sleep.

iii) Sleep Hygiene (SH) (Gellis and Lichtstein 2009) - Nineteen items covering behaviours that affect sleep quality (eg: "smoking tobacco within two hours before bedtime"; "went to bed at approximately the same time"), each scored as "never" (0) to "always" (4) in the last month. A high score means more frequent negative behaviours.

iv) The Dysfunctional Beliefs and Attitudes about Sleep (DBAS) (Morin 1994) - Sixteen items about sleep-related cognitions (eg: "worried about nervous breakdown"; "fear of losing control of sleep"), scored as 1 ("agree" to 5 ("disagree"). The average is calculated (out of 5), and <3 is defined as dysfunctional.

Based on the ISI, 49% of the sample were categorised as suffering from insomnia (27% of total as severe; a score of ≥15).

Comparing the PSQI scores of the two halves of the sample (insomnia vs no insomnia), the insomnia group had poorer overall sleep quality, more problems falling asleep and staying asleep, shorter sleep duration, and more frequent or severe sleep disturbances, for instance.

The SH showed a significant difference between the two groups. The insomnia group showed more negative behaviours (eg: "arousing activities near bedtime"; use of bed for other than sleep" like watching television).

The insomnia group also had lower scores on the DBAS (ie: more dysfunctional beliefs about sleep).

Poor sleep was significantly associated with higher impulsivity, which is a risk for violence.

The environment of the forensic hospital did not help. "A large proportion of the participants drank coffee and smoked cigarettes till late in the evening, in spite of their sleep-disruptive effects. Further, using the bed for other activities than sleep, thereby weakening the association of the bed with sleep, appeared common practice. This may be partly explained by the long time periods patients have to stay in their small multi-functional-(bed)room, where a comfortable chair often lacks, and patients' tendency to perform activities, like watching TV and gaming, in/on their bed. Participants also reported a sleep disruptive condition that is beyond their control: a large proportion experienced to sleep on an uncomfortable mattress" (Tijnster et al 2022 p345). Other problems included limited physical activity during the day to make them tired.

The key methodological limitations of the study were:

i) Volunteers - possible recruitment bias. There were 281 respondents out of 750 patients asked to participate. "Reasons for not participating were not systematically assessed, but likely vary from inability to be present due to obligations, not feeling up to it physically and/or mentally, or a lack of interest" (Tijnster et al 2022 p338).

ii) Subjective and self-reported measures of sleep (though psychometric questions) used. Objective measures of sleep, include EEG, which were not practical. The psychometric questionnaires were developed with community samples, and there was some adaptation for the forensic setting (eg: item about drinking alcohol removed from the SH as alcohol prohibited).

iii) Sleep disorders were not clinically diagnosed.

iv) The vast majority of the sample were male (92%). Substance abuse or dependency, and anti-social personality disorder were common mental disorder diagnoses.

v) The study was cross-sectional, which meant that causality could not be established.

APPENDIX 7A - FRAGMENTED SLEEP AND AGE

Fragmented sleep increases with age (eg: waking more often and difficulty in falling back to sleep). Using mice, Li et al (2022) found that the increased firing of hypocretin/orexin neurons seemed to explain the change. The firing of these neurons is "tightly associated with wakefulness and initiates and maintains the wake state" (Li et al 2022 p838). The researchers compared young (3-5 months old) and ageing (18-22 months old) mice.

Previous research has shown that stimulation of these neurons during sleep produces waking, and suppression of them during wakefulness induces non-REM sleep. Mutations in the genes for these neurons is also linked to narcolepsy (Li et al 2022).

REFERENCES

Bastien, C.H et al (2001) Validation of the Insomnia Severity Index as an outcome measure for insomnia research Sleep Medicine 2, 4, 297-307

Buysse, D.J et al (1989) The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research Psychiatry Research 28, 2, 193-213

Gellis, L.A & Lichstein, K (2009) Sleep hygiene practices of good and poor sleepers in the United States: An internet-based study Behaviour Therapy 40, 1, 1-9

Li, S-B et al (2022) Hyper-excitable arousal circuits drive sleep instability during ageing Science 375, 838 & eabh3021

Morin, C.M (1994) Dysfunctional beliefs and attitudes about sleep: Preliminary scale development and description The Behaviour Therapist Summer, 163-164

Tijnster, T et al (2022) Lying awake in forensic hospitals: A multi-centre, cross-sectional study on the prevalence of insomnia and contributing factors in forensic psychiatric patients The Journal of Forensic Psychiatry and Psychology 33, 3, 335-353

Van Veen, M.M et al (2020) Poor sleep quality at baseline is associated with increased aggression over one year in forensic psychiatric patients Sleep Medicine 67, 1-6

8. SLEEP AND DEPRESSION

Sleep disturbance is common in depression, and it makes the symptoms of depression worse. Meanwhile, anti-depressants can have the side effect of sleep disturbance (Mirchandaney et al 2023).

