

Understanding drivers' motivation to take a break when tired

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Abstract

Evidence shows that drivers are aware of and can report increasing fatigue while driving and most importantly can detect the likelihood of falling asleep prior to crashing. Drivers reporting high likelihood of falling asleep are around four times more likely to crash and nine times more likely to cross the centreline in a driving simulator. This shows that drivers can make an informed decision to drive or not drive when tired. The question is why drivers don't always make the safe choice when tired. The aim of the study was to investigate the impact of motivational factors on drivers' decision to respond or not to fatigue while driving. The study examined two motivational influences affecting fatigued drivers: the fear of fatigue-related crashes and the need to finish the trip in a specified time. The relative strength of influences was manipulated through monetary incentives. Three groups of 30 tired drivers did a two hour drive in a simulator in each of three conditions: Safety motivation - drivers were informed that an amount would be deducted from \$100 whenever they had a serious safety incident; Time motivation - drivers were told that money would be deducted from their \$100 if they were slower than expected; No motivation - drivers were paid \$100 at the end of the trip regardless of safety or time. Preliminary results showed that Safety motivation was effective: many drivers took breaks and driving performance was improved compared to No motivation. Time motivation was also effective in making drivers take fewer breaks and complete the trip earlier.

Introduction

Driver fatigue is a recognised threat to road safety. Estimates of its involvement in fatal crashes go as high as 33%, but often tend to be around half that (e.g., Tefft, 2012). A considerable amount of research has been conducted to identify and better understand risk factors for fatigue and related crashes but relatively little research has investigated factors that affect drivers' implementation of fatigue countermeasures. This issue is particularly important for professional drivers whose use of countermeasures might be shaped by commercial incentives and pressures that favour work over rest (e.g., Golob & Hensher, 1994; Hensher, Battellino, Gee, & Daniels, 1991; Quinlan & Wright, 2008) and for ordinary drivers who want to reach their destination as soon as possible. It is also important for public policy which makes assumptions about how successfully drivers can identify and react to fatigue and about the extent to which they can reasonably be held accountable for fatigue crashes (Fletcher, McCulloch, Baulk, & Dawson, 2005; Jones, Dorrian, & Rajaratnam, 2005).

There is mounting evidence that drivers are sufficiently aware of their own sleepiness and likelihood of falling asleep in the near future that they could decide to take action to avoid crashing (Reyner & Horne, 1998; Williamson, Friswell, Olivier, & Grzebieta, 2014) although it is less clear that drivers relate their sleepy state to crash likelihood (Williamson et al., 2014). In addition, Hockey's effort compensation theory (2012) predicts that tired drivers should be motivated to take breaks due to the increasing effort required to maintain performance when fatigued. However, the fact that fatigue crashes continue to occur raises questions about how effective motivational effects are on fatigued drivers and their decisions to break from driving. The current study investigated whether drivers could be motivated to increase break-taking in response to fatigue by providing

incentives that favoured safe performance or incentives to favour trip completion over safety, compared to no incentives.

Method

Design

The experiment examined the effects of three motivational conditions (No, Safety or Time incentives). Drivers in all groups were told that they would receive \$100 (in retail gift cards) at completion of a 201 km simulator drive. Safety group participants were told they would lose \$20 from a maximum of \$100 every time they drove off the road, crashed, or crossed the centreline, thus providing motivation to avoid fatigue driving errors. Time group participants were told they would lose \$20 for every minute over 2 hours that they took to complete the drive, thus providing motivation not to stop even if fatigued. All groups received the same manipulation aimed to induce fatigue during the drive: a shortened sleep in the night before and testing in the mid-afternoon period and a monotonous drive scenario. Driving performance was indexed by the occurrence of adverse events (crashes, centreline crossings, lane departures and lane edge touches) and variability in lane position. Subjective ratings of sleepiness, the likelihood of falling asleep and of crashing in the following few minutes were measured regularly throughout the drive. The Optalert Drowsiness Management System measured objective blink indices of drowsiness using the proprietary Johns Drowsiness Score (JDS)

Participants

Ninety (n=90) people fully licenced to drive cars in NSW were recruited via electronic and actual noticeboards at UNSW. 63.3% were men and the mean age was 26.4 years (SD=8.05; range 20 to 60). Most (78.9%) had been licenced for less than 10 years and currently drove 77km per week on average (SD=83.85, range 0 to 500). Thirty people took part in each motivational condition and the distribution of age, sex, and driving experience was similar across conditions.

