

**Young Drivers Who Continue to Drive While Sleepy: What are the Associated Sleep
and Driving-related Factors?**

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Abstract

Crashes due to sleepiness account for a substantial proportion of road crash incidents. The purpose of the current study was to examine several sleep-related factors and driving-related factors for their association with self-reports of continuing to drive while sleepy. In total 257 young drivers aged 18-25 years completed an online survey that assessed factors such as sleep quality, sleep duration and consistency, excessive daytime sleepiness, experiences with sleepiness and their driving-related behaviours. The results demonstrate that being older, having a perceived ability to overcome sleepiness, committing more highway code violations and having experienced a sleep-related close call were positively associated with an increased likelihood of continuing to drive while sleepy. The obtained results highlight the acceptance of performing risky driving behaviours among some younger drivers. Younger drivers' risky driving behaviour is certainly a road safety concern given the impairment associated with sleepiness and their over-representation in road crash incidents.

Keywords: young drivers, sleepiness, overcome sleepiness, sleep-related factors, driving-related factors, sleep-related close calls

1. Introduction

Young drivers are overrepresented in the number of fatal road crashes and serious injuries requiring hospitalisation (Bureau of Infrastructure Transport and Regional Economics [BITRE], 2015; A. F. Williams, 2003). The economic cost associated with young driver crashes is substantial as well (BITRE, 2009). Young drivers are also overrepresented in sleep-related crashes (Connor et al., 2002). When younger individuals perform attentional tasks their performance is more impaired by sleepiness compared to older individuals (Adam, Retey, Khatami, & Landolt, 2006) which suggests they are more vulnerable to the effect from sleepiness. The risk perceptions of younger drivers' regarding the dangers of driving while sleepy are also erroneous (e.g., Watling, Armstrong, Obst, & Smith, 2014; L. R. Williams, Davies, Thiele, Davidson, & MacLean, 2012). Thus, younger drivers' overrepresentation in sleep-related crashes represents a significant public health concern.

Ultimately, drivers are responsible for being aware of and regulating their level of sleepiness with effective countermeasures. Yet, a number of studies are highlighting the large proportions of drivers (70-73%) who, when aware of their increasing level of sleepiness, choose to continue to drive while sleepy (Nordbakke & Sagberg, 2007; Watling, Armstrong, & Radun, 2015). Laboratory-based studies demonstrate continuing to drive while sleepy and increasing the amount of effort allocated to the task, has no effect on improving driving performance or reducing physiological or subjective sleepiness (e.g., Watling, 2016). Thus, continuing to drive while sleepy is a volitional, risky driving behaviour, and understanding the associated factors is important for improving road safety outcomes.

Several sleep-related factors could be influential with younger drivers who continue to drive while sleepy. These sleep-related factors could include quality of sleep. A number of studies have previously demonstrated poor sleep quality is associated with sleepiness when driving as well as crashing (Martiniuk et al., 2013; Pizza et al., 2010). Experiencing excessive daytime sleepiness could also be another factor associated with driving while sleepy (Radun,

Radun, Wahde, Watling, & Kecklund, 2015). Sleep duration (Komada, Asaoka, Abe, & Inoue, 2013; Martiniuk et al., 2013) and sleep timing consistency (Soehner, Kennedy, & Monk, 2011) can also lead to experiencing daytime sleepiness and subsequent episodes of sleepy driving. While the sleep-related factors described have all been associated with sleepy driving episodes, it is not known if they are related with *continuing* to drive while sleepy.

