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Effects of a combination of napping and bright light pulses on shift workers' sleepiness at the wheel: a pilot study

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SUMMARY To assess the effects of napping + bright light on shift work drivers sleepiness at the wheel, we performed a pilot study on nine shift workers on three shifts (morning, afternoon, night), driving on a private road circuit. Sleepiness at the wheel was measured by ambulatory polysomnography and assessed using 30-s segments of recordings with a percentage of theta electroencephalogram of at least 50% (15 s) of the period recorded. Sleepiness was also assessed by the Stanford Sleepiness Scale (SSS). Participants drove the same car on two similar 24-h periods of work, with three drivers in each shift (morning, afternoon, night), separated by 3 weeks. During the baseline period, the subjects were told to manage their rest as usual. During the second experimental period, they had to rest lying in a dark room with two naps of 20 min and then exposed to bright light (5000 lux) for 10 min. Subjects showed a significantly decreased sleepiness at the wheel with an average of 10.7 ± 6.7 episodes of theta sleep during the baseline (766 ± 425 s) versus 1.0 ± 1.0 episode lasting 166 ± 96 s during the second period ($P = 0.016$; $P = 0.0109$). The percentage of driving asleep was also significantly reduced (3.7% ± 1.9% versus 0.9% ± 0.6%, $P = 0.0077$). The average SSS score in the group decreased from 2.76 ± 1.27 to 2.28 ± 0.74 ($P = 0.09$). In this pilot and preliminary study, a combination of napping and bright light pulses was powerful in decreasing sleepiness at the wheel of shift work drivers.

KEYWORDS bright light pulses, driving, naps, shift work, sleepiness

According to the International Labor Organisation, one in five workers in the European Community and in North America is a shift worker or a night worker. Outside these countries, data on night work are more limited, but some information is available on national surveys. In Japan, for example, night work concerned 25.2% of companies and 44% in Korea (International Labour Organization, 2004). There are therefore an estimated 270 million individuals who are working at night in this planet. This percentage is increasing everywhere, especially in developing countries (Hornberger *et al*., 2000).

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The most common consequences of shift work are disturbed sleep and sleepiness because of both sleep loss and the desynchronization of the biological clock (Åkerstedt *et al*., 2002, 2004). Sleepiness is said to affect 75% of shift workers (Åkerstedt *et al*., 2004), and more than 70% of shift workers are driving during or at the end of shift work. The most concerned are naturally the professional drivers (Åkerstedt *et al*., 2004; Philip and Åkerstedt, 2006). About 15–30% of their accidents are attributed to 'drowsy driving', which represents an even greater risk factor than alcohol and these accidents result in three times as many fatalities as other accidents (Philip and Åkerstedt, 2006; Horne and Reyner, 1999; Connor *et al*., 2001). However, the risk of falling asleep at the wheel in professional drivers is still often considered as unavoidable.

Many studies have been recently devoted to the efficacy of napping in reducing sleepiness and fatigue at the wheel and during extended shifts (Philip *et al*., 2006; Arora *et al*., 2006;

Guilleminault and Ramar, 2006; Garbarino *et al*., 2004). In one of them, we demonstrated that drinking a cup of coffee or napping at night significantly reduces driving impairment without altering subsequent sleep (Philip *et al*., 2006). Similarly, it has been shown that an on-duty nap during extended shift in residents can increase sleep and decrease fatigue (Arora *et al*., 2006). Despite these convincing studies on napping, the need for a combination of napping and other countermeasures to enhance alertness has been several times underlined (Guilleminault and Ramar, 2006; Garbarino *et al*., 2004). Bright light could be one of these countermeasures.

Napping affects the homeostatic component of shift workers' sleepiness but bright light is strongly recommended to improve the circadian component (Horowitz *et al*., 2001; Skene and Arendt, 2006). It is now demonstrated that single bright light pulses during the shift may be sufficient to entrain the human circadian clock (Baehr *et al*., 1999; Kronauer *et al*., 2000; Khalsa *et al*., 2003; Gronfier *et al*., 2007).

Bright light pulses may be easy to apply in real settings. However, there is no study which has tested the combination of napping and bright light pulses on shift work drivers' sleepiness. Based on this hypothesis, we designed a preliminary study to test the effects of a combination of napping and bright light pulses in a pilot group of shift workers.

