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Brief Communication

Driving drowsy also worsens driver distraction

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ABSTRACT

Objectives: Laboratory-based studies show that drowsiness increases the propensity to become distracted. As this phenomenon has not been investigated in drowsy drivers, we underwent a pilot study under realistic monotonous driving conditions to see if distraction was more apparent when drowsy; if so, how does it affect driving performance?

Methods: A repeated measures counterbalanced design whereby participants drove for two hours in a fully interactive car simulator during the bi circadian afternoon drive, after a night of either normal (baseline) or restricted sleep to five hours (sleep restriction). Videos of drivers' faces were analysed blind for short (<3 s) and long (>3 s) distractions, in which drivers took their eyes off the road ahead. These results were compared with the likelihood of simultaneous lane-drifting incidents, when at least two wheels left the driving lane.

Results: More distractions occurred after restricted sleep ($p < 0.005$) for both short and long distractions ($p < 0.05$). There was an overall significant ($p < 0.02$) positive correlation between distractions and driving incidents for both conditions but with significantly more distraction-related incidents after sleep restriction ($p < 0.03$).

Conclusions: Following restricted sleep, drivers had an increased propensity to become distracted, which was associated with an increased likelihood of poor driving performance as evidenced by the car leaving the driving lane.

1. Introduction

Many serious road traffic collisions on dull monotonous roads are due to drowsiness [1] and tend to be circadian in nature; they are more evident in the early morning hours and during the bi circadian early afternoon dip [1]. Moreover, circadian-related reduction in alertness is worsened by inadequate sleep the previous night [2]. This drowsiness typically manifests as microsleeps, usually comprising a short period of eye closure or fixed staring [3], when steering movements cease, leading to lane drifting or a worse outcome.

Another aspect to drowsiness is an increased propensity to be distracted [4,5], whereby gaze is momentarily diverted away from the task at hand to some peripheral event. We have demonstrated this distractibility under non driving laboratory conditions [4,5]. However, to our knowledge this aspect of drowsiness has received little attention within the context of drowsy driving compared with microsleeps. There are several reasons for this distractibility, ranging from seeking novel stimulation in an attempt to stay awake, to more neuropsychological explanations relating to impaired frontal lobe function [6]. In this latter respect, it also is likely that drowsy individuals are more likely to perseverate [6] over the distraction, with distractions becoming longer. During driving this would mean that drowsiness under monotonous conditions may not only result in more distractions but that these distractions would be longer duration. In response, in terms of lane drifting and failure to steer, outcomes would obviously be more eventful.

The aim of our study was to explore the propensity for distractions and any resulting lane drifting in young adults driving during the bi circadian afternoon dip following a night of restricted sleep.

2. Method

2.1. Participants

Eight young men aged 20 to 26 years were healthy, were medication-free, and were experienced drivers (having driven for over two years for more than three hours per week). They were good sleepers, and scored <10 on the Epworth sleepiness scale [7], and only moderate (2–4 cups daily) drinkers of caffeinated coffee. All participants were of healthy weight (69–89 kg), non clinical body mass index between 20 and 27 and had no sleep concerns, including snoring. They provided full informed consent and were remu-

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nerated for their time. The study was approved by the Loughborough University Ethical Advisory Committee.

2.2. Design and Procedure

All participants completed the two conditions (normal sleep or sleep restricted to five hours by delayed bedtime for one night prior to the drive protocol, identified here as baseline and sleep restriction), in a counterbalanced design, with each condition one to two weeks apart. To ensure compliance with sleep instructions, they wore wrist actiwatches (Cambridge NeuroTec, Cambridge, UK) for three nights prior to each experimental day, and they kept daily logs of estimated sleep onset and morning awakening and rising times. No alcohol was consumed 36 hours prior to each drive, and no caffeine after 18:00 hours the evening before the drive. Participants refrained from eating after 10:00 hours on the morning of the drive and had consumed only a light breakfast. On arrival at the laboratory at 13:00 hours, they were given a light lunch of two cheese rolls and a glass of water. Actiwatches were downloaded to verify that they had complied with the previous night's sleep requirements. At 13:50 hours they settled into the car and a continuous drive began at 14:00 hours. Two hours of driving was chosen because UK road safety organisations recommend that this should be the limit before a break from driving.

