

Promoting alertness with a short nap during a night shift

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Accepted in revised form 2 June 1998; received 9 October 1997

SUMMARY The use of a short (< 1 h) nap in improving alertness during the early morning hours in the first night shift was examined under laboratory conditions. The study contained four experimental, non-consecutive night shifts with a nap of either 50 or 30 min at 01.00 or 04.00 hours. An experimental night shift without a nap served as a control condition. Each experimental shift was followed by daytime sleep. Fourteen experienced male shift workers went through all of the experimental conditions. The results showed that the naps improved the ability to respond to visual signals during the second half of the night shift. Physiological sleepiness was alleviated by the early naps, as measured 50 min after awakening, but not at the end of the shift. Subjective sleepiness was somewhat decreased by the naps. The naps produced sleep inertia which lasted for about 10–15 min. Daytime sleep was somewhat impaired by the 50 min naps. The study shows that a nap shorter than 1 h is able to improve alertness to a certain extent during the first night shift.

KEYWORDS daytime sleep, nap, night shift, sleep inertia, sleepiness

INTRODUCTION

Severe sleepiness and actual incidents of falling asleep are common in night work (for a review, see Åkerstedt 1988) and increase the risk of serious human, environmental, and economic losses (Dinges 1995). The second half of the night shift, in particular, is a time of increased risk because the nadir of alertness is reached at this time (e.g. Åkerstedt *et al.* 1977; Folkard *et al.* 1978).

Previous studies have shown that a nap of one to four hours may counteract sleepiness during an extended period (2–3 days) of wakefulness (e.g. Bonnet *et al.* 1995; Dinges *et al.* 1987, 1988; Lubin 1976; Mullaney *et al.* 1983; Webb 1987).

Five published studies have focused on the alerting effect of a nap taken during a night shift (Gillberg 1984; Matsumoto and Harada 1994; Rogers *et al.* 1989; Saito and Sasaki 1996; Smith and Wilson 1990) and one has examined 'sleep inertia' after a 1 h nap taken at either 00.00 or 03.00 hours (Tassi *et al.* 1992). Sleep inertia is defined as a transient impairment in performance immediately after awakening (Lubin *et al.* 1976).

Both the length and the timing of a nap may be important for the effect on sleepiness. Gillberg (1984) employed a one hour nap starting either at 21.00 or 04.30 hours. He found that especially the latter improved alertness as measured by a 10 min simple reaction time (RT) test at 07.00 hours. The alerting effect was most pronounced for the longest RTs (i.e. lapses), less significant for physiological sleepiness and not present for subjective sleepiness. Saito and Sasaki (1996) reported, however, that subjective sleepiness during the early morning hours was reduced by naps of both one and two hours at 03.00 hours. Matsumoto and Harada (1994) also found that a night-time nap of two hours (0100–0300 or 0300–0500 hours) improved subjective sleepiness in the latter part of the night shift. Rogers *et al.* (1989) reported that a one hour nap taken at 02.00 hours improved performance on two out of eight psychological tests during the early morning hours when compared with a no-nap condition.

Night-time naps may also have detrimental effects on alertness. In addition to sleep inertia mentioned above, a nocturnal nap may also impair the following daytime sleep, which might produce negative influences upon alertness during the next night shift. Matsumoto and Harada (1994) reported, however, that a two hour nap during the night shift shortened the following daytime sleep, but the total sleep time (nap + daytime sleep) did not differ between the nap and no nap