METHODS

Context

The study was requested by the management and the trade unions of a large European car manufacturer which was concerned by several severe accidents attributed to sleepiness at the wheel which occurred on the prototype trial circuit (PTC). PTC is a very strategic part of the company which employs 84 prototypes drivers who are driving night and day, the new and very costly prototypes of the firm, on a private and confidential road circuit. The circuit has been built to represent the usual road conditions in Europe (Fig. 1). It includes a highway simulation circuit of 3.4 miles (maximum speed of 72.7 mph), a town traffic simulation circuit of 2.5 miles (average speed of 22 mph because of red lights and turns) and a high speed ring of 2.5 miles (maximum speed of 56 mph).

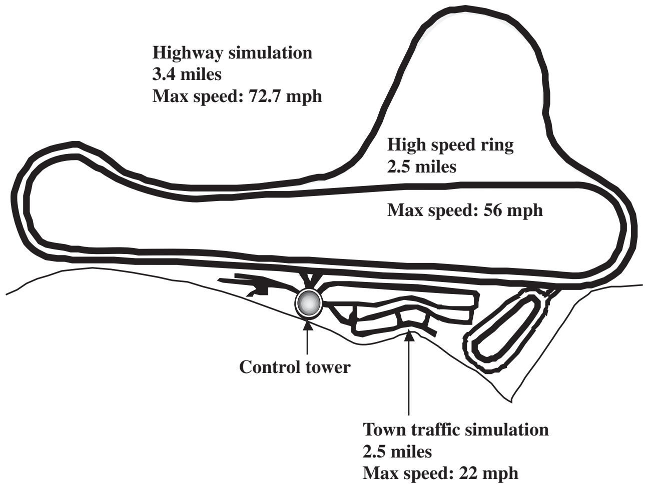

Figure 1. Description of the circuit. It includes three kinds of road condition. Each shift comprises a percentage of the three conditions depending on the car tested.

Study design

The study was designed to test the effects of a combination of napping plus bright light on drivers' sleepiness at the wheel during shift work. Drivers were compared to themselves, before and after intervention. The work conditions were kept similar at the two steps of the study. The goal was not to test separately the effect of nap and bright light which has already been demonstrated but to test the combination. This is why we did not include a control group with partial or no intervention.

The study was performed during two 24-h periods of work including three work shifts (morning, afternoon, night). The two periods were separated by 3 weeks (which was the regular interval between two identical shifts). We took care in making the two periods as similar as possible, except for our intervention. The drivers drove the same prototype, during the same shift, the same day of the week. We also controlled the inside (car) and outside conditions: light, temperature, snacks, caffeine, and smoking were also observed (no more than two cups of caffeine during the 24 h preceding the shift, no caffeine during the shift, no smoking).

During the baseline period, the subjects were told to manage their rest as they usually do in real life. During the second experimental period, they were told to remain lying on a bed in a dark room to get two naps of 20 min each and then exposed to bright light pulse (Philips bright light = 5000 lux) during 10 min.

Driving organization

Drivers have to respect a specific driving process describing their duties during the 8 h and 10 min of each 3 × 8 h shift. They received individually at the beginning of the work period a process book with a check-list describing their schedule and the kind of circuit they have to perform.

In this study, all the drivers drove the same car prototype, and followed the same process with a defined mileage of each circuit written in their process book. The process includes a 10-min transmission with the preceding driver, a 20-min check-in list, 6.5 h driving and a 40-min check-out with transmission to the following driver. The driving period includes two rest periods of 30 min, during which the driver can stop in a rest area, take a snack, and nap if he felt necessary.

About 20 drivers were driving together on the circuit night and day on a 24-h non-stop schedule. They were controlled by a team of staff who were located in a control tower situated in the middle of the circuit. All the cars were equipped with a local radio system and drivers were able to communicate to each other and with the control tower. Our technical staff was also situated in the control tower and included two researchers and two technicians. We also took rest alternatively to stay alert during the two periods of 24 h observed.