2.3. Apparatus

2.3.1. Car Simulator

This apparatus comprised an immobile car with a full-size, interactive, computer generated road projection of a dull monotonous dual carriageway, each having two lanes (as previously used in our laboratory [7]). The image was projected onto a 2.0 × 1.5-m screen, located 2.3 m from the car windscreen. The road had a hard shoulder and simulated auditory rumble strips (incorporated into white lane markings) on either side of the roadway with long straight sections followed by gradual bends. Crash barriers were located either side beyond the rumble strips. Slow moving vehicles were occasionally met, which had to be overtaken (to avoid collision). Lane drifting with more than two wheels out of the driving lane was identified as a driving incident. Split-screen video footage of the roadway and driver's face (filmed by an unobtrusive infrared camera) enabled the detection of head and eye movements indicative of distractions. Participants were instructed to drive in the slower lane (unless overtaking) at a speed appropriate for the road and at which they were able to maintain control of the vehicle. During the drive the investigator was in the room at all times in case of any concerns, but there was no communication between investigator and participant once the drive had begun.

2.4. Distractions

The split screen video incorporated a one-tenth of a second timer and was examined by an experimenter blind to the condition for both signs of distraction and driving incidents. A distraction was defined as a diversion of attention away from the forward roadway. Short diverted gazes (<3 s) away from the road, as in checking mirrors etc., were categorised as 'short', and those longer than 3 s, in which we were more interested in were categorised as long. Data were checked for normality using Kolmogorov–Smirnov tests. Any data that violated assumptions of normality were transformed $[((\sqrt{n}) + (\sqrt{} + 1))]$ prior to parametric statistics. Mean and standard error of the mean were reported.

3. Results

Participants slept 483.2 ± 12.8 minutes prior to baseline drives and 291.4 ± 2.5 minutes prior to sleep restricted drives. A total of 861 distractions were logged for baseline (4.3% were long), and 1447 following sleep restriction (9.6% were long), which was significantly different between conditions ($t = 4.70$; $df = 7$; $p < 0.005$). Separating short from long distractions, these group differences remained significant (short [$t = 4.92$; $df = 7$; $p < 0.005$]; long [$t = 2.39$; $df = 7$; $p < 0.05$]). Group averages and changes for each individual are seen in Fig. 1, left panel. Descriptive statistics, and group comparisons for short and long distractions with and without incident are reported in Table 1.

Across participants there were positive correlations between total number of distractions and total number of incidents for both baseline ($r = 0.93$; $p < 0.0001$) and sleep restriction ($r = 0.74$; $p = 0.018$) conditions Fig. 1; right panel. Of the 2308 distractions assessed, 474 (25.8%) directly resulted in a driving incident. Here, there were more distraction-related driving incidents following sleep restriction compared with baseline ($t = 2.73$; $df = 7$; $p < 0.03$).

4. Discussion

In our preliminary study, we clearly demonstrate that driving during the afternoon following a night of only five hours of sleep leads to enhanced distractibility, which subsequently leads to more driving incidents characterised by at least two wheels of the vehicle leaving the carriageway. More specifically, curtailed sleep on the night prior to an afternoon drive led to a fourfold increase in long distractions (i.e., looking away from the main roadway for >3 s). Moreover, driving incidents that occurred as a direct result of inattention or distraction more than doubled.

These data support our previous findings of enhanced distractibility following sleep loss in the laboratory [4,5]. In our earlier

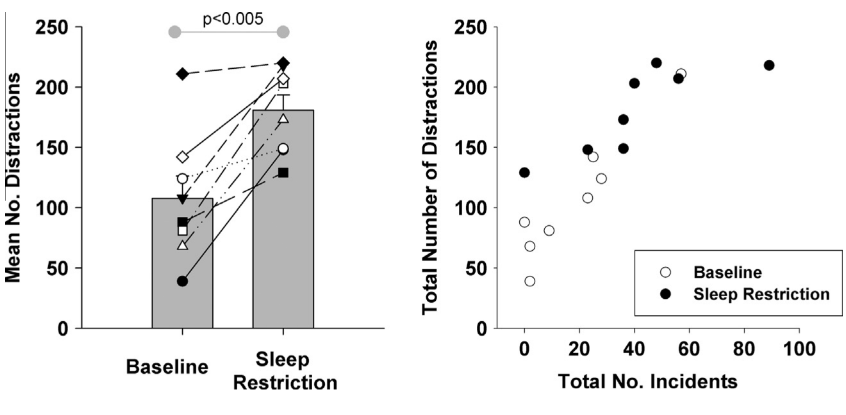

Fig. 1. Group and individual differences in response to prior sleep restriction for total number of distraction (left panel) and the association between total number of distraction and total number of driving incidents (right panel).