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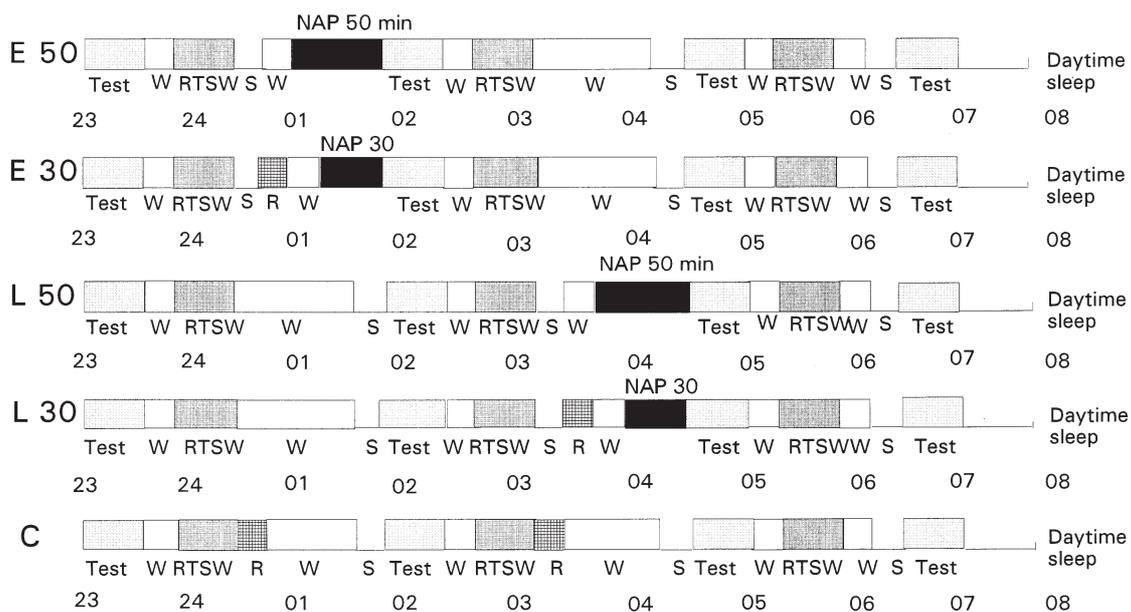


Figure 1. Experimental design. E50=a 50-min nap at 01.00 h, E30=a 30-min nap at 01.20 h, L50=a 50-min nap at 03.50 h, L30=a 30-min nap at 04.10 h, C=control (no nap). Test=a two-choice visual reaction time test, W=work, RTSW=Repeated Test of Sustained Wakefulness, S=a snackbreak, R=a restpause.

groups. In addition, alertness during the next night shift was not affected by the nap taken during the previous night shift.

In summary, naps seem to improve alertness in connection with sleep loss but it is not clear whether the length is important, and whether this interacts with the timing of the nap. This is important since only a short nap would be feasible in connection with night work. The present study sought to address this issue employing naps of either 50 or 30 min in duration and placed in either the first or second half of a night shift. The focus was on their effects on early morning alertness. Sleep inertia and impairment of daytime sleep following the nap also were examined. To increase generalizeability, experienced shift workers were used as subjects.

METHODS

Subjects

Fourteen male process operators, aged between 31 and 52 years, from a large oil refinery, participated. All the subjects were three-shift workers with experience of 2–20 years in three-shift work. The subjects had the following shift system: four morning shifts, one day off, four night shifts, one day off, and four evening shifts. Prior to the study subjects underwent a medical examination to ensure that they were free from illnesses affecting sleep or alertness. Subjects also filled out a sleep disorders questionnaire and gave informed consent prior to the study. They were paid for participation.

Procedure

The study involved a total of five separate experimental night shifts and daytime sleep periods in the laboratory. There were

always at least 16 days between two shifts. Before the beginning of the series of experiments, the subjects spent an adaptation night in the laboratory for practising tests (20.30–22.30 h) and sleeping overnight in the laboratory. Before each experimental shift, the subject's sleep was measured by an actigraph and sleep log for two days. Mean sleep times prior to various experimental conditions varied between 7 h 56 min (E50 condition, see below) and 8 h 26 min (control condition, see below) calculated from the sleep logs. The actigraph data of five nights were lost because of technical failures.

The night shift started at 23.00 hours and ended at 07.10 hours. Before each night shift, the subjects practised the tests used in the study. Subjects started their daytime sleep at 08.00 and they were allowed to sleep for as long as they wanted. Minimum time in bed was set at 5.5 h.

All experimental night shifts were scheduled to occur during the night preceding the first regular night shift at the oil refinery (i.e. after a day off). Daytime napping was not permitted prior to the experiment.

The subjects were required to abstain from the use of alcohol and drugs affecting alertness for 24 h prior to the experiment. Smokers ($n=4$) were permitted to have three cigarettes in connection with the three breaks. None of the subjects drank coffee or tea during the shifts.

