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原 著

Nocturnal Sleep at a Predetermined Time in Healthy Undergraduate Students

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Abstract

This study examind the effect of trying to wake up at predetermined time without any aids on subsequent nocturnal sleep. Polysomnograms were recorded from six male and two female undergraduate students for four consecutive nights. The third night was assigned as the baseline night. In the fourth night, subjects were instructed to wake up at five o'clock the next morning without any aid. Each night subjects were also instructed to press a button four times whenever they perceived their own awakenings from sleep (behaviorally signaled awakening; BSA). Comparing the baseline night with the experimental night showed that there were no significant differences on any sleep variables during the first sleep cycle, but the latency to stage 2 was slightly delayed and BSAs were significantly more frequent during the experimental night. It is suggested that psychological stress related to time pressure might influence sleep onset and could have induced spontaneous awakenigs from sleep.

It has been reported that psychological stress in the pre-sleep state influences subsequent nocturnal sleep and dream content.[1)2)3)4)] For example, Hauri[4)] examined the effect of stress in the pre-sleep state on sleep latency. The results indicated that sleep latency after a period of psychological stress (operationally defined by studying and mental tasks) was significantly longer than after physical stress or a period of rest.

Trying to wake up at predetermined time is one potential sourse of psychological stress in the pre-sleep state. We often need to wake up at a predetermined time to get to work, go to school, etc., using an alarm or other aid, This "time pressure" may be a source of psychological stress and influence sleep satisfaction.[5)6)7)]

Falling asleep after planning to wake up at a predetermined time is called "sommeil attentif". The ability to wake up from sleep at a predetermined time without the aid of environmental stimuli has been investigated by many early researchers.[8)9)10)11)12)] Recent studies used polysomnography to examine the relationships between this ability and sleep stages.[13)14)15)] However, these studies focused on subject's ability to wake up from sleep at a predetermined time. Little is known about sleep structure during such a task, although several studies have shown that there are some people who awaken themselves punctually at predetermined, non habitual times without any external aids.

The present study focused on the structure of sleep when subjects had to wake up at a predetermined time rather than subject's performance. Sleep variables were examined in healthy undergraduate students using sleep-labolatory recording techniques.

Method

Subjects:

Eight healthy undergraduate students (6 males, 2 females) served as subjects. Ages ranged from 18 to 20 years (mean age=19.0 years). Subjects were chosen from a pool of 235 undergraduate students who had answered a questionnaire on their sleep habits in a psychology class. Subjects had to meet the following criteria: (1) usually goes to bed between 23:30 and 0:30, (2) usually wakes up between 7:00 and 8:30, (3) sleep usually lasts 8 hours, (4) no irregular patterns such as often staying up late, (5) no sleep-related disorders, or difficulty in falling asleep, (6) no habit of napping, no use of medication, and could take part in this study over four consecutive nights. Subjects were informed of the purpose of the experiment, the procedure to be used, the task to be performed, the duration (number of nights) of the experiment, and the amount of payment for their participation.

Procedure:

Each sujects slept in a sound-attenuated, electrostatically shielded room for four consecutive nights, which included two adaptation nights, a baseline night (BN), and an experimental nights (EN). Room temperature was maintained between 21.5 and 23.5℃. All subjects kept a one week sleep log prior to the start of the recording period to establish regular and stable sleep-wake patterns. They were instructed to abstain from the use of all drugs, caffeine, alcohol, and napping, and were asked to maintain their normal level daytime activity, starting from a week prior to the start of the recording period up to and including the EN.

Each night subjects came to the laboratory approximately 3 hr prior to their bed time (0:00) for the placement of monitoring devices. They retired at 0:00 and were awakened after about 8 hr from the start of sleep recording. All time cues were excluded from the bed room.

In the adaptation nights and BN, sujects were instucted to press a button taped to their preferred hand four times as soon as possible whenever they were aware of their awakenings during sleep and to fall asleep again after pressing. In the EN, they were instructed to wake up by themselves at 5:00 (target time). They were also instructed to call out when they judged themselves as having awakened at the target time. For other awakenings they pressed a button four times, and after pressing they returned to sleep again.