A factor that could be associated with continuing to drive while sleepy is an individual's perceived ability to overcome sleepiness and to maintain task performance. For instance, some laboratory-based studies highlight how sleepy individuals apply more effort to overcome the impairment from sleepiness (e.g., Odle-Dusseau, Bradley, & Pilcher, 2010; Pilcher & Walters, 1997), yet, other laboratory-based studies found participants did not increase the effort they applied during task performance (e.g., Drummond et al., 2000; Sallinen et al., 2013). The potential reasons for these differential effects of applying effort could be due to intrinsic and extrinsic rewards, and certainly genetic differences could also influence performance outcomes (e.g., Maire et al., 2015). While several studies have highlighted the importance of motivational factors with continuing to drive while sleepy (Nordbakke & Sagberg, 2007; Watling et al., 2014), the overarching issue concerning whether an individual will continue to drive while sleepy could be due to their perceived ability to overcome sleepiness. That is, if an individual perceives they can successfully overcome sleepiness to maintain task performance then this could encourage them to continue driving while sleepy.

In contrast to examining sleep-related factors, driving-related factors could also be associated with continuing to drive while sleepy. Drivers who tend to commit driving errors or violations could be more likely to continue to drive while sleepy. In this regard, continuing to drive while sleepy could be viewed akin to engaging in other risky or aberrant driving behaviours, such that drivers who perform other risky driving behaviours might be more inclined to continue to drive while sleepy as well. Indeed, younger drivers who are involved

in crashes also report receiving more traffic offence notices, as well as performing other risky driving behaviours such as drink driving and or speeding (Fergusson, Swain-Campbell, & Horwood, 2003; Ivers et al., 2009). Moreover, drivers' favourable attitudes towards risky driving behaviours are also associated with more speeding and greater lane deviation during simulated driving tasks (Zicat, Bennett, Chekaluk, & Batchelor, 2018). To date, little is known about the extent of performing other risky driving behaviours and their association with sleep-related driving behaviours.

The reviewed literature suggests that several sleep and driving-related behaviours could be associated with continuing to drive while sleepy. The first aim of the current study was to examine the relationships between sleep functioning, daytime sleepiness, and driver behaviours. The second aim was to determine how sleep functioning, daytime sleepiness, and driver behaviours factors were associated with continuing to drive while sleepy.

2. Method

2.1 Participants

The inclusion criteria for the study required participants to have a valid driver licence (Provisional 1 or 2 or an open class licence) where they could drive without supervision (i.e., not a learners licence) and that they drove a minimum of 1 hour each week on the Queensland road network. In total, 257 participants (53.70% women) took part in the study with a mean age of 21.07 years ($SD = 2.24$; range = 18 to 25). Participants reported driving on average 5935.61 km/year ($SD = 5097.34$; range = 3500 to 37000).

2.2 Measures

2.2.1 Demographics and Traffic-Related Demographics

The demographic information collected included the participants' age and sex. Traffic-related demographic data included a measure of driving exposure (i.e., number of kilometres driven per year) and if the participant had ever been involved in a sleep-related

close call. The outcome variable, continuing to drive while sleepy, was measured on a 7-point Likert scale ranging from 1 (Never) to 7 (Always).

2.2.2 Pittsburgh Sleep Quality Index

The Pittsburgh Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989) is a self-report questionnaire that assesses subjective sleep quality and disturbances. The questionnaire utilises 19 items to generate seven component scores ranging from 0-3. The seven components are subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. The seven component scores are summated to produce a global PSQI score that has a range of 0-21, with higher scores indicative of poorer sleep quality.

2.2.3 Epworth Sleepiness Scale

The Epworth Sleepiness Scale (ESS; Johns, 1991) is a measure of excessive daytime sleepiness in adults. Participants respond to how likely they are to doze off or fall asleep in eight situations (e.g., “sitting and reading”, “sitting and talking to someone”, and “in a car, while stopped for a few minutes in the traffic”). Potential responses range from 0 = “Would never doze”, 1 = “Slight chance of dozing”, 2 = “Moderate chance of dozing”, and 3 = “High chance of dozing”. The range of possible summated scores is 0-24, with higher scores indicative of greater daytime sleepiness.