Design

Four of the five shifts contained a nap which was either 50 or 30 min long ending either at 01.50 or 04.40 hours (Fig. 1). These conditions are called early 50 min (E50) nap, early 30 min (E30) nap, late-50 min (L50) nap, and late-30 min (L30) nap. One shift contained no nap (control condition). The order of

Table 1 Mean (S.D.) total sleep time (TST), amount of the various sleep stages, sleep latency (SL) sleep efficiency (EFF), proportion of slow wave sleep of total sleep time (% SWS of TST), and number of awakenings (No of awa) during the napbreaks. E50 = a 50-min napbreak at 01.00 h, E30 = a 30-min napbreak at 01.20 h, L50 = a 50-min napbreak at 03.50 h, L30 = a 30-min napbreak at 04.10 h, control = no napbreak during the night shift. $n = 14$

Sleep variables	E50	E30	L50	L30	Two-way ANOVA		
					Length <i>F</i> (<i>df</i> = 1,13)	Timing <i>F</i> (<i>df</i> = 1,13)	Length × Timing <i>F</i> (<i>df</i> = 1,13)
TST (min)	38.1 (12.1)	24.5 (6.7)	46.6 (2.1)	27.5 (1.9)	143.76***	7.31*	ns
Stage 1 (min)	4.0 (2.7)	3.1 (2.3)	4.2 (3.4)	1.9 (1.5)	7.19*	ns	ns
Stage 2 (min)	18.7 (8.7)	12.0 (6.0)	21.2 (12.0)	14.0 (5.2)	14.31**	ns	ns
SWS (min)	15.4 (13.1)	9.3 (8.1)	19.0 (13.5)	11.6 (5.8)	10.33**	ns	ns
REM (min)	0.0 (0.0)	0.0 (0.0)	2.2 (8.2)	0.0 (0.0)	ns	ns	ns
SL (min)	11.6 (11.4)	6.9 (6.2)	4.1 (2.2)	3.6 (2.1)	4.26 (<i>P</i> = .06)	13.35**	ns
EFF (%)	73.7 (22.6)	76.1 (21.0)	90.3 (3.8)	87.8 (6.5)	ns	9.36**	ns
% SWS of TST	35.1 (29.4)	34.5 (26.5)	41.1 (29.3)	42.3 (21.2)	ns	ns	ns
No of awa	0.6 (0.6)	0.1 (0.4)	0.6 (0.7)	0.3 (0.6)	9.09**	ns	ns

*, **, and *** denote $P < 0.05$, $P < 0.01$, and $P < 0.001$, respectively.

conditions was counterbalanced for 10 subjects. Subjects 11 and 12 had the following order: E30, E50, control, L30, L50. The order of the conditions for subjects 13 and 14 was the following: E50, E30, control, L50, L30.

Tasks and dependent variables

The work task consisted of monitoring a computer screen to keep a moving object outside a target area by pressing a key. The critical area was approached every 10–90 s. The total amount of work was the same in all the conditions. Performance measures are not reported from this task because of technical failures.

Performance was evaluated by the two-choice visual reaction time test of the NIOSH fatigue test battery (Rosa and Colligan 1988) presented at 23.00, 01.50, 04.40, and 06.45 hours. The subjects were presented the words 'true' and 'false' at random on the screen and they were instructed to press a corresponding button on the joystick as quickly as possible. The stimulus was present for 1 s. RTs longer than 1.5 s were scored as lapses. The interstimulus interval varied between 3 and 7 s so that there were always 10 stimuli per minute. The test sessions of 25 min were divided into two 10 min test epochs, separated by a 5 min break, during which the subject sat in a chair. RTs and the probability of lapses are reported here. The data of one subject was lost because of a technical failure.

Physiological sleepiness was measured by the Repeated Test of Sustained Wakefulness (RTSW) (Hartse *et al.* 1982). The subject's task was to try to stay awake for 20 min lying in a bed with eyes closed. The latency to the first epoch of stage 1 sleep was measured. The RTSW tests were carried out at 23.50, 02.40, 05.30 hours.

Subjective sleepiness was measured with the nine point Karolinska Sleepiness Scale (KSS) (Åkerstedt and Gillberg 1990). Measurements were made before and after each 10 min reaction time task epoch and before the RTSW and day sleep.

In this study, the ratings given before the second 10 min epoch of the RT task session are presented to test the alerting effect of the naps.

