



Original Article

Effects of one night of induced night-wakings versus sleep restriction on sustained attention and mood: a pilot study



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ABSTRACT

Objective: Despite their high prevalence in daily life, repeated night-wakings and their cognitive and emotional consequences have received less research attention compared to other types of sleep disturbances. Our aim was to experimentally compare the effects of one night of induced infrequent night-wakings (of ~15 min, each requiring a purposeful response) and sleep restriction on sustained attention and mood in young adults.

Methods: In a within-between subjects counterbalanced design, 61 healthy adults (40 females; aged 20–29 years) underwent home assessments of sustained attention and self-reported mood at two times: after a normal (control) sleep night, and after a night of either sleep restriction (4 h in bed) or induced night-wakings (four prolonged awakenings across 8 h in bed). Sleep was monitored using actigraphy and sleep diaries. Sustained attention was assessed using an online continuous performance test (OCPT), and mood was reported online using the Profile of Mood States (POMS).

Results: Actigraphic data revealed good compliance with experimental sleep requirements. Induced night-wakings and sleep restriction both resulted in more OCPT omission and commission errors, and in increased depression, fatigue and confusion levels and reduced vigor compared to the normal sleep night. Moreover, there were no significant differences between the consequences of induced awakenings and sleep restriction.

Conclusions: Our pilot study indicates that, similar to sleep restriction, one night of life-like repeated night-wakings negatively affects mood and sustained attention.

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1. Introduction

Night-wakings are ubiquitous throughout the life cycle. In adults, night-wakings often result from nocturnal child-care needs, occupational requirements, environmental disturbance, bladder pressure, and many other physiological, psychological and medical conditions [1–5]. Surprisingly, although there is a wide recognition of the potential detrimental effects of nocturnal awakenings, these effects have rarely been systematically studied using experimental designs. The purpose of this study was to address this neglected area of research.

Decades of sleep research have yielded evidence as to the detrimental effects of sleep loss and disruptions on various aspects of human functioning [6,7]. Specifically, sleep restriction (also referred to as partial sleep deprivation) has been shown to compromise several neurobehavioral and cognitive domains [8,9]. One of

the cognitive functions that seem to be particularly sensitive to sleep restriction is sustained attention. Studies have repeatedly demonstrated that sleep loss is associated with poorer sustained attention, as measured by continuous performance tests (CPT) and the psychomotor vigilance test (PVT) [10–14]. This literature suggests that sleep restriction leads to a general slowing of response times, an increase in the number and duration of attentional lapses, and an increase in errors of commission or false alarms. Moreover, the loss of sleep extensively intensifies the gradual deterioration of performance with sustained focus throughout a cognitive task, known as the ‘time-on-task effect’ [11].

Compared to these cognitive effects, the emotional consequences of sleep restriction have received less attention in the literature [15]. Nevertheless, a meta-analytic review revealed that mood is negatively affected by sleep deprivation, more so than cognitive performance [16]. There is evidence suggesting a consistent decline in mood during sleep restriction [10,17]. Healthy sleep-deprived individuals tend to report more general distress and negative mood scores, as well as more symptoms of depression, anxiety and somatic complaints [18,19].

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Sleep fragmentation is another form of sleep loss that has been shown to adversely affect cognitive performance and mood. A number of studies have used experimental manipulations that are meant to briefly and repetitively interrupt sleep, creating electroencephalographic (EEG) arousals that mimic the arousals characteristic of obstructive sleep apnea or periodic limb movements [20]. Such empirical studies typically use tones to repeatedly disturb sleep or change its architecture, and some target specific sleep stages [21]. This type of sleep fragmentation has been found to hinder performance on tasks that involve vigilant attention [22–24], and to result in more reports of negative mood and depressive symptoms [25–27].

Despite its high prevalence, the fragmentation of sleep by recurrent full nocturnal awakenings has received very little research attention. This type of sleep disturbance may be less analogous to the abnormalities seen in sleep fragmentation related to breathing disorders or seizures, yet it bears relevance to a great many of the general public. Vast proportions of the population experience night-wakings regularly due to occupational demands, environmental circumstances or the very common parental need to tend to a child during the night. Such 'disturbances' often involve awakenings that require prolonged behavioral activity (eg giving advice when on call, or soothing a crying baby). If we consider, for example, parents of infants and young children, data based on a cross-cultural study of close to 30,000 parents in 11 countries indicate that 24.5% report an average of two night-wakings in their 0–3-year-old children [28]. An additional 19.5% of the parents report an average of three or more night-wakings. These high rates increase if only the first year of life is considered (28.5% and 27.6%, respectively). These rates demonstrate the ubiquitous nature of night-wakings in adults caring for young children and the need to explore the effects of sleep fragmentation of this nature. Correlative studies have associated such awakenings with reduced neurobehavioral performance, as well as with more negative mood and depressive symptoms in mothers of young children [2,29,30]. To our knowledge, no experimental studies have been conducted to investigate the cognitive and emotional consequences of this type of sleep disruption. Due to the vast prevalence of this phenomenon, experimental examination of the consequences of sleep repeatedly interrupted by prolonged full awakenings appears to be of great importance.

