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Sleep inertia associated with a 10-min nap before the commute home following a night shift: A laboratory simulation study

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ABSTRACT

Night shift workers are at risk of road accidents due to sleepiness on the commute home. A brief nap at the end of the night shift, before the commute, may serve as a sleepiness countermeasure. However, there is potential for sleep inertia, i.e. transient impairment immediately after awakening from the nap. We investigated whether sleep inertia diminishes the effectiveness of napping as a sleepiness countermeasure before a simulated commute after a simulated night shift. $N = 21$ healthy subjects (aged 21–35 y; 12 females) participated in a 3-day laboratory study. After a baseline night, subjects were kept awake for 27 h for a simulated night shift. They were randomised to either receive a 10-min nap ending at 04:00 plus a 10-min pre-drive nap ending at 07:10 (10-NAP) or total sleep deprivation (NO-NAP). A 40-min York highway driving task was performed at 07:15 to simulate the commute. A 3-min psychomotor vigilance test (PVT-B) and the Samn-Perelli Fatigue Scale (SP-Fatigue) were administered at 06:30 (pre-nap), 07:12 (post-nap), and 07:55 (post-drive). In the 10-NAP condition, total pre-drive nap sleep time was 9.1 ± 1.2 min (mean ± SD), with 1.3 ± 1.9 min spent in slow wave sleep, as determined polysomnographically. There was no difference between conditions in PVT-B performance at 06:30 (before the nap). In the 10-NAP condition, PVT-B performance was worse after the nap (07:12) compared to before the nap (06:30); no change across time was found in the NO-NAP condition. There was no significant difference between conditions in PVT-B performance after the drive. SP-Fatigue and driving performance did not differ significantly between conditions. In conclusion, the pre-drive nap showed objective, but not subjective, evidence of sleep inertia immediately after awakening. The 10-min nap did not affect driving performance during the simulated commute home, and was not effective as a sleepiness countermeasure.

1. Introduction

Shift workers often report falling asleep at the wheel, experiencing near misses and accidents on the commute home from night shift (Steele et al., 1999; Scott et al., 2007; Fallis et al., 2011; Jackson and Moreton, 2013). Statistics show that shift workers driving home from a night shift are up to seven times more likely to be involved in an accident than other automobile drivers (Australian Bureau of Statistics, 1997). A solution has been sought to reduce the dangers of sleepiness on the commute home from night shift. Taking a nap before the commute has been suggested as a potential sleepiness countermeasure (Scott et al., 2007).

The optimal duration of a pre-commute nap is the topic of considerable debate. There is a large body of literature showing the performance and alertness benefits of longer naps (approximately 30 min or longer) (Lumley et al., 1986; Dinges et al., 1987; Kubo et al., 2007; Mulrine et al., 2012; Ruggiero and Redeker, 2014). Longer naps have also been shown to improve driving performance (De Valck et al., 2003; Philip et al., 2006), although this effect has not been investigated at the end of a night shift. Longer naps are typically also associated with sleep inertia – a period of transient sleepiness and performance impairment experienced immediately after awakening (Dinges et al., 1987; Tassi and Muzet, 2000; Tietzel and Lack, 2001; Brooks and Lack, 2006; Signal et al., 2012). Thus a longer nap taken at the end of a night shift before the commute would considerably delay shift workers returning home, due to both the length of the nap and the time needed to recover from sleep inertia.

Shorter naps (<30 min) would be more practical to implement at the end of a night shift. Moreover, studies of short daytime naps have found immediate benefits to driving, cognition, and alertness without the side effects of sleep inertia (Horne and Reyner, 1996; Reyner and Horne, 1997; Tietzel and Lack, 2001, 2002; Brooks and Lack, 2006). This has given rise to the belief that short naps are

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not only practical, but also effective as a sleepiness countermeasure preceding the commute home after a night shift. However, it is unclear whether the findings on daytime naps would generalise to other times of day, when the homeostatic and circadian pressures that influence sleep and sleep inertia are dynamically different (Dinges et al., 1985; Tassi et al., 2006; Miccoli et al., 2008; Scheer et al., 2008).

This study is the first to investigate sleep inertia associated with a short pre-drive nap after a simulated night shift.

2. Materials and methods

2.1. Subjects

Twenty-one healthy adults (9 males, 12 females) completed the study. Their mean age (±SD) was 24.1 ± 3.7 y (range: 21–35 y). Subjects reported habitually obtaining a minimum of 7 h sleep per night, with bedtime before midnight and rise time occurring before 09:00, as confirmed using sleep diaries, wrist actigraphy and time-stamped messages in the week before the experiment. Subjects were intermediate type on the Composite Scale of Morningness (Smith et al., 1989).