2.2.4 Sleep Timing Questionnaire

The Sleep Timing Questionnaire (STQ; Monk et al., 2003) is a self-report questionnaire that assesses the habitual timing of an individual. Measures of an individual’s habitual bedtime (good night time, GNT) and habitual wake-time (good morning time, GMT) are produced from the questionnaire for the week nights and weekend nights respectively. Additionally, the STQ produces a measure of an individual’s stability of habitual bedtime and wake-time. This measure of stability is measured on an arbitrary scale of 1-11, with higher scores indicative of greater instability.

2.2.5 Experience with Sleepiness Questionnaire

The Experience with Sleepiness Questionnaire (ESQ) is a self-report measure of an individual's perceived ability to overcome sleepiness and was custom written for the current study. Participants responded to five statements regarding how true they rated the statement (e.g., "When I feel sleepy, I can control my sleepiness to stay awake", "The day after a poor night of sleep I can push on to get tasks done"). Responses were measured on a seven-point Likert scale (1 = "Not at all true" to 7 = "Very true"). An overall ESQ score is calculated by averaging all items, with higher scores indicative of greater perceived ability to overcome sleepiness.

2.2.6 Driver Behaviour Questionnaire

The Driver Behaviour Questionnaire (DBQ; Reason, Manstead, Stradling, Baxter, & Campbell, 1990) is a self-report questionnaire that assesses aberrant driving behaviours over the preceding year. The original DBQ was developed by Reason et al. (1990) which contained 50 items, however, the original DBQ has undergone several modifications. The version created by Lawton et al. (1997) was utilised in the current study, and comprises 27-items in four subscales, those being: Lapses (8-items), Errors (8-items), Highway Code Violations (8-items), and Aggressive Violations (3-items). Responses were measured on a six-point Likert scale (1 = "Never" to 6 = "Nearly All the Time") with higher scores indicative of greater aberrant driving behaviour. Minor modifications to some DBQ questions were also made to ensure the questionnaire was representative of driving conditions in Australia. It must be noted there has been considerable debate surrounding the use and validity of the DBQ in the road safety setting (see af Wählberg & Dorn, 2012; de Winter & Dodou, 2010). However, it must be noted that the use of the DBQ in the current study is not focused on predicting crash likelihood, but for its association with continuing to drive while sleepy.

2.3 Procedure

An online survey methodology was used to obtain the data. Potential participants were recruited into the study via university email distribution lists. Participants were provided information about the purpose of the research, confidentiality agreements, and that they could withdraw at any time and their anonymity would be preserved. Participants were informed their consent was acknowledged with the submission of their completed survey.

2.4 Statistical Analysis

The internal consistency of the scale scores was evaluated with the Cronbach's alpha coefficient. The first aim was evaluated with Pearson's product moment correlation for continuous variables and point biserial correlations for dichotomous and continuous variables. The second aim was assessed via a multiple regression analysis to examine the strength of the predictor variables with the dependent variable while controlling for the relationships between the predictor variables. The distributions of the PSQI Score, STQ Sleep stability, DBQ Highway Code Violations, and DBQ Aggressive Violations variables had some slight departures from normality which were corrected with transformations. Lastly, the assumptions required for multiple regression analyses were met.

3. Results

3.1 Sleep functioning, daytime sleepiness, and driving behaviours

The means, standard deviations, and ranges for self-reported continuing to drive while sleepy, sleep functioning, daytime sleepiness, and driving behaviours can be seen in Table 1. On average, participants self-reported continuing to drive while sleepy more often than not, with the mean score slightly over the mid-point, there was also a moderate amount of variability with this variable. Participants reported average sleeping durations of 8.35 hours as assessed via the STQ. The scores for all the DBQ subscales were low suggesting the participants did not report performing the various behaviours often when driving.

Table 1. Means (*M*), Standard Deviations (*SD*), Cronbach's alpha, and ranges of the study variables.