After daytime sleep, the subjects provided numerical ratings for the questions: 'How did you sleep?', 'Do you feel rested after awakening?', and 'Did you wake up too early being unable to fall asleep again?'. The first two questions were scaled from one to nine and the last question was scaled from one to five.

Electrophysiological recordings

Electroencephalography (EEG), electro-oculography (EOG), and electromyography (EMG) were recorded with Oxford 9000 ambulant Medilog-II units (Oxford Instruments Ltd). The EEG was obtained from the C4-A1 derivation during the naps and daytime sleep, and from the Oz-P4 derivation during the RTSWs, using silver-silver chloride electrodes. EOG and EMG were recorded with disposable electrodes according to the criteria of Rechtschaffen and Kales (1968). The impedances were kept below 5000 ohms.

Data analyses

Prior to the statistical tests, most of the dependent variables were transformed to approximate a normal distribution. Sleep latencies in the RTSW were transformed to logarithms, RTs were transformed to their inverse and percentage scores were transformed to the arcsine of their square roots. In figures and tables, the original values are shown.

The effects of the naps on early morning alertness were tested with a two-way ANOVA with repeated measures for condition (E50, E30, L50, L30, control) and time of test (23.00–23.50, 05.30–06.45). The main interest was in the interaction effect. The planned contrasts were used to determine whether the change from the beginning to the end of a night

Table 2 Mean (S.D.) reaction times (RT) in a two-choice reaction time test, reported subjective sleepiness measured with the Karolinska Sleepiness Scale (KSS) at different times of various experimental night shifts. E50=a 50-min napbreak at 01.00 h, E30=a 30-min napbreak at 01.20 h, L50=a 50-min napbreak at 3.50 h, L30=a 30-min napbreak at 04.10 h, control=no napbreak during the night shift, $n=14$ in KSS and $n=13$ in RT

Dependent variables	At the beginning of night shift					After the early nap (E50,E30)					At the end of night shift				
	E50	E30	L50	L30	Control	E50	E30	L50	L30	Control	E50	E30	L50	L30	Control
RT (ms)	635 (69)	614 (49)	624 (80)	633 (60)	640 (65)	656 (123)	676 (87)	679 (70)	660 (59)	698 (95)	732 (84)	727 (82)	721 (90)	714 (85)	764 (118)
KSS (1-9)	3.9 (1.8)	4.1 (1.0)	4.1 (1.4)	3.6 (1.7)	3.8 (1.7)	5.9 (1.6)	6.1 (1.5)	5.9 (1.5)	4.9 (1.6)	5.6 (1.7)	6.9 (1.8)	7.6 (1.2)	7.1 (1.8)	6.9 (1.3)	8.2 (1.2)

shift differed between the nap conditions and the control. In the case of the RTSW data, a separate two-way ANOVA was used to reveal whether the early naps alleviated physiological sleepiness about 1 h after awakening.

The presence of sleep inertia immediately after the naps was tested separately for the early and late naps by a two-way ANOVA with repeated measures for condition (E50, E30, control/L50, L30, control) and time since awakening (0 min, 15 min). The RT values were used as dependent variables.

The effects of length and timing of a nap on nap sleep physiology was analysed with a two-way ANOVA. The dependent variables employed were total sleep time (TST), the amount of various sleep stages, sleep latency, sleep efficiency, the percentage of slow wave sleep, and the number of awakenings. Possible effects of the naps on physiological and subjective variables associated with daytime sleep were examined using a one-way ANOVA with repeated measures for condition. The Huynh-Feldt epsilon (ϵ) correction was employed when appropriate. Uncorrected degrees of freedom are given along with ϵ .

RESULTS

Sleep during the naps

Sleep physiology during the four nap conditions is presented in Table 1. The effect of timing was significant for TST, sleep efficiency and sleep latency with more sleep and more rapid onset in the later nap. The effect of the time scheduled for the nap was significant for most variables with more TST, stage 1, stage 2, SWS and awakenings for the longer time in bed.

Alerting effect of the naps

Choice reaction time performance

The increase in RT through the night shift was not affected by any of the single naps when compared with the control condition (Table 2). An additional comparison revealed that the mean RT of all nap conditions increased less from the beginning to the end of the night shift compared with the control condition ($F_{1,12}=33.36$, $P<0.001$).

