Accident Analysis and Prevention 85 (2015) 22–29

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

Examining signs of driver sleepiness, usage of sleepiness countermeasures and the associations with sleepy driving behaviours and individual factors

Christopher N. Watling[a,b,*], Kerry A. Armstrong[a], Igor Radun[b,c]

[a] Centre for Accident Research and Road Safety – Queensland, Institute of Health and Biomedical Innovation, Queensland University of Technology, Australia
[b] Stress Research Institute, Stockholm University, Sweden
[c] Human Factors and Safety Behavior Group, Institute of Behavioral Sciences, University of Helsinki, Helsinki, Finland

ARTICLE INFO

Article history:
Received 10 March 2015
Received in revised form 23 August 2015
Accepted 27 August 2015

Keywords:
Driver sleepiness
Signs of sleepiness
Sleepiness countermeasures
Individual factors
Australian drivers

ABSTRACT

The impairing effect from sleepiness is a major contributor to road crashes. The ability of a sleepy driver to perceive their level of sleepiness is an important consideration for road safety as well as the type of sleepiness countermeasure used by drivers as some sleepiness countermeasures are more effective than others. The aims of the current study were to determine the extent that the signs of driver sleepiness were associated with sleepy driving behaviours, as well as determining which individual factors (demographic, work, driving, and sleep-related factors) were associated with using a roadside or in-vehicle sleepiness countermeasure. A sample of 1518 Australian drivers from the Australian State of New South Wales and the neighbouring Australian Capital Territory took part in the study. The participants' experiences with the signs of sleepiness were reasonably extensive. A number of the early signs of sleepiness (e.g., yawning, frequent eye blinks) were related with continuing to drive while sleepy, with the more advanced signs of sleepiness (e.g., difficulty keeping eyes open, dreamlike state of consciousness) associated with having a sleep-related close call. The individual factors associated with using a roadside sleepiness countermeasure included age (being older), education (tertiary level), difficulties getting to sleep, not continuing to drive while sleepy, and having experienced many signs of sleepiness. The results suggest that these participants have a reasonable awareness and experience with the signs of driver sleepiness. Factors related to previous experiences with sleepiness were associated with implementing a roadside countermeasure. Nonetheless, the high proportions of drivers performing sleepy driving behaviours suggest that concerted efforts are needed with road safety campaigns regarding the dangers of driving while sleepy.

1. Introduction

Driver sleepiness is a substantial contributor to road crashes. Current estimates suggest that the effect from sleepiness accounts for 20% of all fatal and severe crashes (Connor et al., 2002; Kecklund et al., 2012; Nabi et al., 2006). However, without an objective measure of a driver's level of sleepiness, such as breath alcohol content level as with drink driving, the exact incident levels are suggested to be greater than current estimates (Cercarelli and Haworth, 2002). Many crashes are multifactorial in nature and it is likely that sleepiness could have contributed to crashes ascribed to other risky driving behaviours (Watling et al., 2013). Reducing the occurrence of driving while sleepy in the general driving population is largely reliant on educational campaigns that publicise the risks associated with driving while sleepy. Therefore, mitigating the risk from sleepiness is largely reliant on drivers' awareness of the signs of sleepiness and their subsequent actions they take to counteract their sleepiness.

1.1. Experiencing signs of sleepiness

The ability of a sleepy driver to perceive their level of sleepiness is an important consideration for road safety. Simulated driving studies reveal a good correspondence between a driver's awareness of sleepiness and their likelihood of falling asleep (Horne and Baulk, 2004; Reyner and Horne, 1998b; Williamson et al., 2014). Moreover, drivers who rate themselves at a high levels of sleepiness and at a high likelihood of falling asleep also have impaired driving performance levels with more centreline crossings and crashes during simulated driving (Williamson et al., 2014). Other driver simulator

* Corresponding author at: 130 Victoria Park Road, Kelvin Grove, QLD 4059, Australia.
E-mail address: christopher.watling@qut.edu.au (C.N. Watling).

http://dx.doi.org/10.1016/j.aap.2015.08.022
0001-4575/

studies reveal good correspondence between drivers' subjective and physiological sleepiness, as well as greater frequency of line crossings when subjective and physiological sleepiness is high (Horne and Baulk, 2004; Reyner and Horne, 1998b). Considered together, these results suggest that drivers have some level of insight of their level of sleepiness and high levels of subjective sleepiness corresponds with impaired driving performance.

The insight of individuals regarding their ability to recognise particular signs of sleepiness has been explored. For instance, Kaplan et al. (2007) examined the associations between experiencing certain signs of sleepiness with the ability to predict sleep onset with a computerised task. The results suggest individuals were aware of their sleepiness and could report experiencing particular signs of sleepiness – as sleepiness levels increased the amount of signs of sleepiness experienced also increased. A study by Howard et al. (2014) examined the relationships with particular signs of sleepiness and the corresponding physiological, subjective, and performance indices during a simulated driving task. As physiological and subjective sleepiness increased and driving performance subsequently became more impaired, the frequency with which the signs of sleepiness were reported increased correspondingly. Signs of sleepiness that were specifically associated with severely impaired simulated driving performance were related to visual disturbances (e.g., struggling to keep your eyes open) and overt signs of sleepiness impaired driving performance (e.g., difficulty keeping to middle of road). These studies of *specific* signs of sleepiness similarly suggest that drivers have some level of insight into their level of sleepiness and are able to report specific signs of sleepiness.