Direct experimental comparisons of different types of sleep disruption and their cognitive and emotional impact are also relatively scarce. To our knowledge, the cognitive consequences of partial sleep restriction and sleep fragmentation caused by prolonged night-wakings (designed to simulate nocturnal awakenings experienced by parents of young infants for instance) have not yet been scientifically compared. Moreover, the effects of different forms of sleep disruption on measures of mood have yet to be compared within the same experiment. The potential value of such comparison studies is considerable, since they may help establish direct links between different forms of sleep loss or disruption and their outcomes [20].

With regard to methodology, sleep deprivation, restriction, and fragmentation studies have traditionally been conducted in laboratory settings to maximize control over sleep schedules and measurement. However, recent studies have demonstrated the feasibility of conducting naturalistic studies investigating the effects of sleep disruptions, using actigraphy to monitor compliance with prescribed sleep schedules [13,31–33]. For example, in a pilot study of anesthetists, sleep disruption caused by on-call work, as measured using actigraphy, was associated with deteriorated vigilance performance [34]. Recent evidence has also confirmed the feasibility of conducting online tests of sustained attention, suitable for home-based experimental use [35,36]. These are important, in light of recent findings concerning the potential negative cognitive and emotional impact of the laboratory environ-

ment itself [37,38]. Moreover, the ecological value of naturalistic studies such as these is substantial, because they allow measurement of sleep patterns and related outcomes in participants' natural settings.

To the best of our knowledge, the cognitive and emotional consequences of different types of sleep disruptions have not yet been experimentally compared in a home-based naturalistic setting. In this pilot study, we used a sleep schedule consisting of induced prolonged awakenings (of at least 10 min) in an effort to simulate the sleep of populations that experience such fragmentation due to demands of their life circumstances. The goal of the study was to evaluate the effects of sleep restriction compared to induced prolonged night-wakings (meant to simulate the phenomena of recurrent awakenings that require a behavioral response, commonly experienced by parents, on-call residents, etc.) on sustained attention and mood of young adults in their natural home environment. We hypothesized that, in comparison to normal sleep, both night of sleep restriction and night of induced night-wakings would lead to compromised performance on a sustained attention task and would have a negative impact on participants' mood.

2. Methods

2.1. Participants

Sixty-one undergraduate students (40 females) participated in this study (mean age = 23.08 years; SD = 1.64; range = 20–29). Participants received research credit hours according to their academic requirements. Due to software compatibility problems, 13 participants failed to complete all online continuous performance tests (OCPTs), and were excluded from the relevant analyses. Additionally, sleep data of three participants were incomplete due to technical problems, and these were excluded from the relevant analyses. All participants reported good health and being free of prescription medications for health problems.

2.2. Measures

2.2.1. Sleep assessment

Activity-based sleep monitoring (actigraphy) and sleep diaries were used to monitor compliance with the sleep requirements. Actigraphy has been established as a non-intrusive reliable method for naturalistic studies of sleep-wake patterns in infants, children and adults [31,39,40]. The actigraph is a miniature wristwatch-like device that enables continuous recording of movements, which are later translated to valid sleep-wake measures. Participants were given actigraphs (Mini Motionlogger, Ambulatory Monitoring, Inc., Ardsley, NY, USA), with amplifier setting 18 and 1 min epoch interval according to the standard working mode for sleep-wake scoring. Actigraphic raw data were then translated into sleep measures [41].

Actigraphic sleep measures used in this study included: (i) true sleep time: sleep time excluding all periods of wakefulness during the sleep period; and (ii) number of long waking episodes: night-wakings lasting a minimum of 5 min. Daily sleep logs were completed by the participants and included information on sleep schedule and subjective sleep quality. The diary data were used to corroborate the actigraphic data, and to detect and correct any potential artifacts of these data.

2.2.2. Online continuous performance test

Sustained attention was assessed using the OCPT (eAgnosis Inc., Newark, DE, USA), which is a standard CPT designed and programmed for delivery over the Internet. It uses two geometric stimuli: equilateral triangles and circles, both presented in the middle of the screen within a rectangle that is presented con-

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