Sleep disturbance is a diagnostic symptom of depression, either too little (insomnia) or too much (hypersomnia). Though both of them can co-occur in around a quarter of individuals with major depressive disorder (MDD) (Mirchandaney et al 2023).

There is also a circadian aspect to depression and sleep. "Specifically, depressed patients with evening circadian preference (ie: a diurnal preference for activity and alertness in the evening) experience more severe depressive symptoms, greater functional impairment, and higher rates of suicidal ideation compared with patients without evening preference" (Mirchandaney et al 2023 p35). Morning circadian preference can be seen as a protective factor against depression (O'Loughlin et al 2021).

In terms of the bidirectional relationship between sleep and depression, Blanken et al (2020) showed that insomnia (specifically, difficulty falling asleep) predicted first-onset of MDD in a six-year follow-up (ie: two to threefold greater risk). While in one study of cognitive therapy (Boland et al 2020), "greater baseline sleep disturbance predicted worse response to treatment, but patients whose sleep disturbance improved (as opposed to persisted) over time had significantly higher rates of treatment response and depression remission" (Mirchandaney et al 2023 p36).

Three main treatments are used for sleep disturbances in depression (Mirchandaney et al 2023):

i) Pharmacology - eg: benzodiazepines; "Z-drugs" (eg: zolpidem).

ii) Cognitive behavioural therapy (CBT) - eg: sleep restriction techniques; sleep education.

iii) Triple chronotherapy - The combination of sleep deprivation, sleep phase shifting, and bright light therapy. It assumes that there is a "circadian misalignment", where the physiological aspects of the circadian rhythm (eg: melatonin release) are out of sync with behaviour.

Concluding their review on sleep and depression, Mirchandaney et al (2023) stated: "Sleep disturbance is an important factor in the development and maintenance of major depression. Treating specific sleep disturbances in the context of existing depression has the potential to improve outcomes for both conditions, although evidence is mixed" (p38).

REFERENCES

Blanken, T.F et al (2020) Network outcome analysis identifies difficulty initiating sleep as a primary target for prevention of depression in a 6-year perspective study Sleep 43, zsz288

Bland, E.M et al (2020) Is sleep disturbance linked to short- and long-term outcomes following treatments for recurrent depression? Journal of Affective Disorders 262, 323-332

Mirchandaney, R et al (2023) Recent advances in sleep and depression Current Opinion in Psychiatry 36, 1, 34-40

O'Loughlin, J et al (2021) Using Mendelian Randomisation methods to understand whether diurnal preference is causally related to mental health Molecular Psychiatry 26, 6305-6316