When subjects signalled their perception of the target time, an experimenter went into the bedroom and interviewed them concerning their subjective experience and the expected time. If they signalled more than one hour prior to the target time, they were informed of the real time and were told to try to wake up at 5:00. If their signal was within one hour after the target time, they were permitted to sleep until a final self-determined awakening.

Sleep recording and scoring:

Sleep monitoring was conducted using the following measures: electroencephalogram (EEG), electrooculogram (EOG), electromyogram (EMG), and electrocardiogram (ECG). EEG was recorded from C3, C4, and O1 referred to the contralateral mastoid, and from Fz, Cz referred to each mastoid according to the International Ten-Twenty Electrode System. Vertical EOG was recorded from above and below the midpoint of the orbital ridges of left eye. Horizontal EOG was recorded from the outer canthus of each eye. EMG was recorded from the submental. ECG was monitored with a single lead I.

The continuous sleep recordings (polysomnograms) were monitored with a Nihon-kouden Instruments model EEG-4314D, 16-channel EEG machine. The polysomnographs ran at a paper speed of 15 mm/sec.

Sleep stage scoring of all records was performed by one expert rater using a 20-s scoring epoch with the Rechtschaffen and Kales criteria (1968)[16].

Behavioral response (button-pressing):

Button-pressing by subjects to signal the perception of their awakenings is a commonly employed method to detect awakenings.[17][18][19][20][21] Subjects slept with a small button taped to their preferred hand. The button was activated by a pressure of about 250 g with the thumb.

Data analysis:

Sleep variables analyzed included the latencies of each sleep stage from light off, the latencies of stages 3, 4, and REM from sleep onset, and percentages of each sleep stage during the first sleep cycle. Sleep onset was defined by the first occurrence of K-complex or sleep spindles. The first sleep cycle was defined by the period from sleep onset to the end of the first REM period. In addition the awakenings defined by EEG (the appearance of alpha activity for at least 10 s.) and the behavioral awakenings defined by manual signals (four button presses) were counted throughout each night.

Paired t-tests compared the BN data with the EN data.

Results

Fig.1 illustrates an example of sleep profiles and the appearance of BSAs (○) and verbal signaling of awakening at the target time (●) in one subject. Clearly he had more awakenings on the EN than on the BN. He generated a BSA at around 6 o'clock on the BN. On the EN, however, he generated a BSA three times and verbally signaled to the experimenter twice as having woken up at the target time. Inspecting this figure, there seemes to be little difference between nights in the distribution of each sleep stage. However SWS (slow wave sleep; stages 3 and 4) was observed between the second sleep cycle and the third sleep cycle following waking up at a time thought to be the target time on the EN. This was not seen on the BN.

Table 1 lists the mean latencies of each sleep stage both on the BN and the EN. The latency of stage 2 from light off appeared longer on the EN than on the BN. The latencies of stages 3, 4, and REM from the first occurrence of K-complex or sleep spindles appeared shorter on the EN than on the BN. However there were no significant differences between the BN and the EN on any latency parameter.

As indicated in Table 2, the percentages in each sleep stage during the first sleep cycle also showed no significant differences between nights. The length of the first sleep cycle and the number of stage changes also indicated no significant differences. The mean number of BSAs were, as shown in Table 3, more frequent on the EN than on the BN. This difference was significant (t (7) = 3.05, $p<0.05$). However, EEG-defined awakening showed no significant differences between nights.

As illustrated in Fig. 1, SWS (Slow Wave Sleep; stages 3 and 4) tended to occurr during the sleep cycle following the interview conducted when subjects woke up thinking it was the target time. A total of 13 awakenings thought to be at the target time were obtained in all subjects. Of these, 7 awakenings were followed by SWS.

Discussion

This study examined the effect of a psychological stressor related to time pressure on a nocturnal sleep (in particular early sleep) as measured by polysomnographic techniques in undergraduate students.