Participants

Participants were recruited on a volunteer basis. There was a deep concern among drivers about sleepiness and accidents. We first organized a meeting with 78 of the 84 drivers (all males) to explain the basis of the study. We recruited 17 volunteers. The subjects received no compensation for the study, which was approved by the Ethics Committee of the university and of trade unions. Inclusion criteria included professional experience of at least 1 year. We excluded subjects with an history of chronic disease, treatments (or those who smoke or consume caffeine regularly) which may affect alertness, and those with a suspicion of sleep disorders, with the help of specialized interview and questionnaire (Leger *et al*., 2000). Three subjects were excluded for snoring on a regular basis, two had a past history of insomnia or severe anxiety. We then retained 11 subjects. They signed a consent form.

All 9 were males, aged 25 to 41 years old (Table 1). They were drivers with an average experience of 4.5 years in the same job. One of the nine was a group manager, the other eight were only prototype drivers. To better reflect the 24-h shift work, we decided to observe three drivers in each shift (morning, afternoon, evening). The shifts of the nine drivers were not randomized and all the drivers have observed the same protocol, which was no intervention for the first shift and naps and light during the second shift.

Napping and exposure to bright light pulses during the second phase

Two periods of napping (of 20 min lying in a dark room) and exposure to bright light (of 10 min) were scheduled in the second phase at different timings depending on the shift.

1 For the morning shift (5:00 hours to 13:00 hours) the first nap was scheduled at 7:00 hours and the second one at 22:00 hours.
2 For the afternoon shift (13:00 hours to 21:00 hours) the first nap was scheduled at 15:00 hours and the second one at 18:00 hours.
3 For the night shift (21:00 hours to 5:00 hours) the first nap was scheduled at 23:00 hours and the second one at 15:00 hours.

For napping, the subjects received the instruction of staying quiet and relaxed for 20 min in a dark room without fighting against sleep. They were normally dressed except shoes off. The temperature was 20 °C. At the end of the nap, they were awakened by one member of our team.

They then had to sit facing the bright light (Philips bright light: 5000 lux at 30 cm) which was on a table at an average 30 cm from their eyes during a 10-min period and then were went back to work.

Sleep recording and sleepiness data

The detection of sleepiness at the wheel was based on a polysomnographic recording (Oxford Medilog 900-II; Oxford Technology, Oxford, UK) of electroencephalogram (EEG) (eight channels), electro-oculogram (two channels), and chin electromyogram during the shifts. Each driver arrived 1 h before the starting time. The electrodes were then installed by an experienced technician and removed after 8 h and 10 min of working. Data were stored and transferred on a Nihon Koeden-Nightingale sleep software system (Nightingale, Nihon-Koeden, Stockholm, Sweden) to be analyzed. Sleepiness was assessed using 30-s segments of recordings with a percentage of theta EEG of at least 50% (15 s) of the period recorded according to the international standardized rules (Rechtschaffen and Kales, 1968). Sleepiness has been well related to an increase in theta activity (Strijkstra *et al*., 2003). Slow wave sleep and rolling eye movements were also observed. The sleepiness scoring was made independently by two sleep experts. The reliability of scoring and re-scoring has been tested (the reliability rate was 0.92 between

Table 1 Individual and sleep characteristics of the nine drivers

Driver	*Age*	*BMI*	*Shift*	*TST1*	*TSTM1*	*SEM1*	*TST2*	*TSTM2*	*SEM2*
1	35	32.1	Morning	6.25	6.9	97	4.5	6.2	96
2	32	24.2	Afternoon	11.75	9.6	91	11.5	10.75	92
3	32	23.6	Night	7.5	7.7	96	9	8	98
4	27	23.4	Morning	5.8	8	99	6.5	7.2	92
5	36	23.7	Afternoon	8.5	7.75	90	8.5	8.9	95
6	36	24.1	Night	7.5	7.75	98	7.5	7.7	99
7	37	31.9	Morning	5.75	5.9	97	5.5	5.8	98
8	41	27.7	Afternoon	8.75	8.1	97	8.25	8.8	95
9	50	21.7	Night	7.5	7.8	99	6	7.7	98

BMI, body mass index; TST1, total sleep time in the 24 h before period one; TSTM1, average sleep time in the 72 h before period one; SEM1, average sleep efficiency in the 72 h before period one; TST2, total sleep time in the 24 h before period two; TSTM2, average sleep time in the 72 h before period two; SEM2, average sleep efficiency in the 72 h before period two.
No significant difference was found between TST1 and TST2 ($P = 0.77$), TSTM1 and TSTM2 ($P = 0.66$), SEM1 and SEM2 ($P = 0.26$).

the two experts). This test was based on the detection of pages of 30 s with more than 15 s of theta. The entire period of 8 h and 10 min was analyzed but, with the help of the process books completed by the subjects, we concentrated only on sleepiness at the wheel by eliminating periods when subjects were working but not driving (i.e. the check-in and check-out periods). This was used to calculate the ratio of theta sleep while driving.