9. MANAGERS AND SLEEP

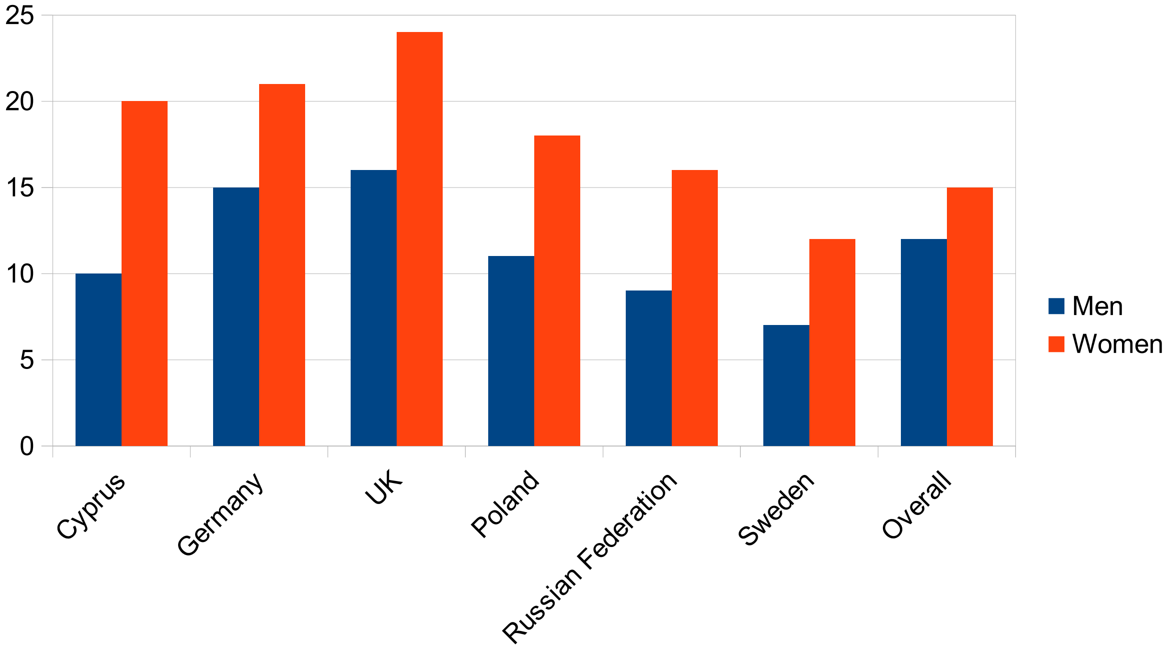
Tan et al (2021) began: "Sleep is increasingly understood as another form of inequality connected to our waking lives" (p1). They referred to the impact of work on sleep. "Negative experiences at work often result in poorer sleep quality. Sleep complaints are also higher for those who have physically strenuous working conditions, psycho-social job strain and work-family conflicts" (Tan et al 2021 p1). What about managers, asked these researchers?

Tan et al (2021) applied the higher status theory (Schieman et al 2009), which argued that workers in higher status and more demanding jobs experience more stress. Managers may have greater power, control and resources than subordinates, but high status workers "report more work-to-home conflict especially among those working longer hours, with more authority, greater demands and more involvement" (Tan et al 2021 p3). From this idea, Tan et al (2021) hypothesised that managers, carrying stressors into their sleep, will have worse sleep than other employees.

The study used data from the 2012 European Social Survey (ESS), and the United Nation's Human Development Data (1990-2018) covering over 27 000 25-64 year-olds in twenty-nine European countries. The outcome variable was sleep quality, which was measured by a four-point scale in response to "how much of the time during the past week was your sleep restless?". Scores of three ("often") and four ("all or almost all of the time") were combined (14% of respondents) and compared to the rest (categorised as "good sleep"). Data were available on gender equality in each country as well as information about the workplace (eg: number of hours worked), and family, and self-reported health, for instance.

It was found that "compared to non-managers, managers were more likely to report restless sleep across Europe... [But] this link between the managerial position and restless sleep is significantly structured by gender and economic development in ways that are distinctly gendered. Women managers report more restful sleep in countries with higher gender development. By contrast, men managers report more restful sleep in countries with stronger economies, or higher GDP [Gross Domestic Product]. Collectively, our results indicate men managers experience a sleep premium from economic development and women managers from gender empowerment" (Tan et al 2021 p14).

Looking at the findings in more detail, in all but two countries, a larger number of female workers reported restless sleep than male workers. In sixteen countries, this was a significant difference (figure 9.1). Overall, 12% of men and 15% of women were poor sleepers.



(Data from Tan et al 2021 table 1)

Figure 9.1 - Selected countries with significant differences between men and women reported "restless sleep" (%).

The work demands of managers are "significantly shaped by gendered expectations and cultural stereotypes surrounding family life" (Tan et al 2021 p4). Female executives in the USA, for example, are expected to focus on both work and family, while male executives have no such "competing devotions" (Blair-Loy 2003).

Other research has shown that gender equality in a country is good for health. Self-reported health is similar for men and women in gender equal countries as compared to a gap in unequal countries (Tan et al 2021).