A significant condition by test time interaction was found for the percentage of lapses ($F_{4,48}=33.36$, $P<0.05$, ($=1.12$)) (Fig. 2). Planned comparisons showed that all nap conditions had a lower change in lapses than the control condition ($F_{1,12}=4.96-6.46$, $P<0.05$ in all cases).

Subjective sleepiness

Subjective sleepiness increased across the night but did not differ between conditions (Table 2). An additional comparison showed that the mean KSS value calculated across all the nap conditions increased less from the beginning to the end of the night shift compared to the control condition ($F_{1,13}=8.59$, $P<0.05$).

Physiological sleepiness

Sleep latencies of the RTSW decreased (i.e. sleepiness increased) from 23.50 hours to 05.30 hours but there were no differences among conditions in an increase in physiological sleepiness (Fig. 3). A separate comparison of the early naps to the control condition, however, revealed significant condition by timing of test interaction effect ($F_{2,26}=6.98$, $P<0.01$, ($=0.84$)) at 02.40. The contrasts showed that the decrease in sleep latencies from 23.50 to 02.40 was greater for the control condition than for the E50 ($F_{1,13}=11.43$, $P<0.01$) and the E30 ($F_{1,13}=9.62$, $P<0.01$).

Sleep inertia after the naps

RTs tended to decrease from the first (immediately after awakening) to the second (15 min after awakening) 10 min epoch during the early and late nap conditions (Figs. 4a, b). The opposite was true for the control condition. This observation was confirmed by the significant condition by epoch interaction effect in the case of the early ($F_{2,24}=3.90$, $P<0.05$, ($=0.70$)) and late ($F_{2,24}=5.42$, $P<0.05$, ($=0.99$)) naps. The contrasts showed that the change from the first epoch to the second one was different for the E50 ($F_{1,12}=4.87$, $P<0.05$), E30 ($F_{1,12}=7.22$, $P<0.05$), L50 ($F_{1,12}=5.12$, $P<0.05$) and L30 ($F_{1,12}=9.85$, $P<0.01$) conditions than for the control.

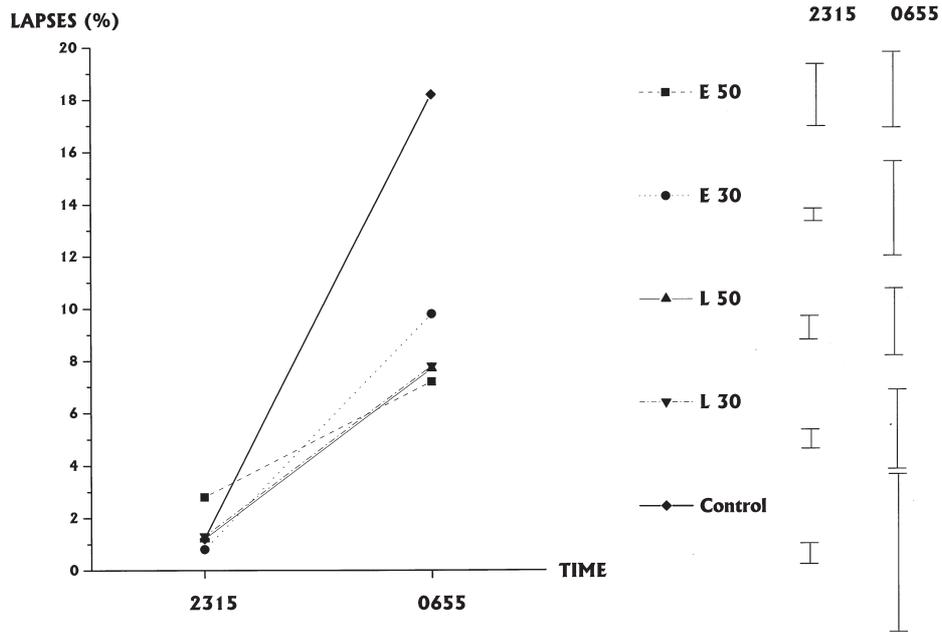


Figure 2. The probability of lapses in a two-choice visual reaction time test during various experimental night shifts. The standard errors are shown as vertical bars. E50=a 50-min nap at 01.00 h, E30=a 30-min nap at 01.20 h, L50=a 50-min nap at 03.50 h, L30=a 30-min nap at 04.10 h, control=no nap during the night shift, n = 13.