Sleepiness was also assessed subjectively every hour using the Stanford Sleepiness Scale (SSS), a validated 7-point scale. On this scale, a score of 1 point indicates 'feeling active and vital, alert, wide awake' and a score of 7 points indicates 'almost in reverie, sleep onset soon, and losing struggle to remain awake' (Hoddes *et al*., 1973).

To avoid disturbing sleep before driving, we did not register sleep the nights before the study. We did, however, check sleep using sleep logs 72 h before every period. Based on these logs, we calculated the total sleep time (TST) in the 24 h before each shift (TST1 and TST2), the TST in the 72 h before each shift (TSTM1 and TSTM2), and the sleep efficiency averaged on the 72-h period before each shift (SEM1 and SEM2) (Table 1).

Statistical analysis

Data obtained during the baseline period 1 were compared with those obtained during the second period. Values are reported as means ± SD. Because of the small sample size, the Wilcoxon-signed rank test for paired data was used to compare intrasubject differences. For testing correlation between two independent samples we used the Spearman's correlation test. A two-tailed *P*-value of less than 0.05 was considered to indicate statistical significance. Calculations were performed with the use of the SAS system software (SAS Institute Inc., Cary, NC, USA).

RESULTS

The nine drivers performed the scheduled program till the end without any incident and we collected all the data. There was fortunately no accident or automobile breakdown during the two periods. Drivers had no leave of absence between the two periods and they had regular sleep the week before. We did not find any significant difference regarding sleep characteristics (TST and sleep efficiency) before the two periods observed (Table 1). There was no significant difference regarding the outside and inside temperature of the car, and the outside light level. Subjects drove an average of 195.5 ± 18.4 miles in the first period and 209.4 ± 18.5 miles during the second one ($P = 0.34$).

Sleepiness at baseline period 1

All drivers had several periods of sleepiness at the wheel during baseline with an average of 10.7 ± 6.7 episodes and an average duration of theta sleep length of 766 ± 425 s (3.7 ± 1.9%) of the driving time (Table 2). They also felt subjectively sleepy, rated by the SSS (Table 3), with an increasing score during the night shift. During the afternoon shift, the score slightly

Table 2 Number of episodes and length of theta sleep at the wheel during period 1 and period 2 depending on the shift and percentage of driving asleep

		Morning				*Afternoon*				*Night*					
	Driver	*1*	*4*	*7*	*Mean*	*2*	*5*	*8*	*Mean*	*3*	*6*	*9*	*Mean*	*Mean*	*P*
Nb of episodes	Period 1	22	3	12	12.3 ± 9.5	7	2	6	5.0 ± 2.6	15	17	12	14.7 ± 2.5	10.7 ± 6.7	0.016
	Period 2	0	1	2	1 ± 1	0	2	0	0.7 ± 1.2	2	0	2	1.3 ± 1.2	1.0 ± 1.0	
Length(s)	Period 1	425	167	1304	632 ± 596	397	737	475	536 ± 178	1190	929	1270	1130 ± 178	766.0 ± 425.2	0.0109
	Period 2	172	214	293	226 ± 61	22	149	121	97.3 ± 66.7	107	99	320	175 ± 125	166.3 ± 95.7	
% of driving	Period 1	2.75	1.19	6.83	3.6 ± 2.9	1.7	3.3	2.3	2.4 ± 0.8	4.94	4.97	5.63	5.2 ± 0.4	3.7 ± 1.9	0.0077
	Period 2	1.2	1	1.86	1.4 ± 0.5	0.008	0.74	0.62	0.5 ± 0.4	0.99	0.47	1.46	1.0 ± 0.5	0.9 ± 0.6	

Nb of episodes: number of episodes of theta sleep equal to or above 20 s while driving.
Length (s): length of episodes of theta sleep in seconds during the whole driving.
% of driving: percentage of the time asleep while driving.