The data were cross-sectional, and the measure of sleep was one item. "Further, since the questionnaires were translated into different languages across countries, the wording of the item (sleep was restless) and interpretation may vary. However, these limitations are inevitable in large-scale cross-country surveys like the European Social Survey which employs advanced survey techniques to ensure validity across countries. Other measures of sleep may also be important, for example time spent in sleep, which is likely associated with time spent in work and managers often spend longer hours in work" (Tan et al 2021 p14).

REFERENCES

Blair-Loy, M (2003) Competing Devotions: Career and Family Among Women Executives Cambridge, MA: Harvard University Press

Schieman, S et al (2009) When work interferes with life: Work-non-work interference and the influence of work-related demands and resources American Sociological Review 74, 966-988

Tan, X et al (2021) Do managers sleep well? The role of gender, gender empowerment and economic development PLoS ONE 16, 3, e02047515 (Freely available at https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0247515)

10. CHILDREN WITH NEURODEVELOPMENTAL DISORDERS

The term "neurodevelopmental disorders" (NDDs) refers to conditions including autistic spectrum disorders (ASDs), attention-deficit/hyperactivity disorder (ADHD), and learning disabilities (LDs), and children with such conditions suffer from sleep disturbances more often than the general population (Belli et al 2022).

1. ASDs - Sleep disturbances are reported in up to 90% of children here compared to less than 5% of children generally (Belli et al 2022). The key problem is insomnia, manifest as delayed sleep onset (and high bedtime resistance), frequent and prolonged nocturnal awakenings, and early morning waking, all producing reduced total sleep duration (which worsens some ASD symptoms, and causes parental stress and sleep problems).

Melatonin secretion abnormalities have been reported (eg: Rossignol and Fyre 2011). Medication may also impair sleep (Belli et al 2022).

2. LDs - Sleep problem prevalence rates of one-quarter to one-third of the child here. There may be common physiological mechanisms that cause the LD as well as the sleep problems, and these children "may struggle to learn good sleep habits, not registering or understanding the environmental cues about when it is time to sleep" (Belli et al 2022 p346).

As well as the common problems of insomnia, and obstructive sleep apnea syndrome (eg: 50-80% of children with Down Syndrome), specific disturbances have been observed, like alterations of the circadian sleep-wake rhythm in boys with X-Fragile Syndrome (Belli et al 2022).

3. ADHD - Sleep disturbances in up to three-quarters of these children. "It has been shown that ADHD and sleep problems are probably in a reciprocal relationship, in which children with more severe ADHD have more severe sleep disorders as a consequence of ADHD, whereas inadequate sleep may worsen the ADHD symptoms. In fact, some of the symptoms of insomnia (including difficulties with executive functions and emotional regulation) are closely related to symptoms of ADHD" (Belli et al 2022 p347).

Shared physiological mechanisms have been proposed, like certain regions of the thalamus (eg: its volume linked to inattention, and sleep spindles), or neurotransmitters (eg: dopamine; serotonin). Children with ADHD are more likely to have "restless legs syndrome" ("which consists of an urge to move their legs when they are at rest in order to counter unpleasant sensations, often resulting in difficulty initiating and maintaining sleep"; p347) (eg: up to 50% vs around 2% of non-ADHD children) (Belli et al 2022).

Stimulation medicine prescribed for ADHD does not help (Belli et al 2022).

4. Other NDDs - For example, sleep disturbances are more common in children with developmental dyslexia than controls (eg: altered sleep spindles activity in NREM sleep) (Belli et al 2022).

The "BEARS" screening tool (Owens and Dalzell 2005) has been proposed to help clinicians in diagnosing sleep problems in children with NDDs (Belli et al 2022):

- B - Bedtime issues (eg: resistance)
- E - Excessive daytime sleepiness
- A - night Awakenings
- R - Regularity (and routines)
- S - Snoring

Belli et al (2022) ended: "Poor sleep compromises the quality of life of children and their families and is associated with worse developmental outcomes. Recognising and treating sleep disorders is fundamental for the correct management of children with NDDs and may positively impact on their daytime behaviour" (p349).