Variable	M	SD	Cronbach's	
			alpha	Possible Range
Continuing to drive while sleepy	4.03	1.52	-	1.00-7.00
PSQI Score ^a	5.54	2.03	.81	0-21.00
ESS Score	7.42	3.28	.78	1.00-24.00
STQ Sleep duration	8.32	1.11	-	-
STQ Sleep stability ^a	4.91	1.94	-	1-11
ESQ Score	4.15	0.60	.74	1.00-7.00
DBQ Lapses	1.94	0.38	.80	1.00-6.00
DBQ Errors	1.59	0.31	.71	1.00-6.00
DBQ Highway Code Violations ^a	2.26	0.46	.76	1.00-6.00
DBQ Aggressive Violations ^a	1.66	0.41	.70	1.00-6.00
Sleep-related close call	Yes: 72	-	-	-

^aUntransformed variable scores displayed.

3.2 Relationships between sleep functioning, daytime sleepiness, and driver behaviours

A number of the study variables were significantly correlated with continuing to drive while sleepy, as seen in Table 2. Among the study variables, ESQ Score, Sleep-related close calls, and DBQ Highway Code Violations had the largest correlations with the outcome variable of self-reports of continuing to drive while sleepy. The variables PSQI score, Age, and DBQ Errors all had small correlations with continuing to drive while sleepy. The largest correlation was observed between the DBQ Lapses and DBQ Errors.

Table 2. Bivariate correlations between sleep functioning, daytime sleepiness, driving behaviours continuing to drive while sleepy variables.

Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1. Continuing to drive while sleepy	-												
2. Age	.28**	-											
3. Sex (female) ^a	.04	.01	-										
4. PSQI Score	.21**	.24**	.06	-									
5. ESS Score	.11*	.01	.30**	.23*	-								
6. STQ Sleep duration	.07	.10	.09	-.03	-.08	-							
7. STQ Sleep stability	-.01	-.04	-.09	.16**	.11*	.01	-						
8. ESQ Score	.38**	.16**	-.05	.09	-.06	.33**	.14*	-					
9. DBQ Lapses	.10	.10	.38**	.21**	.39**	-.12*	.34**	-.04	-				
10. DBQ Errors	.15**	.27**	.36**	.37**	.31**	-.05	.25**	-.01	.61**	-			
11. DBQ Highway Code Violations	.29**	.28**	-.03	.22**	.13*	-.09	.24**	.15*	.38**	.53**	-		
12. DBQ Aggressive Violations	.01	.06	-.23**	.09	-.03	.02	.13*	.07	-.11*	-.05	.38**	-	
13. Sleep-related close call (yes) ^a	.26**	.21**	.01	.23**	.07	-.05	.04	.08	-.02	.12	.11*	.08	-

** $p < .01$, * $p < .05$; ^a = point bi-serial correlation

3.3 Associations with continuing to drive while sleepy

The results from the hierarchical linear regression can be seen in Table 3. The demographic variables of age and sex were entered at the first step – this model was a significant predictor of continuing to drive while sleepy (accounting for 2.80% of the variance) and Age was significantly associated with the outcome variable. At the second step the sleep functioning, daytime sleepiness, and driving behaviours variables were entered into the model. This second model was a significant predictor of continuing to drive while sleepy which overall, accounted for 21.7% of the variance. The variables of ESQ score, DBQ Highway code violations, and Sleep-related close calls were significantly associated with the outcome variable continuing to drive while sleepy. That is, reporting greater ability to perform well when sleepy, reporting having committed more highway code violations, and having experienced more sleep-related close calls were associated with a greater likelihood of continuing to drive while sleepy.

Table 3. Hierarchical linear regression of sleep functioning, daytime sleepiness, and driving behaviours with continuing to drive while sleepy.