Latencies of each sleep stage did not indicate a significant difference between the BN and the EN, although the latency of stage 2 from light off was longer on the EN than on the BN. The latter result is in accord with that reported by Lavie et al.,[14] in which the sleep latency was longer during sleep with a predetermined wake-up time (mean=25.4 min) than on a BN (mean=13.6 min). Their experiment also showed that, in two subjects who had more success in waking up at predetermined time, their mean sleep latency

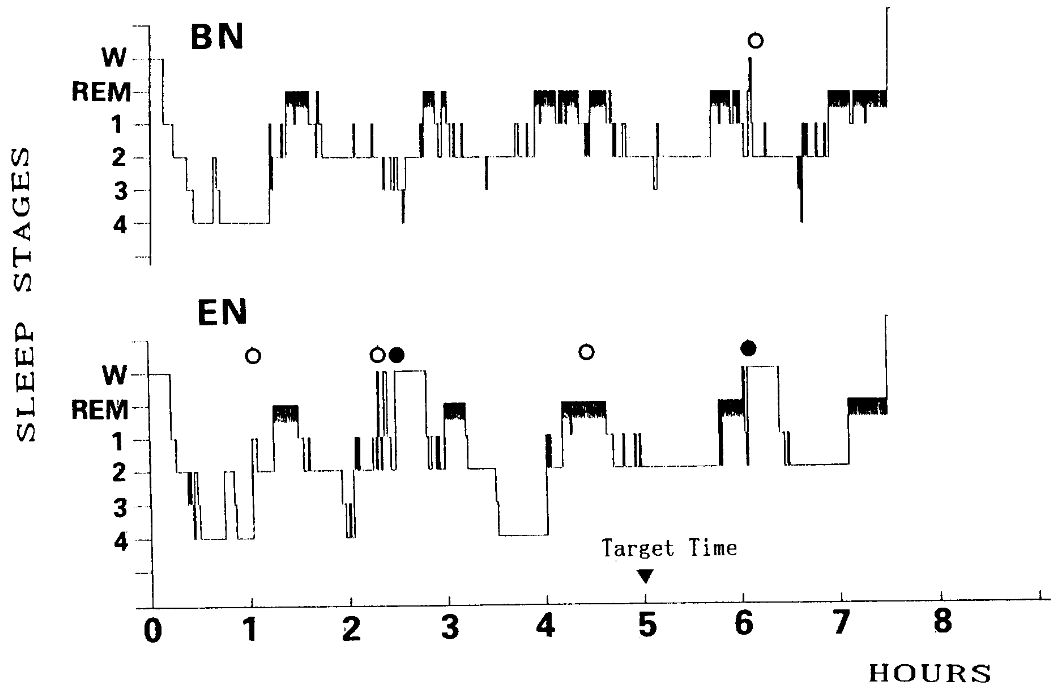

Fig. 1 An example of sleep profiles in one subject. BSAs (○) and verbally signaling the target time (●) are plotted. On the baseline night (BN), a BSA was observed, but 3 BSAs and 2 verbal signals were observed on the experimental night (EN).

Table 1 Latency to each sleep stage (n= 8)*

Interval (min)	Night BN	EN
From light to		
stage 1	17.4 (18.2)	14.7 (13.8)
stage 2	24.8 (20.9)	28.5 (25.6)
stage 3	38.3 (27.4)	38.2 (28.3)
stage 4	41.0 (27.5)	41.3 (28.1)
stage REM* (n=6)	100.6 (24.9)	98.0 (23.6)
From first K-complex or sleep spindle to		
stage 3	13.6 (7.4)	10.6 (3.2)
stage 4	16.4 (7.6)	13.1 (2.9)
stage REM* (n=6)	71.1 (29.9)	66.8 (17.2)

Abbreviations : BN, Baseline Night ; EN, Experimental Night. All values are in min and indicate the mean averaged over 8 subjects. The asterisk indicates 6 subjects due to excluding two subjects. One woke up to go to the bathroom, and another woke up thinking it was the target time before the occurrence of first REM sleep.) Values in parentheses indicate Standard Deviations.