REFERENCES

Belli, A et al (2022) Children with neurodevelopmental disorders: How do they sleep? Current Opinion in Psychiatry 35, 345-351

Owens, J.A & Dalzell, V (2005) Use of the "BEARS" sleep screening tool in a paediatric residents' continuity clinic: A pilot study Sleep Medicine 6, 63-69

Roosignol, D.A & Fyre, R.E (2011) Melatonin in autism spectrum disorders: A systematic review and meta-analysis Developmental Medicine and Child Neurology 53, 783-792

11. SLEEP AND ARTIFICIAL LIGHT

Artificial light at night impacts humans both awake and asleep. in the latter case, Park et al (2019), for example, reported an association between obesity in women and sleeping with any self-reported artificial light in the bedroom, including small nightlight or clock radio, light from outside the room (eg: streetlights), or light from television left on (table 11.1). "Emerging evidence indicates that light exposure plays a role in human metabolic regulation, with evening light exposure having unfavourable effects on metabolic functions including decreased glucose tolerance and decreased insulin sensitivity" (Mason et al 2022 p1).

- Data from "Sister Study" (on genetics and breast cancer) (Sandler et al 2017).
- 50 884 US and Puerto Rican women 35-74 years old recruited between 2003 and 2009.
- Compared to those not sleeping with artificial light (relative risk = 1.00), any artificial light during sleep increased the risk of obesity (after adjustment for demographic variables) to between 1.03 and 1.12 (depending on measure of obesity used). This was a significant increased risk, though it appears small.

Table 11.1 - Details of Park et al (2019).

Mason et al (2022) proposed that nighttime light alters metabolism directly, and indirectly vis disturbed sleep, and/or changes in circadian rhythms. Light also stimulates the sympathetic part of the autonomic nervous system (eg: increased cortisol or heart rate).

Mason et al (2022) investigated these ideas with twenty healthy adults at an US university who slept in dim light or bright light for one (experimental) night at a sleep laboratory. All participants slept in dim light the night before to give baseline data.

Sleep was different in the bright light condition - shorter overall than the dim light condition, and less time in REM sleep compared to baseline and the dim light condition. Participants reported no difference in subjective sleepiness. Heart rate during sleep significantly increased in the bright light compared to baseline, and there was increased insulin resistance the next morning (a sign of impaired glucose homeostasis).

The key finding was the increase in heart rate in the bright light condition.

The participants were in a controlled environment during the study period (eg: standardised meals), but the sample was small, and only one night of sleep in bright light was observed. Fourteen of the participants were female

REFERENCES

Mason, I.C et al (2022) Light exposure during sleep impairs cardio-metabolic function PNAS 119, 12, e2113290119

Park, Y.M et al (2019) Association of exposure to artificial light at night while sleeping with risk of obesity in women JAMA Internal Medicine 179, 1061-1071

Sandler, D.P et al (2017) The Sister Study cohort: Baseline methods and participant characteristics Environmental Health Perspectives 125, 12, 127003

12. PROCESSING INFORMATION DURING SLEEP

The brain can still respond to selective environmental stimuli during sleep. Ameen et al (2022) tested seventeen sleepers by playing recordings of a familiar voice (FV) (eg: parent) or an unfamiliar voice (UFV) saying their own name or two unfamiliar names.

Before the experiment the participants were asked to keep a regular sleep-wake cycle for at least four days, and then they spent two nights in the sleep laboratory in Austria. The first night in the laboratory was an "adaptation night" (or baseline measures), and the experiment took place on the second night. A control condition during wakefulness was also included.

The auditory stimuli were divided into six elements:

1. Own name FV
2. Own name UFV
3. Unfamiliar name 1 FV
4. Unfamiliar name 2 FV
5. Unfamiliar name 1 UFV
6. Unfamiliar name 2 UFV

These were randomised in order and played continuously for 90 minutes with thirty minutes of silence in cycles during the night. The researchers did not control for the gender of the FV and UFV.

Based on the measurement of electrical activity during sleep (known as polysomnography), it was found that the UFV produced more micro-arousals than the FV. There was no difference, however, between the familiar and unfamiliar names. It was speculated that "in a safe sleep environment, the brain might be 'expecting' to hear FVs and consistently inhibits any response to such stimuli to preserve sleep" (Ameen et al 2022 p1801).

This fitted with the idea of "sentinel processing mode" (Blume et al 2018), "where the brain engages in the important internal processes that are ongoing during sleep while still maintaining the ability to process vital external sensory information" (Ameen et al 2022 p1791). It also shows that sleep is "far from a homogenous state of unconsciousness" (Ameen et al 2022 p1801).

This study comes over half a century after classic research on the topic by Oswald et al (1960) (table 12.1).