Variable	<i>B</i>	SE <i>B</i>	β	<i>r_{ab.c}</i>	<i>r_{a(bc)}</i>
Step 1					
Age	0.19**	0.04	.28	.28	.28
Sex (female)	0.12	0.18	.04	.04	.04
Constant	-0.12	0.91			
Adjusted $R^2 = .071$; $F(2, 254) = 10.78^{**}$					
Step 2					
Age	0.08*	0.04	.13	.13	.11
Sex (male)	0.07	0.20	.02	.02	.02
PSQI score	0.35	0.22	.10	.10	.09
ESS score	0.04	0.03	.08	.08	.07
STQ Sleep duration	-0.02	0.08	-.02	-.02	-.01
STQ sleep stability	-0.39	0.22	-.11	-.12	-.10
ESQ score	0.84**	0.15	.33	.34	.30
DBQ lapses	0.16	0.31	.04	.03	.03
DBQ errors	-0.55	0.41	-.11	-.09	-.07
DBQ Highway code violations	2.66**	0.78	.26	.21	.18
DBQ Aggressive violations	-0.77	0.40	-.12	-.12	-.10
Sleep-related close call (yes)	0.59**	0.19	.19	.17	.16
Constant	-4.58**	1.30			
Adjusted $R^2 = .262$; $F(12, 244) = 8.59^{**}$; R^2 change = .191; $F_{\text{change}}(10, 244) = 7.59^{**}$					

* $p < .05$, ** $p < .01$.

4. Discussion

The current study sought to examine a number of factors that could be associated with young drivers' self-reports of continuing to drive while sleepy. Overall, four of the study variables were associated with continuing to drive while sleepy – these four variables were Age of the participant, ESQ score, DBQ Highway Code Violations, and having experienced a sleep-related close call in the past. The implications of these findings are discussed below.

The association of Age of the participant with continuing to drive while sleepy was a notable finding, largely because of the positive direction of the relationship. Numerous studies have shown Age and sleepy driving behaviours are negatively related (Nordbakke & Sagberg, 2007; Radun et al., 2015; Watling, Armstrong, & Radun, 2015). The main difference between these studies and the current study is the wide age range used in previous

studies (i.e., 17-83) and the narrow age range (i.e., 18 to 25 years) of drivers in the current study.

Potential reasons for the positive relationship between the age of participants and continuing to drive while sleepy could be due to younger drivers having limited driving experience with sleepiness and driving at night. Obtaining a licence in Australia requires a novice driver to complete a Graduated Driver Licensing (GDL) program, which includes having to obtain a minimum of 10 hours night-time driving experience during the learning period of licencing. This required 10 hours of night-time driving is a limited proportion of the overall time spent learning to drive. It has been suggested that younger adults are more reliant on experiential decision making when engaging in risky behaviours (Reyna & Farley, 2006). Further, a study focusing on younger drivers (18-22 years) sleepy driving behaviours, attitudes, and risk perceptions, found two-thirds of participants who had not previously driven while impaired by sleepiness, reported greater perceptions of risk with sleep-related crashes (Lucidi et al., 2006). Thus, a lack of on-road driving experience during periods of increased sleepiness could be acting as a protective factor, but as the young driver's experience with driving while sleepy gradually increases so too would their confidence with performing the risky driving behaviour (e.g., Reyna & Farley, 2006). This interpretation is also consistent with the positive correlation between Age and having experienced a Sleep-related close call. Nonetheless, more research is needed to first confirm the current finding and to explore the potential theoretical and practical underpinnings.

The obtained findings also demonstrate an individual's perceived ability to overcome sleepiness was associated with continuing to drive while sleepy. The ESQ variable had the largest association with continuing to drive while sleepy. While previous research has highlighted that motivational factors such as time pressure and close proximity to one's destination as important factors associated with continuing to drive while sleepy (Armstrong, Obst, Banks, & Smith, 2010; Nordbakke & Sagberg, 2007) it is likely that perceived ability

to overcome sleepiness would also be an important factor as well. The current finding that an individual's perceived ability to overcome sleepiness was associated with continuing to drive while sleepy extends upon the existing knowledge and provides further understanding regarding a driver's decision to continue to drive while sleepy.