Subjects met the following inclusion criteria: non-smokers; drinking less than two cups of caffeinated drinks and less than two standard drinks of alcohol per day on average; no transmeridian travel in the past three months; no shift work in the past two years; habitually taking no more than one nap per week; body mass index below 30; no current medication or recreational drug use (apart from oral contraception); absence of illicit drugs confirmed by urine test; general health confirmed by blood chemistry; and no medical conditions, psychological disorders or sleep disorders assessed by self-report and Beck Depression Inventory (Beck et al., 1961) and Pittsburgh Sleep Quality Index (Buysse et al., 1989). Subjects were asked to maintain their habitual bedtime routine and to refrain from napping, caffeine and alcohol in the seven days prior to the experiment.

The study was approved by the University of South Australia Human Research Ethics Committee. Subjects gave written, informed consent and were reimbursed for their time.

2.2. Study design

During the study, subjects resided in a windowless and sound-insulated sleep laboratory. Light intensity was set to <50 lux at head height during all wake periods of the protocol, and lights were turned off during all scheduled time in bed. Ambient room temperature was maintained at 22 (±1) °C.

Subjects spent two nights and three days in the sleep laboratory: one day for adaptation and training, one baseline night and day, one night of simulated shift work, and one recovery day. Subjects arrived at the laboratory at 13:00 and spent the adaptation day practicing various performance tasks. They had a 9 h sleep opportunity between 22:00 and 07:00 on the baseline night. On the baseline day, subjects performed neurobehavioural test bouts and simulated driving.

On the simulated night shift, subjects were randomly assigned to one of two conditions: a 10-min nap ending at 04:00 and a 10-min nap ending at 07:10 (10-NAP), or total sleep deprivation (NO-NAP) in which subjects sat quietly during the time that subjects in the 10-NAP condition were napping. Here we focus on the 07:10 nap at the end of the simulated night shift and subsequent performance and fatigue in the 10-NAP condition, as compared to the NO-NAP condition.

A driving task performed after the end of shift nap simulated the commute home. After the simulated commute, subjects had breakfast and were allowed a 6 h daytime recovery sleep opportunity before going home.

Subjects did not have regular access to any clock-bearing or telecommunication devices, but were allowed to use their mobile phones for 10 min at the start of a 90-min free-time period on the baseline day. They were not allowed to access the Internet. Between neurobehavioural test bouts, subjects were permitted to read books, play card/board games, watch DVDs, and listen to music. Subjects were not allowed to perform any vigorous activities during the study.

2.3. Nap sleep

Nap sleep was recorded using polysomnography (PSG). The electrode montage included derivations C3/M2, C4/M1, F3/M2, F4/M1, O1/M2, two channel electrooculogram (EOG), electromyogram (EMG), and electrocardiogram (ECG). PSG was recorded to a digital data acquisition, storage and analysis system (Grael; Compumedics, Melbourne, Australia). A trained sleep scorer, blinded to the experimental aims, used standardised criteria (Rechtschaffen and Kales, 1968) to score all sleep periods. Sleep variables analysed include: total sleep time (TST), sleep onset latency (SOL), wake after sleep onset (WASO), amounts of stage 1, stage 2, and slow wave sleep (SWS, stages 3 and 4 combined) and rapid eye movement sleep (REM). Sleep stage at lights on was defined as the sleep stage scored in the 30 s epoch immediately prior to lights on.

2.4. Neurobehavioural testing

A neurobehavioural test bout was administered at 06:30, 07:12 and 07:55. In the 10-NAP condition, these time points correspond to 30 min before the nap, 2 min after the nap (to capture sleep inertia), and immediately after the simulated end of shift drive, respectively. The test bouts included, in order of presentation, a 3-min psychomotor vigilance test (PVT-B) and the Samn-Perelli Fatigue Scale (SP-Fatigue). Performance testing was conducted on a desktop computer positioned next to the bed in each subject's room. In the 10-NAP condition, at 07:10 (the scheduled time of awakening) the lights were turned on, and subjects immediately moved from their bed to a computer chair adjacent to the bed to begin testing at 07:12.

The PVT-B is a 3-min simple reaction time task that has been validated as an objective assay of sleepiness (Basner et al., 2011). The PVT-B requires subjects to press a button on a hand-held device as soon as a visual stimulus is presented. The inter-stimulus interval is varied randomly between 1 s and 4 s. Subjects were instructed to respond as quickly as possible without making false starts. Response speed, defined as the mean of reciprocal reaction times, was used as the outcome measure. The PVT-B data from one subject in the 10-NAP condition were removed from analysis due to non-compliance with the task.

The Samn-Perelli Fatigue Scale (SP-Fatigue) is a 7-point Likert-type scale on which subjects rated their subjective fatigue, with scores ranging from 1 ('fully alert, wide awake') to 7 ('completely exhausted, unable to function effectively').

2.5. Simulated commute driving task

At 18:30 on the baseline day (start of the simulated night shift), a 40-min York simulated driving task was performed. This task was repeated at 07:15 (at the end of shift), immediately after the PVT-B that started at 07:12. This monotonous, daytime, highway driving task required subjects to maintain a set speed and central position in their lane for 40 min. Subjects drove in one lane of a two-lane track that included straight sections and both right- and left-hand bends. There were no other vehicles in the driver's lane. At random