- The researchers produced a recording of 56 forenames "being spoken urgently and with slightly unnatural clarity of individual syllables in a randomised order" (p442).

- Ten participants at the sleep laboratory (who had been sleep deprived for one night) were told to awaken and clench their left fist when they heard their name or a pre-arranged other name during sleep.

- Hand movements were observed on 33 of the 131 occasions that the own name was said compared to seventeen in the period of the preceding ten names (out of 1330). This was a statistically significant difference (25% vs 0.75%). Hand movements in response to the pre-arranged name was observed 15 times (out of 124 occasions) compared to twenty-one to the ten names preceding this (out of 1270). This was also a statistically significant difference (12% vs 1.7%). These reactions were not found when the tape was played backwards (ie: meaningless sounds).

Table 12.1 - Oswald et al (1960).

REFERENCES

Ameen, M.S et al (2022) The brain selectively tunes to unfamiliar voices during sleep The Journal of Neuroscience 42, 9, 1791-1803

Blume, C et al (2018) Standing sentinel during human sleep: Continued evaluation of environmental stimuli in the absence of consciousness Neuroimage 178, 638-648

Oswald, I et al (1960) Discriminative responses to stimulation during human sleep Brain 83, 3, 440-453

13. CREATIVITY AND PROBLEM-SOLVING

There are a few studies showing that sleep can help in problem-solving (eg: Perdomo et al 2018). The "twilight zone" between sleep and wakefulness (known as non-rapid eye movement (NREM) sleep stage 1 or N1) has "received little attention" (Lacaux et al 2021 p1). However, Craig et al (2018) reported that ten minutes of "awake quiescence" (ie: a quiet rest in a silent darkened room) significantly improved the ability to spot a hidden rule in a number reduction task (NRT) compared to "active wakefulness". This is not the same as N1, but it inspired Lacaux et al (2021), who stated: "we believe that N1 presents an ideal cocktail for creativity. Creative cognition is supposed to rely on a dynamic interplay between brain networks involved in spontaneous thinking (default mode network) and cognitive control, which respectively support creative idea generation and evaluation. Neuroimaging studies of the sleep onset period have shown that N1 precisely engages these networks instrumental to creativity" (p1).

Lacaux et al (2021) used a NRT with 103 French participants. The participants were presented with a string of eight digits, and they had to decide the rule before stating the next number. there was a hidden rule that made it faster to complete. There were two blocks of thirty trials each.

In between the two blocks, participants either stayed awake for twenty minutes (n = 49), or rested in a dark room (and experienced brief N1 (n = 24) or N2 sleep (n = 14)). The outcome measure was finding the hidden rule after the break, which significantly more participants in the N1 group did (83% vs 31% awake vs 14% of the N2 group). None of the participants had discovered the hidden rule before the break because such individuals were excluded (n = 16). Participants who found the hidden rule all reported an "Eureka moment".

The "create sweet spot" was only one minute of of N1 sleep (Lacaux et al 2021).

REFERENCES

Craig, M et al (2018) Rest on it: Awake quiescence facilitates insight Cortex 109, 205-214

Lacaux, C et al (2021) Sleep onset is a creative sweet spot Science Advances 7, eabj5866

Perdomo, V.L et al (2018) Sleep fosters insight into real-life problems Archives Italiennes de Biologie 156, 3, 87-98

14. JET LAG

"Jet lag" after a flight across multiple time zones is described as "a transient state of circadian misalignment causing temporary malaise" (Ullrich et al 2021 p2). The symptoms include trouble falling asleep at the appropriate times, indigestion, and concentration problems (Ullrich et al 2021).

The severity of symptoms is linked to number of time zones crossed, the direction of travel, and light exposure, for example, and, Ullrich et al (2021) argued, prior expectations of symptoms. These researchers studied ninety inexperienced German-speaking air travellers (aged 18-37 years old) crossing at least three time zones. They were surveyed about their expectations one week prior to the journey, and actual jet lag symptoms after the flight (for the following seven days). The latter used the Charite Jetlag Scale (German version) (Becker et al 2015), which gives a total score based on fifteen symptoms (up to 60).

Expected jet lag duration significantly predicted severity, but not length of post-flight symptoms after controlling for other factors assumed to explain jet lag. This suggested placebo or nocebo effects (Ullrich et al 2021).