Materials and Procedure

Participants first attended a training session involving completing brief demographic and sleep questionnaires, a 60km practice drive on a desktop STISIM simulator and being fitted with Optalert glasses to record blink data. They were then instructed to reduce their hours in bed to five on the night before the test session by delaying bedtime but retaining usual waking time. Actigraphs (Respironics Actiwatch 2) and a brief sleep diary were provided to validate the sleep restriction.

On the next, test day, they completed a brief questionnaire about caffeine, alcohol and medication use, were fitted with the Optalert glasses and were reminded to drive according to the road rules. The Safety and Time condition participants were told of the incentive rules that would apply to their performance. All participants then rated their sleepiness, sleep likelihood and crash likelihood and commenced driving at 14:30. The drive scenario lasted 1:59 at the posted speed limits (80, 100, and 110 kph). The route was a monotonous, rural road. A trip odometer, digital clock and the rating scales were visible to participants during the drive. Verbal subjective ratings were prompted by a tone 35 times across the drive. At the end of the drive, participants again rated themselves and were debriefed. All participants received the full \$100 value regardless of their performance.

The motivation groups were compared on sleepiness-related and driving performance variables using Chi square and ANOVA with $p < .05$ and Bonferroni corrected post-hoc tests.

Results

Success of fatigue manipulation

Actigraph data showed that participants fell asleep on average at approximately 2:35 and woke at approximately 7:05 am on the test day, achieving an average of 4:49 h sleep (Table 1). There were no significant differences between incentive conditions on any diary recorded sleep variables, including subjective ratings of quality and feeling refreshed on waking, nor on actigraph measures of sleep. Similarly, there were no significant differences between the motivation conditions in maximum rated sleepiness, maximum JDS measured during the drive, or percentages of people who fell asleep while they were driving (or at any time during the drive).

Table 1. Manipulation of sleepiness

	Control	Safety motivation	Completion motivation	All participants	p-values
Actual sleep hours measured by actigraph (Mean, SD)	M=4:43h, SD=1:00h	M=4:42h, SD=0:45h	M=4:54h, SD=0:56h	M=4:49h, SD=0:56h	$F_{2,86}=.401$, p=.671
Rated sleep quality (/100; Mean, SD) ^a	M=61.43, SD=24.44	M=54.93, SD=25.77	M=56.97, SD=21.52	M=57.78, SD=23.86	$F_{2,86}=.577$, p=.564
Refreshingness of sleep (/100; Mean, SD) ^a	M=33.9, SD=17.48	M=39.37, SD=22.91	M=46.33, SD=18.88	M=39.87, SD=20.32	$F_{2,86}=2.945$, p=.058
Hours since waking at start of drive (Mean, SD)	M=7:27:39, SD=1:23:11	M=7:30:38, SD=1:10:53	M=7:17:21, SD=1:30:38	M=7:25:11, SD=1:21:13	$F_{2,86}=.216$, p=.806
Highest KSS (/9) rating during drive (Mean, SD) ^b	M=7.63, SD=1.77	M=7.53, SD=1.61	M=7.50, SD=1.73	M=7.56, SD=1.69	$F_{2,86}=.049$, p=.952
Highest Optalert JDS score during drive (Mean, SD) ^c	M=3.21, SD=1.92	M=2.84, SD=1.43	M=3.24, SD=1.73	M=3.10, SD=1.70	$F_{2,86}=.493$, p=.613
Participants reported falling asleep during drive (%)	46.7	23.3	36.7	35.6	$X^2_{(2)}=3.588$, p=.189

^a Higher ratings indicate better subjective sleep; ^b Higher ratings indicate greater subjective sleepiness; ^c Higher JDS indicates greater drowsiness

Driving performance

Table 2 compares the motivation conditions on measures of driving performance. There were significant differences between conditions in minutes taken to complete the drive and the percentage of drivers taking breaks. Consistent with their incentive instructions, post hoc comparisons confirmed the Time group took significantly less time to finish the drive than the No motivation condition, and were less likely than both the other conditions to stop during the drive. Post hoc tests showed the number and length of breaks was significantly lower in the Time group than in the No motivation group. Number of lane edge touches and variability of lane position both showed a significant effect of motivation condition. Post hoc tests confirmed that Safety motivation participants had fewer lane edge touches and less variability of lane position than No motivation drivers. The conditions did not differ significantly on any other measures of lane departure or the proportion of people who crashed although as this was low in all groups. This finding may be due to sample size limitations.