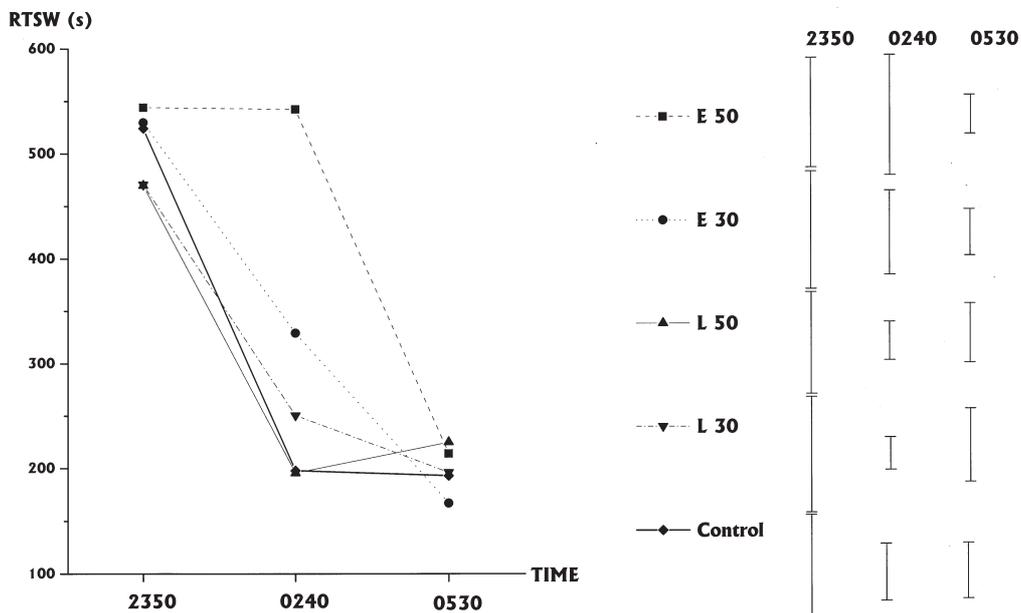


Figure 3. The mean latencies to the first epoch of stage 1 sleep in the Repeated Test of Sustained Wakefulness during various night shifts. The standard errors are shown by vertical lines on the right. E50=a 50-min nap at 01.00 h, E30=a 30-min nap at 01.20 h, L50=a 50-min nap at 03.50 h, L30=a 30-min nap at 04.10 h, control=no nap during the night shift, n = 14.

Daytime sleep after the naps

The time spent in SWS and subjective sleep quality were the only sleep variables which showed significant differences across conditions. The amount of SWS was greater in the control

condition (mean 124 min, S.D. 36.8) than in the E50 (mean 99 min, S.D. 31.9) ($F_{1,13} = 8.51, P < 0.05$) and L50 (mean 100 min, S.D. 45.5) ($F_{1,13} = 5.34, P < 0.05$) conditions. There were also significant differences between nap conditions in terms of the time spent in SWS. The time was longer for the L30 condition