Table 3 Subjective sleepiness assessed at the Stanford Sleepiness Scale (SSS) for each hour of driving time by drivers between the two periods

	SSS1	*SSS2*	*SSS3*	*SSS4*	*SSS5*	*SSS6*	*SSS7*	*SSS8*	*SSSm ± SD*	
Night										
Period 1	1.33	1.67	1.67	3.67	4.00	5.33	5.00	6.00	SSSN1	3.58 ± 1.83*†
Period 2	1.67	1.33	1.67	2.33	2.67	2.33	3.00	3.67	SSSN2	2.33 ± 0.78
Morning										
Period 1	2.50	2.33	2.33	4.50	2.00	2.67	2.00	3.00	SSSM1	2.67 ± 0.81
Period 2	2.33	2.33	2.33	3.00	2.67	2.67	2.33	3.00	SSSM2	2.58 ± 0.30†
Afternoon										
Period 1	1.67	1.33	1.67	2.00	2.00	2.67	3.00	3.00	SSSA1	2.17 ± 0.64*
Period 2	1.00	1.33	1.67	2.33	1.67	3.00	2.00	2.33	SSSA2	1.92 ± 0.64

SSS, Stanford Sleepiness Scale; SSSN, average SSS on night shift; SSSM, average SSS on morning shift; SSSA, average SSS on afternoon shift; SSSx, value of the Stanford Sleepiness Scale for each hour (x) of driving time; SSSm, mean value of SSS for the shift.
*Average SSS during period 1 is significantly above average SSS during period 2 ($P < 0.05$).
†SSSN1 is significantly above SSSA1 ($P = 0.003$), and SSSM2 is significantly above SSSA2 ($P = 0.05$).

increased among the shifts. During the morning shift, no significant variation of the SSS was observed except at the fourth evaluation, SSS4 = 4.50.

Sleepiness during period 2

We observed a significant reduction of both the number of episodes and of the duration of sleepiness at the wheel during period 2, compared with period 1 (Table 2): 1.0 ± 1.0 episode versus 10.7 ± 6.7 episodes ($P = 0.016$) and 166 ± 96s versus 766 ± 425 s ($P = 0.0109$) and of the percentage of driving asleep (3.7% ± 1.9% versus 0.9% ± 0.6%; $P = 0.0077$). Only one subject was more sleepy during period 2 than during the baseline; it was a morning shift subject (subject 4) who was very alert during the baseline. Subjective sleepiness was also significantly improved in the total group, with an average SSS score in the group coming from 2.76 ± 1.27 to 2.28 ± 0.74 ($P < 0.05$) (Table 3).

All the subjects, except subject 3 (afternoon), slept during one of the naps, with an average TST of 2 min during the first nap (0–8.5 min) and 7 min during the second nap (0–19.5 min). Sleep latency, TST, and time spent in stages 1–2 and 3–4 are reported in Table 4. We found no episode of rapid eye movement (REM) sleep during these naps. We found no significant correlation between the duration of the nap and the time of theta at the wheel ($P = 0.38$).

DISCUSSION

We believe that our study is the first trial testing a combination of nap and bright light on sleepiness at the wheel in a real shift work setting. The role of napping on the improvement of alertness in shift workers and in long-haul drivers is well recognized and has been previously clearly demonstrated (Connor *et al*., 2001; Philip *et al*., 2006; Arora *et al*., 2006; Guilleminault and Ramar, 2006; Garbarino *et al*., 2004; Takahashi and Arito, 2000; Rosa, 1993; Sallinen *et al*., 1998). Prophylactic naps help to maintain performance and alertness and to avoid accidents particularly in shift workers and in case of sleep debt (Garbarino *et al*., 2004; Takahashi and Arito,

Table 4 Characteristics of sleep during the naps in the first (Nap 1) and the second period (Nap 2): sleep latency, duration of each sleep stage, and total sleep time