Table 2. Driving performance

	No motivation	Safety motivation	Time motivation	p values
Minutes to complete drive (Mean, SD)	122.31, 5.80	121.65, 7.86	118.28, 3.01	$F_{(2,87)}=4.02, p=.02$
Drivers who stopped (%)	36.7	40	6.7	$X^2_{(2)}=10.08, p=.006$
Number of stops (Mean, SD)	1.4, 2.3	1.0, 1.7	.1, .3	$F_{(2,87)}=4.71, p=.01$
Total time(s) stopped (Mean SD)	129.1, 295.3	40.9, 69.3	.2, .8	$F_{(2,87)}=4.25, p=.02$
Drivers who crashed (%)	16.7	6.7	10	$X^2_{(2)}=1.58, p=.46$
Drivers with centreline crossings (%)	13.3	3.3	6.7	$X^2_{(2)}=2.17, p=.34$
Number of lane edge touches across the drive (Mean, SD)	85.63, 101.87	29.80, 47.66	54.70, 71.15	$F_{(2,87)}=3.98, p=.02$
Variability of lane position across the drive (Mean, SD)	.45, .23	.32, .17	.38, .18	$F_{(2,87)}=3.27, p=.04$

Discussion

This analysis showed that providing safety-related incentives to respond to increasing fatigue meant that drivers were more likely to take breaks from driving than drivers provided incentives to complete the drive under time pressure. The Time incentive group, as expected, completed the trip faster with only a small minority stopping. The Safety incentive group produced the best driving performance overall. In contrast, the No motivation group, who were given no incentive instructions, showed poorest driving performance with more lane edge touches and greater lane variability than the Safety group.

Participants reached similar levels of fatigue in all study conditions. The sleep, sleepiness and drowsiness measures indicated that participants in the three groups were similarly affected by the sleep restriction protocol during the drive. The results suggest the simultaneous operation of two processes. First, the poor performance of the No motivation group suggests that any incentive can improve the driving performance of tired drivers in monotonous conditions. This explanation is consistent with findings of previous research on train driving showing that even small manipulations to reduce the monotony of the driving task markedly improved driving performance (Dunn & Williamson, 2012). Second, the finding that driving performance was best for the Safety incentive group suggests that this incentive encouraged more breaks from driving which would be expected to refresh the drivers and improve driving performance, at least in the short term. Further, in-depth analysis should reveal more about the relations between break-taking, driving performance and sleepiness under different incentive conditions.

Previous research suggests that despite being aware of the symptoms of fatigue and sleepiness before they fall asleep during driving, drivers underestimate the link between these symptoms and falling asleep and potentially overestimate their ability to overcome these symptoms (Nordbakke and Sagberg, 2007). There is also some evidence that individuals differ in their propensity to take a break from driving when sleepy. Characteristics like age, gender, motivation and risk perception (Watling, Armstrong, Obst and Smith, 2014) and more tolerant attitudes to driving while tired (Watling, 2014) have been linked with continuing to drive while sleepy. All of these studies

involved self-report questions requiring drivers to recall instances when they have experienced fatigue or fallen asleep at the wheel. The strengths of the current study are that it manipulated motivators to take breaks from driving or not and investigated actual driving behaviour when drivers were experiencing fatigue. The results indicate that incentives to manage fatigue were effective in improving driver performance.

Overall, these results suggest that providing incentives to drivers to modify their driving behaviour can be effective. Drivers will take breaks from driving if provided a motivation to do so. On the other hand, however, drivers motivated to 'push on' and reach their destination quickly will also do so. Clearly, our attempts to reduce driver fatigue must develop strategies that highlight and increase drivers' motivation to take breaks strategically in response to their fatigue state. This is especially important for professional and long distance drivers who already face incentives that favour continuing to drive rather than taking breaks to manage fatigue.

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