Perhaps the greater issue of the relationship between the ESQ and continuing to drive while sleepy is one of driving safety. While laboratory-based studies have demonstrated that increased effort can, to a degree, overcome sleep-related impairment on simple cognitive tasks (e.g., Horne & Pettitt, 1985; Watling, 2016), increased effort cannot completely overcome the impairment due to sleepiness on complex cognitive tasks (e.g., Sallinen et al., 2013; Watling, 2016). Moreover, sleep deprived participants' perceptions of their actual performance levels can be erroneous (Ogle-Dusseau et al., 2010; Pilcher & Walters, 1997) and applying extra effort to the task of driving does not result in any improvements to driving performance (e.g., Watling, 2016). In addition, the ESQ variable was significantly and positively correlated with Age and thus driving experience could be an important factor related to an individual's perceived ability to overcome sleepiness while driving.

Overall, two of the driving-related factors, being DBQ Highway Code Violations and having had a Sleep-related close call were both significantly associated with continuing to drive while sleepy. Individuals that reported performing more highway code violations as measured by the DBQ were more likely to report continuing to drive while sleepy. While the DBQ Highway Code Violations scale (which specifically assesses speeding behaviours) has typically been associated with risky speeding behaviours (e.g., Helman & Reed, 2015; Zhao et al., 2012) it has also been associated with other risky driving behaviours, including more erratic and dangerous driving behaviours (de Winter, Spek, De Groot, & Wieringa, 2010; Zhao et al., 2012). Thus, the current finding is supported by the previous research but is unique, as this is the first study to demonstrate the DBQ Highway Code Violations scale is associated with a risky sleepy driving behaviour.

The other driving-related factor associated with continuing to drive while sleepy was having a sleep-related close call. Research supporting the current finding includes the study by Powell et al. (2007) where it was shown drivers who previously experienced a sleep-related close call were more likely to also report having a sleep-related crash. Other research suggests experiencing more signs of sleepiness while driving mediates the relationship between continuing to drive while sleepy and having a sleep-related close call (Watling, Armstrong, & Haworth, 2015). When considering all of these findings together, the association of the two driving-related factors of the DBQ Highway Code Violations and Sleep-related close call with continuing to drive while sleepy can be interpreted as an acceptance of engaging in risky driving behaviours.

The results from the current study need to be considered in relation to its limitations. The current sample was not representative of the licenced younger driver population and thus limits the generalisability of the obtained results. Additionally, given the cross-sectional and retrospective nature of the study design, causality of the obtained relationships cannot be inferred, as the issue relating to recall bias needs to be considered. It is worth noting that a number of psychological factors (i.e., impulsivity, risk taking, decision making) could also have accounted for the obtained results and exploring the relationship between these factors and sleepy driving behaviours is worth pursuing with future research. Information about the participants' medication and drug use was also lacking, and illicit as well as licit drug use is known to be involved in crashes that include aspects of arousal or inattention (Brubacher et al., 2018). Future research could also include exploring factors that inhibit the youngest of drivers with continuing to drive while sleepy. Previous studies noted that the younger the age of the driver, the more likely they were to engage in sleepy driving behaviours (Nordbakke & Sagberg, 2007; Radun et al., 2015; Watling, Armstrong, & Radun, 2015) and the current finding needs to be confirmed and then explored in greater detail.

In conclusion, the variables of Age, ESQ score, DBQ Highway Code Violations, and Sleep-related close calls were positively associated with an increased likelihood of continuing to drive while sleepy in a sample of young drivers. The ESQ score variable had the largest association with continuing to drive while sleepy, and as such, the finding is concerning for road safety as applying extra effort to the task of driving when sleepy does not improve driving performance. The association of Highway code violations and Sleep-related close calls suggests a general acceptance for performing risky driving behaviours, which is also a concerning finding given the heightened crash risk of younger drivers. Continued efforts to explore and understand the factors involved in young drivers' decisions to drive while sleepy is needed.

5. References

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