Table 1
Overview of distractions while driving after normal sleep (baseline) and restricted sleep to 5 hours (sleep restriction).

Performance indicator		Mean ± standard error of the mean		%		Total *n*		Significance
		Baseline	Sleep restriction	Baseline	Sleep restriction	Baseline	Sleep restriction	
Total number of distraction		107.6 ± 18.8	180.9 ± 12.6	*n*/a	*n*/a	861	1447	$p < 0.005$
Distractions without incident	Short (<3 s)	87.0 ± 11.5	130.5 ± 6.8	80.8	72.1	696	1044	$p < 0.03$
	Long (>3 s)	2.4 ± 1.32	9.4 ± 1.8	2.2	5.2	19	75	$p < 0.018$
Distractions with incident	Short (<3 s)	16.0 ± 5.9	33.0 ± 6.7	14.9	18.2	128	264	$p < 0.016$
	Long (>3 s)	2.25 ± 1.1	8.0 ± 3.0	2.1	4.4	18	64	$p < 0.048$*

* Denotes data transformed prior to *t* test comparison.

study, individuals sought other stimuli and diverted attention away from the primary task (Psychomotor Vigilance Test) presumably in an attempt to enhance alertness via novel simulation [4,6]. In an assessment of drowsy drivers, Wierwille and Ellsworth [8] described the behavioural markers of drowsy (or sleepy) drivers as "rubbing the face or eyes, scratching, facial contortions, and moving restlessly in the seat, among others". In view of our findings, distractibilty also is an important characteristic of sleepy/drowsy driving, with distractions becoming longer in duration, which might be indicative of perseveration (see Section 3). Furthermore, such warning signs including other sleepiness-related behaviours; opening the vehicle's window for fresh air, and turning up the radio [9], may be self-evident to the driver that they are sleepy/drowsy, and should make drivers consider stopping driving, taking a break, and utilising sleepiness countermeasures such as a nap and/or caffeine [7]. We suggest that increased distractibility be added to current educational resources and awareness campaigns on the warning signs of drowsy driving to further inform individuals of the risks of drowsy driving.

Conflict of interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: http://dx.doi.org/10.1016/j.sleep.2012.11.014.

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References

[1] Horne JA, Reyner LA. Sleep related vehicle accidents. Br Med J 1995;310:565–7.
[2] Cohen DA, Wang W, Wyatt JK, et al. Uncovering residual effects of chronic sleep loss on human performance. Sci Transl Med 2010;2:14ra3.
[3] Poudel GR, Jones RD, Innes CR, Watts R, Signal TL, Bones PJ. FMRI correlates of behavioural microsleeps during a continuous visuomotor task. Conf Proc IEEE Eng Med Biol Soc 2009;2009:2919–22.
[4] Anderson C, Horne JA. Sleepiness enhances distraction during a monotonous task. Sleep 2006;29:573–6.
[5] Anderson C, Wales AW, Horne JA. PVT lapses differ according to eyes open, closed, or looking away. Sleep 2010;33:197–204.
[6] Horne JA. Human sleep, sleep loss and behaviour. Implications for the prefrontal cortex and psychiatric disorder. Br J Psychiatry 1993;162:413–9.
[7] Horne JA, Reyner LA. Counteracting driver sleepiness: effects of napping, caffeine, and placebo. Psychophysiology 1996;33:306–9.
[8] Wierwille WW, Ellsworth LA. Evaluation of driver drowsiness by trained raters. Accid Anal Prev 1994;26:571–81.
[9] Reyner LA, Horne JA. Evaluation of "in-car" countermeasures to driver sleepiness: cold air and radio. Sleep 1998;21:46–50.