		Morning				*Afternoon*				*Night*			
	Driver	*1*	*4*	*7*	*Mean*	*2*	*5*	*8*	*Mean*	*3*	*6*	*9*	*Mean*
Sleep latency	Nap 1	0	19	0	6.3	14	11.5	19	14.8	0	16.5	18	11.5
	Nap 2	12.5	0.5	14.5	9.2	14	12.5	9.5	12	0	17	12	9.6
St 1–2	Nap 1	0	1	0	0.3	3	5	1	3	0	2.5	2	1.8
	Nap 2	7.5	14	5.5	9	6	7.5	6	6.5	0	3	3	2
St 3–4	Nap 1	0	0	0	0	0	3.5	0	1.1	0	0	0	0
	Nap 2	0	5.5	0	1.8	0	0	4.5	1.5	0	0	0	0
TST	Nap 1	0	1	0	0.3	3	8.5	1	4.2	0	2.5	2	1.5
	Nap 2	7.5	19.5	5.5	11	6	7.5	10.5	8	0	3	3	2

TST, total sleep time in minutes; REM, rapid eye movement; St, stage.
Sleep latency: time (in min) between the beginning of the nap and the first epoch of stage 1 or 2.
St 1–2: duration of stages 1 and 2 in minutes.
St 3–4: duration of stages 3 and 4 in minutes.
No REM sleep was assessed during the naps.

2000; Rosa, 1993; Sallinen *et al*., 1998). It may also improve perceptual task learning (Mednick *et al*., 2003) and decrease fatigue of residents (Arora *et al*., 2006). In a recent study, we have also demonstrated that drinking coffee or napping significantly reduces driving impairment without altering subsequent sleep (Philip *et al*., 2006). However, it is often difficult to apply napping in the real world. For the purposes of conducting this study, we faced difficulties in trying to obtain a quiet room inside the circuit and many workers said they did not have good enough work conditions to take a nap. In normal traffic and work conditions, it is also very difficult for shift workers and drivers to take naps in quiet and isolated conditions.

Bright light resets the biological clock and increases performance and alertness (Horowitz *et al*., 2001; Skene and Arendt, 2006; Baehr *et al*., 1999). It usually takes at least several hours (3–4 h) during several days to reset the biological cues to the new schedule (Campbell, 1995; Eastman *et al*., 1995); but it has also been shown that bright light exposure of about 30 min or repetitive shorter bright light pulses are effective in humans to entrain the human circadian rhythms to night work (Baehr *et al*., 1999; Kronauer *et al*., 2000; Khalsa *et al*., 2003; Gronfier *et al*., 2007).

However, the impact of bright light pulses on alertness during night shift or long-term driving is more controversial. The power of bright light on alertness depends on many factors varying from dose (illuminance levels), exposure duration, timing, and wavelength as well as their temporal relationship to endocrinological and electrophysiological variations of alertness (Cajochen, 2007).

Lowden *et al*. (2004), in one study, have shown the impact of bright light on sleepiness and melatonin level in 18 night workers with a single exposure to 20 min of bright light compared with 4 h to normal light in a cross-over design during four consecutive weeks. The effect was particularly powerful on sleepiness at 4:00 hours. In another work, however, Landström *et al*. (2004) did not find any effect of exposure to bright light on subjective alertness in truck drivers exposed to 30 min of light during a break on a 9-h driving night shift. Åkerstedt *et al*. (2003) also did not demonstrate any effect of exposure to 30 min of bright light on objective (EEG) and subjective alertness of 20 students exposed to bright light versus control red light. In our study, we used shorter pulses of 10 min which is unusual and we associated light pulses to naps. We believe that pulses of 10 min of bright light are easier to apply in the real world of shift workers.

The key finding of our preliminary study is that the combination of napping and two pulses of bright light is effective in reducing both subjective and objective sleepiness at the wheel at any time of the 24-h cycle. Both the number and the duration of the episodes of sleepiness are reduced by this intervention. We identified an average of 10.7 episodes of sleepiness on the first baseline period versus an average 1 episode on the second intervention period (P = 0.016), and this reduction concerns not only the night shift but also the morning and the afternoon shifts. Kaida *et al*. (2006) have already shown that short-term exposure to natural bright light improves afternoon levels of physiological arousal, though its effect may be weaker and shorter than that of a short nap. In our study, we are unable to compare the power of bright light versus nap, but we assume that the combination may be proposed in larger samples to better understand the respective effect of these countermeasures.