1.2. Usage of sleepiness countermeasures

When a driver becomes aware of experiencing certain signs of sleepiness, the individual can choose to implement a sleepiness countermeasure. A number of sleepiness countermeasures are available to the driver. These sleepiness countermeasures can be grouped broadly into categories based on where they are implemented, being at the roadside or in-vehicle. When implementing a roadside sleepiness countermeasure, the driver must first cease driving by pulling their vehicle over to the roadside – this action automatically eliminates the possibility of the driver falling asleep while driving.

Roadside sleepiness countermeasures include: stopping and taking a rest break (which could also include eating and or having a drink (e.g., coffee), 'stretching' ones legs, amongst other activities), stopping and napping, or swapping drivers. Experimental studies suggest that napping and consuming caffeine are the most effective countermeasures for reducing physiological and subjective sleepiness (De Valck and Cluydts, 2001; Horne and Reyner, 1996; Watling et al., 2014b). Direct comparisons of napping and caffeine suggest caffeine produces the most consistent effects (Horne and Reyner, 1996); this is likely due to ease of administering caffeine versus the obvious difficulty of napping on cue. Rest breaks are a commonly employed roadside countermeasure (Anund et al., 2008); although, experimental studies suggest the effectiveness of rest breaks are short lived when compared to nap breaks (Watling et al., 2014b). Swapping drivers is a commonly promoted countermeasure although its effectiveness in relation to the other roadside countermeasures is unknown. Last, Cummings et al. (2001) demonstrated drivers who used a highway rest break area had a lower relative risk of being involved in a crash along a rural interstate highway.

In-vehicle sleepiness countermeasures are actions the driver initiates while driving to increase their level of arousal. These can include listening to music and opening the window or turning on the air conditioner. Overall, experimental studies suggest the effectiveness of in-vehicle countermeasures is relatively low. For instance, listening to music has a small effect for reducing subjective sleepiness, with a less pronounced effect for reducing physiological sleepiness (Reyner and Horne, 1998a; Schwarz et al., 2012). Similarly, opening the window/turning on the air conditioner has a small, albeit, transient effect on subjective sleepiness; however, the effect on physiological sleepiness is negligible to non-existent (Reyner and Horne, 1998a; Schwarz et al., 2012). Overall, in-vehicle countermeasures have limited effectiveness for reducing sleepiness. However, these two in-vehicle countermeasures are popular with drivers and are utilised more so than the more effective roadside sleepiness countermeasures (Anund et al., 2008; Armstrong et al., 2010; Nordbakke and Sagberg, 2007).

It is possible that a number of demographic, work, driving, and sleep-related factors could influence an individual's use of a sleepiness countermeasure. Demographic factors such as age (being younger) and sex (being male) have been previously related to driving while sleepy, employing rest breaks (Phillips and Sagberg, 2013; Radun et al., 2015; Watling, 2014), and having a sleep-related crash (Åkerstedt and Kecklund, 2001). Work related factors might influence the choice of sleepiness countermeasure as shift workers and professional drivers have greater experience with sleepiness and driving (Anund et al., 2008; Di Milia, 2006) and this could predispose them to utilise the more effective roadside countermeasures.

Another set of factors that could influence the choice of a sleepiness countermeasure could be the individual's previous experiences with driving while sleepy. That is, previous experiences with having a sleep-related close call or crash might lead an individual to use roadside sleepiness countermeasures as they are more effective. Additionally, survey studies suggest drivers also perceive roadside countermeasures as effective sleepiness countermeasures (Anund et al., 2008; Armstrong et al., 2010). Sleep health related factors might also influence an individual's choice of sleepiness countermeasure. Individuals that experience frequent daytime sleepiness or have poor sleep quality are likely to suffer from excessive daytime sleepiness (Bartlett et al., 2008) and might be inclined to utilise the more effective roadside sleepiness countermeasures.

The utility of outcomes derived from laboratory and simulator studies restricts the generalisation of these studies to the general driving population. Specifically, it is unknown what proportions of Australian drivers have previously experienced specific signs of sleepiness and the associations between specific signs of sleepiness and sleepy driving behaviours are also unknown. The usage of the various countermeasures has yet to be quantified in a large sample of Australian drivers and identifying factors associated with implementing a roadside or in-vehicle countermeasure needs to be performed on a large sample of Australian drivers. Understanding the associations with the signs of sleepiness and countermeasure usage with driving behaviours and individual factors could be important information for road safety educational campaigns. The first aim was to examine the proportion of drivers who have previously experienced the signs of sleepiness and how these signs of sleepiness were associated with the two sleepy driving behaviours of continuing to drive while sleepy and having a sleep-related close call. The second research aim sought to identify the sleepiness countermeasures that are used by drivers and what individual factors were associated with using a roadside or in-vehicle sleepiness countermeasure.

2. Method

2.1. Participants

In total, 1518 participants took part in the study. The inclusion criteria for participation were being aged 17 years or older, having