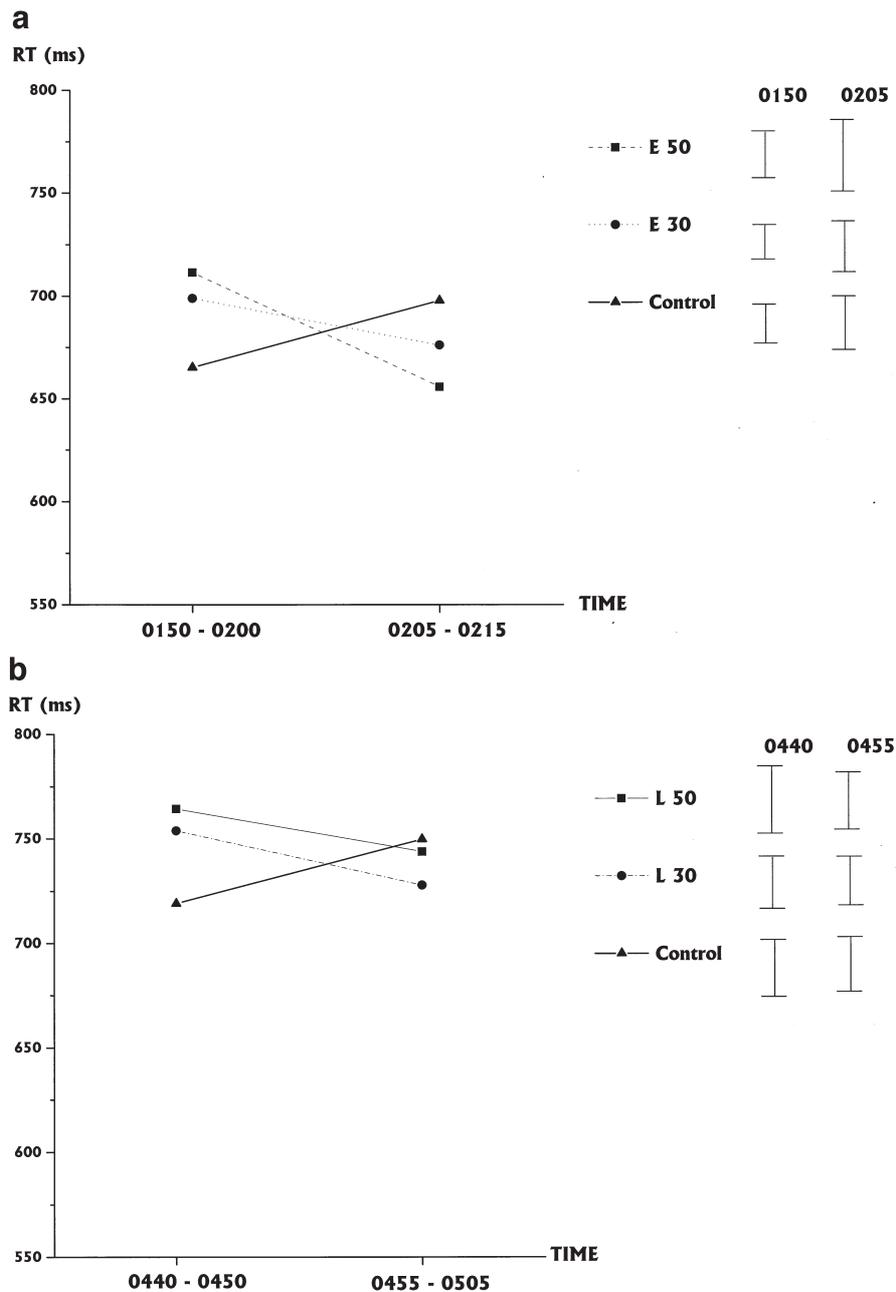


Figure 4. (a) The mean reaction times measured by a visual reaction time test immediately (01.50–02.00 h) and 15 min (02.05–02.15 h) after the early 50 (E50) and 30 min (E30) naps. (b) The mean reaction times measured by a visual reaction time test immediately (04.40–04.45 h) and 15 min (04.55–05.05 h) after the late 50 (L50) and 30 min (L30) naps.

(mean 117, S.D. 41.6) than for the E50 ($F_{1,13}=4.94$, $P<0.05$) and L50 ($F_{1,13}=10.39$, $P<0.01$) conditions. The subjects felt that they slept better in the control condition than in the E50 ($F_{1,13}=5.83$, $P<0.05$) and L50 ($F_{1,13}=14.42$, $P<0.01$) conditions. The responses to the question 'How did you sleep?' were also more positive in the E30 ($F_{1,13}=6.84$, $P<0.05$) and L30 ($F_{1,13}=18.20$, $P<0.001$) conditions than in the L50 condition. When the naps and daytime sleep were combined, none of the objective sleep variables differed across the conditions.

DISCUSSION

The results showed that alertness can be improved to a certain extent by a nap of either 50 or 30 min taken during either the first or the second half of the first night shift. The present study remains open whether this holds also for the subsequent night shifts. Especially, the lapse measure of the RT test showed the alerting effect of the naps. Physiological sleepiness was decreased temporarily by a nap of either 50 or 30 min taken during the first half of the night shift. Subjective sleepiness was

improved somewhat by the naps. In spite of the alerting effects of the naps, they were unable to remove a clear increase in sleepiness towards the end of the night shift. The naps produced significant sleep inertia of about 10–15 min. Day sleep after the night shift was not markedly affected by the naps.