One other issue in our study is that sleepiness is not based only on subjective assessments but also on an objective sleep recording which is unusual in real settings conditions. Mitler *et al*. (1997) have also recorded sleep in truck drivers and found a severe amount of somnolence at the wheel. It may be suggested that putting sleep recorders on drivers may improve the vigilance of the subjects compared with ordinary driving conditions. Conversely, recording theta sleep reflects more accurately sleepiness than wrist actigraphy or subjective ratings. One interesting point is that the effect we have shown on subjective sleepiness seems to be less demonstrative (but significant) than the effect on objective assessment. One possible explanation is that the 2-h interval between each subjective assessment is too large to carefully describe this subjective variation. Another possibility is that the drivers engaged in the study were not persuaded of the efficacy of the countermeasures. As we previously underlined, previous accidents on the road circuit have understandably concerned the prototype drivers and the trade unions.

Another important point to discuss is that sleepiness at the wheel seems unavoidable in driving shift workers. We found that all the drivers were asleep at the wheel for a duration of 22 to 1304 s of theta sleep on a 8-h shift (0.008–6.83% of the time spent driving). Sleepiness is a major complaint of shift and night workers (Hornberger *et al*., 2000; Philip and Åkerstedt, 2006), and several authors have already described the occurrence of sleepiness at the wheel in shift workers (Åkerstedt *et al*., 2004; Philip and Åkerstedt, 2006; Philip *et al*., 2006; Garbarino *et al*., 2004; Mitler *et al*., 1997). Mitler *et al*. (1997) reported that 56% of the drivers recorded had at least one 6-min interval of drowsiness while driving. According to Hakkanen and Summala (2000), 40% of the long-haul drivers and 21% of the short-haul drivers have problems staying alert on at least 20% of their drive. In our group, six drivers out of nine (67%) thought they had sleepiness in the first period and three out of nine drivers (33%) during the second period.

The fact that such drowsiness periods did not result in accidents was surprising, but probably reflects the reality of drowsy driving. Mitler *et al*. (1997) have already underlined that sleep EEG patterns associated with marked unresponsiveness to stimuli have not been associated to crashes and that it may not be correct to use the standard sleep screen criteria when the subject is behaviorally active. In another group of 184 truck drivers, 20% reported having dozed at least twice while driving and 17% have had near misses because of dozing; however, none had an accident (Hakkanen and

Summala, 2000). Sleepiness, sleep debt, and work patterns interfering with normal sleep are associated with decreased performance in driving simulators (Åkerstedt *et al*., 2004; Philip and Åkerstedt, 2006; Horne and Reyner, 1999). Sleepiness affects reaction time and may be the cause of lapses which may lead to accidents (Philip and Åkerstedt, 2006; Horne and Reyner, 1999). Moreover, Philip *et al*. (2005) recently confirmed sleepiness at the wheel was associated with lateral deviations, which are a frequent cause of sleep-related accidents.

One limitation of our study was the absence of sleep recording the night before the recorded shift. However, we believed that polysomnography may be susceptible to disturb the subjects' sleep and therefore increase artificial sleepiness at the wheel. Sleep was then assessed by sleep logs in the prior days and was not significantly different in the group of subjects between the two periods. The sleep duration is shorter for participants of the morning shift and longer in the afternoon shift which is consistent with the literature (Åkerstedt *et al*., 2002).

Another limitation of our study is related to the sample size. It is obviously not possible to make conclusions based on the results of a nine-subject trial. However, these results have encouraged us to try this combination of countermeasures in a larger group of shift work drivers.

The last but not the least limitation is that there is no real control group with no intervention. We have demonstrated in a preliminary work that the combination of nap and bright light may be active on alertness at the wheel of shift workers; however, we did not show what was the incremental gain in administering both procedures compared with one procedure alone. As this is essentially a report of a feasibility study and demonstrates no harm to subjects in performing both procedures, we have considered these results as preliminary acceptable ones, but a larger study should allow us to evaluate the effects of each measure independently and the effect of both, and this investigation could be carried out without too much difficulty with randomization of the three conditions.

Finally, we used only visual analysis of EEG to assess sleepiness in our subjects and not computerized theta or alpha spectrum analysis. We believe that for short periods of somnolence at the wheel it was more precise to score visually. We understand, however, that in larger groups it may be useful to computerize the EEG spectrum of drivers.

In conclusion, the combination of napping and bright light pulses decreases sleepiness at the wheel in a small and preliminary group of shift work drivers in a real setting. This intervention has to be extended to larger and more representative groups of shift workers to better promote accident prevention at the workplace.

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