The researchers considered three factors that might have influenced the findings:

i) Measurement of jet lag via subjective reporting - "there is an inherent uncertainty if reported symptoms match objective symptom occurrence or strength, as participants may under- or over-estimate their symptoms" (Ullrich et al 2021 pp12-13).

ii) Uncontrolled confounding - eg: detailed information on light exposure was not collected.

iii) Wider issues - eg: circadian mis/re-alignment may have a complex relationship with jet lag symptoms, rather than the assumed linear one.

REFERENCES

Becker, T et al (2015) A new German charite jetlag scale for jet lag symptoms and application Ergonomics 58, 811-821

Ullrich, M et al (2021) Jetlag expectations, not circadian parameters, predict jetlag symptom severity in travellers bioRxiv (https://www.biorxiv.org/content/10.1101/2021.04.23.441149v1)

15. REASONS FOR SLEEP

Many theories have been proposed to explain why organisms sleep, but the two leading hypotheses are (Cao et al 2020):

i) "the repair and clearance needed to correct and prevent neuronal damage" (p1). This is supported by the damage done by sleep deprivation, which when prolonged leads to death.

ii) "the neuronal reorganisation necessary for learning and synaptic homeostasis" (p1). Studies show that learning is improved with sleep afterwards [4].

Cao et al (2020) argued that sleep covers both the above functions. These researchers suggested a mathematical theory that linked total sleep time, types of sleep, brain and body size, and body and brain metabolic rate. Data on human children (0-12 years old), collected by other researchers, were analysed.

It was found that REM sleep was "likely crucial for the initial growth of babies and perhaps especially for the regulation of synaptic weights throughout the nervous system" (Cao et al 2020 p8). This was based on the observation that REM sleep as a percentage of time sleep time changes as humans grow.

The researchers also found that "sleep is used primarily for neural reorganisation until about 2 to 3 years of age, at which point, there is a critical transition, and the function shifts sharply toward sleep being for repair and clearance. We identify the specific turning point as occurring at an unexpectedly precise age of around 2.4 years old, reflecting a critical physiological or cerebral developmental change" (Cao et al 2020 p9).

APPENDIX 15A - SKILL LEARNING

A new skill can be improved by practice. "However, the same amount of practice results in significantly different skill depending on the presence or absence of waking rest within the training schedule, a phenomenon termed the spacing effect" (Buch et al 2021 p1). Distributed practice (ie: practice interspersed with rest) is superior to massed practice (ie: continuous

[4] There are exceptions (appendix 15A).

practice) (Buch et al 2021).

It is argued that skill memory consolidation develops during the waking rest periods, and it is more effective than sleeping during the rest periods (Buch et al 2021). The mechanism of consolidation appears to be neural replay in the hippocampus and neocortex, according to a recent study by Buch et al (2021).

Participants were asked to learn a keypress sequence ("41324"). There were 36 10-second practice periods with ten-second rest periods inbetween each. The skill was measured by the correct sequence and the speed of typing. Brain activity was measured at the same time by magnetoencephalography (MEG).

Early skill improvements were explained by rest period ("micro-offline") gains rather than during active practice ("micro-online gains"). This was because the MEG showed compressed neural replay of the full keypress sequence during the waking rest periods.

REFERENCES

Buch, E.R et al (2021) Consolidation of human skill linked to waking hippocampo-neocortical replay Cell Reports 35, 109193

Cao, J et al (2020) Unravelling why we sleep: Quantitative analysis reveals abrupt transition from neural reorganisation to repair in early development Science Advances 6, eaba0398

16. DREAMING

Dreaming is important, yet it is "so little understood" (Hoel 2021 p1). Dream deprivation is detrimental in animal studies, and "dreaming is homeostatically regulated in that there even appears to be a 'dream drive' [Dement 1960]" (Hoel 2021 p1).

In terms of the content and experience of dreams, this is studied by suddenly waking individuals and asking them to recall their dreams (eg: 50-70% of participants report dreams in such studies) (Hoel 2021).

The physiology of sleep and dreaming is studied with electroencephalgrams (EEGs) to measure the electrical activity of the brain, or lesion studies with animals (ie: deliberately damaging certain areas of the brain) or naturally occurring brain injured human patients. "As far as is currently known, dreaming of [sic] is a brain-wide state where the brain is experiencing a single narrative or event, which is supported by the activation of the default-mode network during dreaming" (Hoel 2021 p2).