A critical question to be considered is whether the improvements associated with napping observed in the present study are of practical significance. As mentioned, the percentage of lapses in the RT test was most sensitive to the effects of napping. This result is consistent with previous studies by Gillberg (1984) and Dinges *et al.* (1987). It is likely that the decrease in the percentage of lapses after the naps is a result of a decrease in the occurrence of microsleeps. Bjerner (1949) found that lapses occur frequently in connection with microsleeps. The practical importance of this finding is obvious because it shows that a person's ability to respond signals can be improved by a short nap in the night shift. In traffic and many monitoring tasks, missed signals may have serious consequences for safety.

Subjective sleepiness was less clearly decreased by the naps as compared with the lapse measure of the RT test. This finding is also consistent with the studies of Dinges *et al.* (1987) and Gillberg (1984). Conversely, Saito and Sasaki (1996) and Matsumoto and Harada (1994) reported that a nap clearly improved subjective alertness during a night spent otherwise awake. This discrepancy may be related to methodological differences between the studies. Saito and Sasaki (1996) reported that the Fatigue Feelings Scale, but not the Stanford Sleepiness Scale (SSS), was sensitive to the alerting effect of a nap. Dinges *et al.* (1987) used the SSS while Gillberg (1984) used a test of subjective sleepiness similar to that used in the present study.

Physiological sleepiness at 02.40 hours was alleviated by the early naps. In the later test at 05.30 h, however, none of the naps was able to improve physiological sleepiness. It is, however, possible that the naps had some alerting effect on physiological sleepiness also at the end of the night shift but the RTSW was not sensitive enough to show it because of a basement effect. In the study of Gillberg (1984), physiological sleepiness measured by the sleep latency test (Carskadon and Dement 1977) at 06.00 hours was improved somewhat by a 1 h nap ending 30 min before the test. It is possible that this discrepancy between the present and Gillberg's study is due to the fact that the interval between the end of the nap and the test session was 20 min longer in our study. Thus, it is possible that the alerting effect of a short nap on physiological sleepiness is short-lived, especially when sleepiness is severe before the nap.

The detrimental side-effects of the naps were relatively small. Significant sleep inertia of about 10–15 min is, however, an issue that must be taken into consideration. This duration is comparable with that found by Tassi *et al.* (1992) after a 1 h nap at 00.00 (15 min) and 03.00 hours (9 min). It is noticeable, however, that performance after the early naps did not fall below the level observed in the control condition during the early morning hours. Thus, sleep inertia after an early nap

can not be considered to impair performance below the level observed during the night shift without sleep.

The effects of the naps on subsequent daytime sleep were marginal. The only important finding was that the amount of SWS, which has been considered to represent an important part of the core sleep (Horne 1988), was reduced by the 50 min naps. The total amount of SWS during the no-nap condition, however, was not different from that of the nap conditions (nap + day sleep).

The finding that the early 50 min nap was at least as effective as the late one in improving behavioural and subjective alertness during the early morning hours is somewhat surprising because the subjects slept more efficiently during the later naps. In addition, the time between the nap and the measurements was shorter for the late naps than the early ones. This supports the hypothesis that naps can effectively prevent behavioural sleepiness. This conclusion is in contradiction to the study of Gillberg (1984) showing that a 1 h nap starting at 21.00 hours was less effective in improving alertness between 06.00 and 07.10 hours as compared with a 1 h nap starting at 04.30. The time between the early nap and the measurement of alertness was, however, considerably longer in the study of Gillberg (9 h) than in the present one (3–5 h). Secondly, the subjects were allowed to sleep only between 03.00 and 07.00 hours during the preceding night in the Gillberg's study. Thus it is likely that they were unusually sleepy during the night shift which may have reduced the effectiveness of the early nap to prevent sleepiness. In the present study, the subjects slept normally for at least two nights prior to each experimental night shift.

CONCLUSION

The current results suggest that a short nap is a feasible countermeasure for sleepiness in night work although it is unable to keep alertness at the level observed at the beginning of the night shift. It is, however, noticeable that during the first 10–15 min after awakening from a short nap some sleep inertia may exist.

ACKNOWLEDGEMENT

The study was supported by a grant from the Finnish Work Environment Fund.

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¹Saito and Sasaki have presented an abstract that a 30 min nap at 03.00 does not improve subjective alertness in the night shift. *Shiftwork International Newsletter*, 1995, 12 (1).