



## Q2 Drowsiness and driving performance on commuter trips

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### ABSTRACT

**Introduction:** Driver fatigue is a major road safety problem. While much is known about the effects of fatigue and the factors that contribute to it, fatigue on commuter trips has received comparatively little attention in road safety. Most interventions have focused on longer trips, while investigations of commuting have typically examined particular groups, such as shift workers. **Method:** This study examined the effects of mild sleep deprivation on driving performance in simulated driving tasks in the morning and evening. Three groups of participants with different levels of sleep deprivation (Group 1: no deprivation; Group 2: two-hour deprivation; Group 3: four-hour deprivation) drove in a simulator for 45 min in the morning and evening, following a practice session the previous day. **Results:** Results showed that participants reported feeling more drowsy in the afternoon, and performance impairments (increased lane deviations) were most evident in the morning for those with sleep deprivation. Measurements of eye closure did not reflect drowsiness in participants, despite performance impairments. **Practical applications:** These results suggest that mild levels of sleep deprivation (2 h), which many people regularly experience, can result in poor on-road performance, and that these effects are present in the morning, and on relatively short trips. These results warrant follow-up in naturalistic and on-road studies.

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41 Driver fatigue is recognized as a major contributing factor to road  
42 crashes (McCartt et al., 1996; Sagberg, Jackson, Kruger, et al., 2004;  
43 Scott et al., 2007; Williamson et al., 2001). It is also increasingly  
44 recognized as a workplace health and safety issue, due to the possible  
45 impact of fatigue on work-related driving including commuters and  
46 professional drivers (Mitchell, Driscoll, and Healey, 2004; Williamson  
Q7 and Boufous, 2007). Fatigue was implicated in 15–20% of fatal crashes  
48 in New South Wales (NSW) from 2011 to 2015 (NSW Centre for Road  
49 Safety, 2016).

50 Commuting, defined as traveling between home and work and back,  
51 is an activity relevant to road and workplace safety risks. Commuting  
52 crashes have been the largest single cause of work-related fatalities in  
53 Australia, accounting for almost one-third of them (Safework  
54 Australia, 2012a, 2012b). Recent data (to 2016) demonstrates that  
55 vehicle related crashes are still the most common cause of workplace fa-  
56 talities (Safework Australia, 2017), although information on commuting  
57 deaths has not been provided since 2012. Little has been done to  
58 address commuter driving since then, and the lack of data underscores  
59 that this problem is poorly recognized, and makes it harder to address.  
60 Fatigue is relevant to driver safety while commuting because the capac-  
61 ity to drive safely will depend on the driver's state when he/she gets into  
62 the vehicle. Fatigue can be produced by a range of work-related factors  
63 (e.g. lost sleep due to short turnaround time between shifts, time on

work task, nature of work tasks, work schedule, and time of day; see  
Williamson et al., 2011). Fatigue while commuting has been overlooked  
as a potential safety risk possibly because commuting trips are usually  
short and fatigue effects are usually associated with long periods of  
driving. Many fatigue prevention campaigns encourage drivers to  
avoid fatigue during holiday periods when people are known to drive  
long distances (e.g. "Stop. Revive. Survive" campaign; holiday road  
rest stops; NSW RMS, 2016 [http://www.rms.nsw.gov.au/geared/your\\_](http://www.rms.nsw.gov.au/geared/your_driving_skills/staying_safe/driver_reviver.html)  
driving\_skills/staying\_safe/driver\_reviver.html see also Fletcher,  
McCulloch, Baulk, and Dawson, 2005). These strategies assume that  
only long trips, which involve considerable driving time, often at  
unusual hours, are important with respect to fatigue, though there are  
now also additional public awareness campaigns that do not target  
specific trip durations. Nevertheless, there is evidence that fatigue  
effects may manifest in driving periods of a short duration, and  
these commuting trips of a short duration account for a high proportion  
of road use (Symmons and Haworth, 2004; Wheatley, 1997). Clearly,  
there is a gap in our understanding of the nature and extent of  
drowsiness and fatigue while commuting.

The conceptual framework for this study follows the model of  
Williamson et al. (2011), which describes how fatigue can affect safety  
outcomes. In this model, fatigue is defined as a biological drive for  
recuperative rest, which, if unsatisfied, will result in performance im-  
pairments. Fatigue is affected by the time of day, the amount of time  
the person has spent awake, the amount and quality of prior sleep, as  
well as features of the task being undertaken and those of tasks recently

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undertaken (Williamson et al., 2011). Drowsiness is the aspect of fatigue most akin to sleepiness: feelings of tiredness and that one is about to fall asleep. It can be measured as one index of a fatigued state; however, a fatigued state can also be measured by decreasing alertness and increasing variability in performance.

## 1. Fatigue on commuter trips

Interest has arisen in commuter trips due to patterns of fatalities and injuries that have been found on work related trips of professional drivers and commuters. Boufous & Williamson (2009) matched 5 years of compensation data to road crash data to examine factors that contribute to work-related crashes in New South Wales (NSW). Seventy-five percent of work-related driver casualties occurred on commuter trips (i.e., driving between home and work rather than driving during work time), with 23% of these being serious crashes. Drivers in a commuter crash were more likely to die or be permanently injured than those involved in a crash while on duty (i.e., while driving for work). Of course it must be noted that short trips may also be the bulk of trips that drivers make.

Commuter trips, especially the trip after work, may be particularly vulnerable to fatigue, as they occur after a significant period of time awake and after a full day of work (Williamson et al., 2011). Factors such as long, or irregular work hours may also make fatigue more likely. Commuter trips therefore deserve more attention as situations where fatigue and its effects may manifest.