Table 2 Means for various sleep parameters during the first sleep cycle (n= 6)

sleep parameters (%)	Nights BN	EN
stage 1	7.0 (5.0)	6.1 (5.4)
stage 2	33.8 (12.7)	35.7 (12.7)
stage 3	9.0 (5.0)	8.6 (2.0)
stage 4	34.4 (15.6)	32.4 (18.1)
stage REM	14.4 (2.2)	15.9 (8.4)
MT	0.7 (0.7)	1.0 (0.8)

Abbreviations : BN, Baseline Night ; EN, Experimental Night ; MT, Movement Time. All values are in percentage and indicate the mean averaged by 6 subjects. SDs are in parentheses.

Table 3 Mean number of awakenings from sleep defined by EEG or BSA (n= 8)

Variables	Nights BN	EN
BSA*	1.3 (1.3)	3.0 (1.4)
EEG-Wake	3.0 (3.7)	4.1 (2.1)

Abbreviations : BN, Baseline Night ; EN, Experimental Night ; BSA, Behaviorally Signaled Awakening. EEG-Wake was defined by the occurrence of alpha activity for more than 10 sec. SDs are in parentheses. * $p < 0.05$.

tended to be delayed on the EN. Watanabe[13] also reported that sleep latency (the occurrence of low voltage waves after the disappearance of alpha activity) on a BN or on a night with a predetermined wake-up time were 8.1 min and 12.2 min, respectively. Thus psychological stress related to time pressure might delay sleep onset, although no significant difference was found in these studies. Such results also might be related to Hauri's[4] findings. He examined the effect of various kinds of stress (physical, psychological, or none) for 6 hours in the pre-sleep state on sleep onset. The results clearly indicated a significant delay in sleep onset on the night following psychological stress (as induced by studying and mental tasks).

We also compared the percentages of each sleep stage during the first sleep cycle between the BN and the EN. The results revealed no significant differences for all sleep stages. No studies revealed a significant difference in any sleep parameters following psychological stress in the pre-sleep state.[3)13)14]

However, it was clearly indicated in this study that BSAs were significantly more frequent on the EN than on the BN. By contrast, EEG-defined awakenings yielded no significant differences between nights. Bell[5] examined the performance of subjects who tried to wake up at a target time. His subjects recorded the time of spontaneous awakenings and tried to wake up at the target time. The results indicated more frequent awakenings on the EN than on the BN. It was assumed that subjects were more responsive to the perception of their spontaneous awakenings during sleep when they tried to wake themselves up without aid. More frequent awakenings during sleep in one of the important variables in insomnia.[22)23)] It is plausible that sleeping when asked to wake up at a predetermined time is similar to that seen in insomnia. Psychological stress in the pre-sleep state might influence the process of sleep onset, and increase the perception of spontaneous awakenings from sleep, but does not apper to effect the EEG sleep stages at least in early sleep.

Little is presently known about the effect of various activities (physical or mental) in the daytime on subsequent nocturnal sleep, although much is known about the effect of nocturnal sleep on the daytime performance. Relationships between psychological stressor in the pre-sleep state and subsequent sleep should be elucidated by future studies.

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要　　約

本研究では，翌朝ある時刻に起床しなければならないと言う覚醒企図を就寝前に課した場合，それがその後の終夜睡眠経過にどの様な影響を及ぼすかを検討した．心身共に健康な大学生８名（男子６名，女子２名）を対象に，連続４夜の終夜睡眠ポリグラフ記録を実施した．１，２夜目を順応夜，３夜目を基準夜，４夜目を実験夜に割り当てた．実験夜では，被験者に対して，翌朝必ず５時に起床するよう就寝前に教示した．被験者はまた，睡眠中に覚醒したと気づいた時にはいつでも，ボタン押しを４回行うよう教示された（行動的覚醒；BSA)．実験夜では，５時に起床したと判断した時は，ボタン押しを行いその旨を実験者に伝えるよう要請した．その結果，(1)睡眠段階２までの潜時が実験夜でやや延長する傾向が認められた，(2)第１睡眠周期における各睡眠段階の出現率を基準夜と実験夜で比較したが，有意な差は認められなかった，(3)一夜全体の行動的覚醒（BSA）の総出現数は，基準液に比べ実験夜で有意に増加した．この結果から，就寝前の時間に関連した心理的ストレス状態が，入眠を遅らせ，中途覚醒を増加させることが示唆された．