Concerning the function of sleep in evolutionary terms, as sleep appears "across the Tree of Life", Hoel (2021) noted two important developments in the 21st century:

a) The discovery of the glymphatic system in the brain (Xie et al 2013), "showing that sleep involves the brain-wide flushing of metabolites with cerebral spinal fluid" (Hoel 2021 p2). The relationship to dreaming has "not been explicitly established" (Hoel 2021 p2).

b) The "Synaptic Homeostatis Hypothesis" (SHY) (Tononi and Cirelli 2003). "According to SHY, daily learning leads to net synaptic potentiation across the brain, which, if left unchecked, would lead to a saturation of synaptic weight and a cessation of learning. SHY hypothesizes that slow waves trigger a brain-wide down-scaling of synaptic weights" (Hoel 2021 p2).

These two ideas suggest the importance of sleep to "clear" and "repair" the brain, which Hoel (2021) viewed as "dreamless sleep" (ie: non-REM [rapid-eye movement] sleep or SWS [slow wave sleep]). Then there is dreaming. Hoel (2021) proposed the "overfitted brain hypothesis" (OBH) to explain the purpose of dreams, after outlining the main contemporary theories of dreams.

Any theory must explain "three phenomenological properties unique to dreams" - their sparseness (ie: less detail than in waking life), their hallucinatory quality (ie: unusual aspects compared to waking life), and their narrative property (Hoel 2021).

The main groups of theories of dreams are (Hoel 2021):

i) Dreams as emotion regulators - Drawing on Freudian ideas, theories here emphasise that dreams are important to deal with emotions of the day (eg: as an "emotional thermostat") (Hoel 2021).

ii) Dreams to aid memory consolidation - Theories here focus on dreams as part of the process of storing memories, or linking new ones to old memories, or dreams as a byproduct of this process. There is disagreement as to whether dreaming is the "replay" of memories or not. For example, rats taught a maze prior to sleep show a neural replay in the hippocampus during sleep, versus dream journals of stressed humans rarely replay specific events (Hoel 2021).

iii) Dreams aid in forgetting - Rather than dreaming aiding memory consolidation, "the point of dreaming is somehow to remove 'undesirable' connections and help the brain 'unlearn'" (Hoel 2021 p5).

iv) Dreams to help in problem-solving - Dreams can act as opportunities to test out solutions to waking problems, "although this is problematic given the generally amnesiac nature of dreams" (Hoel 2021 p5).

v) Dreams and predictive processing - "Predictive processing is the view that the brain continuously tries to predict its own future states in relation to extrinsic sensory input... Predictions are then compared with inputs, with the goal of minimising prediction errors, which corresponds to improving the brain's predictions about its own future states" (Hoel 2021 pp5-6).

THE OVERFITTED BRAIN HYPOTHESIS

The OBH combines a number of elements from other theories, and ideas from machine learning (specifically, deep neural nets; DNNs). The other theories include sleep as a time to deal with memory consolidation and forgetting, the SHY, and predictive processing.

Everyday learning and memories are highly similar, but "dreams offer a biologically realistic 'noise injection'" (Hoel 2021 p7). In other words, dreams are "a form of purposely corrupted input", which helps the brain distinguish between the many similar events from waking life. The "corrupted input" explains the sparse, hallucinatory, and narrative properties of dreams (Hoel 2021).

This theory relies on the analogue of DNNs, and how they learn, with jargon like "weighting", "input", "noise", and "drop-outs". Put simply, DNNs learn by being given a dataset (eg: pictures of cats), and generalising from it (ie: characteristics of a cat) to recognise in a new situation. The dataset should include variety because too many of the same stimuli will limit generalisation ability.

REFERENCES

Dement, W (1960) The effect of dream deprivation Science 131, 1705-1707

Hoel, E (2021) The overfitted brain: Dreams evolved to assist generalisation Patterns 2, 2, 100244

Tononi, G & Cirelli, C (2003) Sleep and synaptic homeostasis: A hypothesis Brain Research Bulletin 62, 2, 143-150

Xie, L et al (2013) Sleep drives metabolite clearance from the adult brain Science 342, 373-377