An early self-report study by Fell & Black (1997) highlighted the importance of fatigue on short trips compared to longer trips. In a sample of people who had experienced a fatigue related crash, Fell and Black found that 36% of the crashes occurred in metropolitan areas, and many cited the influence of working hours on prior sleep as a factor. Thirty-five percent of those with city crashes had their crash on their regular trip to or from work, and 46% of these were trips of a planned duration of less than 45 min. This suggests that short regular trips represent a significant proportion of fatigue related road crashes.

Others have studied particular occupational groups to ascertain the effects of fatigue while commuting. A log book study of nurses driving to and from work found that 66% reported at least one drowsy driving episode during the 2-week study period (Scott et al., 2007). The mean trip length was 27 min. Several other studies have shown similar self-reported levels of drowsiness while commuting among medical residents (e.g. Geer, Jobs, and Tew, 1997; Marcus and Loughlin, 1996). A prospective study based on self-reported drowsiness, crashes, and work shifts of medical interns found that extended shifts increased the risk of falling asleep while driving home by 16% (Barger et al., 2005). A study of Australian nurses found that extreme drowsiness was reported while driving to or from work on approximately 10% of shifts, with a mean trip length of 19 min (Dorrian et al., 2008). Fifty percent of the incidents occurred at the end of nightshift, and 40% at the end of the day shift, between 2 p.m. and 6 p.m. In all these studies, the effects of fatigue related to work tasks and schedules manifested on driving performance relatively quickly — on a relatively short commuter trip.

While it seems obvious that sleep deprivation due to work shifts will have an effect on drowsy driving, studies that have examined the effects of work shifts on driver fatigue are limited by relying on self-report data. Self-reported fatigue and crash occurrence data are problematic because they rely on participants' recall, accurate reporting, and typically only measures major incidents, rather than indexing changes in driving performance. Degraded driving performance may not necessarily culminate in a crash, but indicates situations of increased risk. At the same time, there are significant disincentives for drivers to admit to have fallen asleep at the wheel, which can bias these data. While these studies are informative regarding the potential for fatigued driving after long working hours that interrupt circadian rhythms, they may also underestimate the true extent of the driver drowsiness problem on commuter trips. More systematic, objective measurement of

drowsiness on short trips is required for both shift workers and non-shift workers to clarify the true nature and extent of the effects of drowsiness on driving performance. Given the lack of research in this area, a driving simulator provides the best approach for initial studies of the effects of drowsiness on driving performance because it affords the best control of extraneous variables. Findings from simulator studies can then be tested further on-road.

## 2. Methods for measuring driver drowsiness

Quantifying the exact level of contribution of fatigue to road crashes is difficult because there is a lack of in-situ measures that quantify fatigue. Limitations associated with how fatigue is recorded as a contributing factor to crashes are widely recognized (e.g. Boufous and Williamson, 2009; McCartt et al., 1996; Symmons and Haworth, 2004; Williamson and Boufous, 2007). Whereas speed and alcohol consumption can be assessed before a crash by the driver, and after a crash by law enforcement agencies, fatigue is often recorded as a contributing factor either by self-report from drivers or passengers, or inferred by police observation of the driver's state or performance (e.g., veering onto the wrong side of the road), and the absence of any other relevant causal factors (NSW Centre for Road Safety, 2016a). This means that the contribution of fatigue to crashes could be underestimated. Furthermore, the use of crash occurrence data to index the extent of fatigue on the roads can also be misleading because not all episodes of fatigued driving lead to crashes. Fatigue or drowsiness can lead to "near misses" that are never recorded in crash figures (Landstrom et al., 2010; McCartt et al., 1996). These observations point to the need for better measurement of fatigue and its contribution to poor driving performance and road safety in general.

Several methods exist to measure physiological correlates of driver fatigue. These methods include electroencephalogram (EEG) data and face and eye movement data. EEGs collect information on brain activity using electrodes attached to the scalp, and several aspects of the EEG signals have been found to correlate with drowsiness (Lin et al., 2005). However, EEGs have disadvantages in terms of real time recording, noise in the signal, and practical constraints such as cost, skills, and facilities (Brookhuis and de Waard, 2010). Several studies have involved observers coding video of drivers, indexing drowsy driving by eye blinks, eye closure, head movements, and yawning (Hanowski et al., 2006; Barr et al., 2005). These have been informative on the involvement of drowsiness in on-road driving, but these methods are labor intensive, lack clear indicators for coding drowsiness, and are subject to inter-rater inconsistencies. The percentage of eye-closure or PERCLOS has been found to be a valid measure of drowsiness, and while originally relying on observer coding, has since been incorporated into an automatically coded system (see De Rosario et al., 2010; Brookhuis and de Waard, 2010). A number of drowsiness detection devices have since been developed that record parameters from which PERCLOS can be calculated. These include FaceLAB (Seeing Machines) and Smart Eye Pro (Smart Eye AB) both of which collect human eye, face and head movement, and gaze direction unobtrusively and in real time (US Department of Transportation, 2009). Other indicators including blink duration and pupil diameter have also been used to reliably index drowsiness (Akerstedt et al., 2010; Wang and Xu, 2016; Jin et al., 2013).

## 3. Aims

Understanding the nature and extent of driver fatigue on commuter trips and how it affects driving performance is an important research and public safety issue. This project aims to examine the nature and extent of driver fatigue on short trips involving commuting between home and work, and its effects on driver performance in a simulator. This project was designed to investigate the effects of a night of short sleep for

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